Reducing Lead Times for Organizations Handling Multiple Projects in an Engineer to Order Environment

A Case Study at Jensen Sweden

Master's thesis in Master Programmes International Project Management, Quality and Operations Management

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CHALMERS UNIVERSITY OF TECHNOLOGY
Master's Thesis ACEX30-19-71
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ABSTRACT

This report is based on a case study made at an organization working in a multi-project engineer to order environment and aims to shorten the total customer project lead time for their customer projects. The report is based on interviews, workshops and quantitative data collection. Some identified challenges are that the organization is operating with a traditional structure without any appointed project manager. This type of organizational structure hinders effective communication, coordination and collaboration between departments. The structure is an essential element in the organizational design and the effects of it reveals itself in long lead times and unclear responsibilities. The solutions presented in this report are aimed at reorganizing the company structure from a traditional structure to a matrix structure. The report also aims at investigating what type of matrix structure is most suitable for the organization and how a project manager role could be implemented. Furthermore, by changing the organizational structure, processes are also affected, and by doing a business process reengineering, processes can be resettled upstream the supply chain and a more cross functional integration can be achieved. By doing this, the report fulfils its intended purpose to reduce project lead times.

Key words: Engineer to Order Environment, Project Management, Business Process Reengineering, Process Mapping, Organizational Design, Project Interconnectedness, Multiple Projects, Cross Functional Integration.

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Preface

This paper declares the ending of our education at Chalmers University of Technology. The thesis is a result of a case study at Jensen Sweden and the knowledge that we have obtained during our studies at Chalmers. We would like to give a special thanks to our supervisor Christian Koch for his inputs, which contributed to the result of this report.

We would also like to send a big thank you to Jensen Sweden as their hospitality has been invaluable for this master thesis. We would like to give a special thanks to Per Antonsson, the CEO at Jensen Sweden, for his commitment. Without Pers willingness to carry out this master thesis, it would never have been conducted. We would also like to thank all departments and employees at Jensen Sweden who have participated in interviews and workshops, without their input and willingness to contribute, none of this would have been possible.

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1 Introduction

Due to rapid changes in market conditions, technology and customer requirements, the dynamics of business has changed, where competition has switched from a local to the global arena (Dubey & Gunasekaran, 2015). In order to meet the specific needs of the ever-changing market, organizations must take actions to improve their operations, regarding performance and strategic positioning, to stay competitive (Hallgren and Olhager, 2009). According to Girod and Karim (2017), companies must reorganize periodically to keep up with changes in market conditions. However, it is not guaranteed that a company needs a new structure. Sometimes it is preferable to tweak the existing one since the benefits must outweigh the costs. For a company to choose the right reorganization it is essential to tailor it after their circumstances and decide in what pace the changes are going to be implemented. Even for the most successful reorganizations, it can take several years until the changes show signs of improvement. Karlöf and Lövingsson (2007) state that the organization's structure is often made a scapegoat when managers want to change the organization and/or suffers from poor interpersonal relations.

The organizational structure characterizes how different activities such as task allocation, coordination and supervision are directed to fit the aims of the organization. It determines how roles, responsibilities and power are controlled, delegated and coordinated between management levels. Furthermore, the structure of the organization can advance communication, decisions and actions (Renani et al., 2017). Karlöf and Lövingsson (2007) state that identifying an organization's structure can be a complex reality since they often are complicated. The relationship between organizational structure and processes is vital for the performance of the organization. Where the success for projects are impacted by both the structure and the executed processes to complete them. Thus, a more efficient organization can be designed by understanding the involved processes better while obtaining the ability to adapt to its environment (Zhang et al. 2018). Therefore, it is useful to not only look at the organizational structure, which is often the case when trying to establish a chart for the structure, but also give attention to the company processes (Karlöf & Lövingsson, 2007). For companies that operate in an environment with high complexity and increased demand for customized products, it is necessary to have flexible processes to be ideally positioned for rapid customer changes. Furthermore, companies that operate in an engineer to order environment (ETO) are complex by nature since they are driven by a specific customer demand (Grabenstetter & Usher, 2014). To satisfy their customers, companies need to ensure that projects are completed on time, and focus needs to be directed to flow oriented processes that can handle changes in customer requirements while improving the overall performance for projects. Therefore, to fill an academic gap, it would be interesting to investigate how structures and processes can be set up, or be changed, to decrease lead times for companies handling multiple projects in an ETO environment.

1.1 Purpose

The purpose of this study is to understand how the flow of customer projects works today for a company operating in an engineer to order environment and to develop improvements that can decrease the total lead time for every type of customer project.

1.2 Problem Analysis and Research Questions

New and changed customer requirements happen daily at Jensen Sweden (JESW). The variation and constant changes therefore require lots of planning and re-planning, since multiple projects are run simultaneously, and potential projects book up resources. Each project is unique, and it can either be a new or reconstruction of an existing customer project that has already been delivered. As it is now, every department oversees its own planning and when changes occur, the departments must meet and "puzzle" together their plans, since no department or manager alone is responsible for the projects. Therefore, projects are not satisfying coordinated and synchronized. This makes lead times longer, and to cope with the long lead times, specific products and components are designed and manufactured on preliminary specifications. Even though JESW has never missed a delivery time, which they take pride in, customers are not satisfied with lead times. Therefore, this master thesis would like to study the following research questions:

First, to understand what the organizational design looks like, there is a need to map the current structure and processes with clear descriptions to be able to evaluate them. Therefore, the first research question is:

What does the customer project flow look like?

Second, as the structure and processes have its challenges in terms of long lead times due to many projects being run simultaneously combined with high uncertainty from customers, hence making planning and re-planning vital. It is crucial to properly identify what is disturbing the lead times for the project processes. Thus, research question two is:

What challenges does the customer project flow have?

When processes and structures have been properly identified along with the challenges, improvement suggestions can be created. The aim is to provide JESW with solutions that will address the challenges to decrease the lead times for customer projects. Hence, research question three is:

What improvements can be made to handle the identified challenges of the customer project flow?

1.3 Delimitations

This thesis is limited to those departments that are involved in the main customer project flow and directly affecting the lead times for a project. Therefore, the decision was made to exclude human resources, the development departments and the spare part department. Once this thesis was initiated, workshops and interviews were undertaken for the spare part and development departments. These departments are affecting project to a certain point since it is required some developments for a system to be able to be implemented with the functions customers require. The spare part department is not involved in projects, but the department is affecting the customer projects since production must allocate personnel for producing their spare parts orders. However, since these departments are not involved in the ordinary project flow, these departments were not included in this thesis.

The thesis also excludes some challenges that has emerged in the workshops and interviews with departments and their representatives. These limitations were based on the relevance of the problems for this thesis. Therefore, challenges related to for example IT and ERP are delimited from this thesis.

Furthermore, this thesis is also limited to the extent that it makes improvement suggestions that may affect the project lead times at the studied company. The thesis is therefore not providing an implementation strategy for those intended improvements.

2 Methodology

In this chapter, the design of the research and the data collection procedure will be explained. In total, this chapter consists of four parts: the research strategy, the used data collection methods, the reliability and validity of the study, and the ethical considerations.

2.1 Research Strategy

The research strategy for this master thesis has been an abductive approach. According to Bryman and Bell (2015, pp. 27), an abductive research approach allows the researchers to compare empirical data with theory during the study continuously. The empirics will affect the type of literature that is studied, and the literature will affect the understandings of the empirics. The abductive approach suited this master thesis well, as it allows the researchers to move between theory and empirics freely.

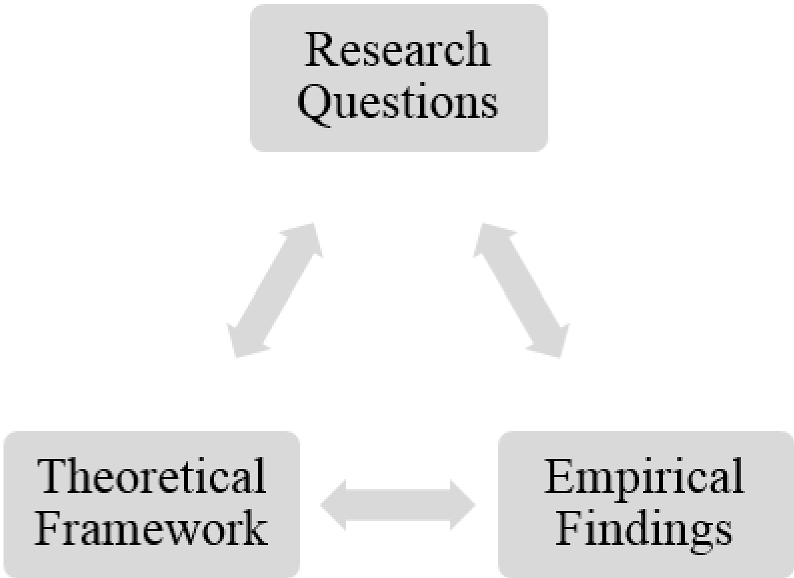

Figure 1 - *Overview of the abductive approach for this research.*

In figure 1, the abductive approach for this master thesis is presented. At the beginning of this study, the purpose was to gain a general understanding of how the company operates and what challenges it faces. This understanding was made by having two semi-structured interviews with the CEO, as well as observing the management office and production to gather knowledge about the work environment. By gathering this information, it ensured that the scope and research questions could be based on data and not intuition. Then the authors started to work on the theoretical framework to gather knowledge about how the industry operates and how others have set up their organizations. When the empirical studied started, the data collection were combined with theory to further build on the theoretical framework. Furthermore, as more empirical data were collected, more theoretical knowledge was needed. The theoretical framework and the empirical study have therefore been conducted in coherence to strengthen the study further while at the same time being tested against the research questions to make sure that the authors still were working in the right direction.

2.2 Data Collection Methods

In this section, the tools used for collecting data during this master thesis will be presented. The purpose of this section is to explain why each tool was chosen, when it was used and how it was used.

2.2.1 Literature Review

As providing an academic perspective to organizational challenges at JESW is relevant for this master thesis, the major focus has been to find theories and tools from the theory that has the potential to address the identified challenges in the total customer project flow. Literature has been obtained through electronic databases such as the library at Chalmers University of Technology and Google Scholar. The obtained literature came mainly from academic books and scientific articles. According to Blomkvist and Hallin (2015), only credible and quality ensured sources should be used. Therefore, only peer-reviewed literature has been used in this thesis. The literature study has been conducted continuously during the work process to bring together empirical data with existing theory (Bryman & Bell 2015, s. 27).

2.2.2 Observations

Evjegård (2009, pp.76) states that observations are a method used to closely study a group or a process to gain a deep understanding of it. Personnel in every process that is involved with a project has been observed, and the aim was to gather as much information as possible on how each process operates. One useful strength with observations is that it can capture details that are not mentioned in an interview since people forget to mention details that are obvious to them, these details are crucial to identify since they impact the whole process (Bryman, 2011). Therefore, to be able to give a detailed description, and ensure credibility, about how operations are run within the company, the observations have been followed up with semi-structured interviews to deepen the understanding of the processes further. According to Ejvegård (2009, pp.76), there are some drawbacks with observations as the observer can be subjective and biased towards the observed group or process.

The purpose of the observations was to gain a deeper understanding of how processes within the company operate and not only rely on what was said during the workshops. They were conducted after the workshops had been held and the processes had been mapped, where employees got to show how they operate their processes. Observations were useful to test and see how the drawn process map compared to the real-life scenario. It also gave additional data that were used to update the process map, if needed, and to gain further understanding about the operations.

2.2.3 Process Mapping

Process mapping is a method that is used to visually illustrate the basic details of a business process since boxes and arrows can replace text. It should provide a visual road map from beginning to end, including the sequence of activities, inputs and outputs of each event and the persons performing them. Process mapping allows stakeholders to get an overview of the whole process from start to finish (Bradford & Gerard, 2015). The process map is therefore useful for analyzing complex flows as it can explain relationships in a clear way (Bhaskar, 2017). The purpose of the process mapping was to gain an understanding of how processes function at each department and it was performed before the workshop for finding challenges at the company started, and the focus was on creating an understandable description of each process at the company. According to Bradford and Gerard (2015), a process map should indicate what is happening, where it is happening, when is it happening, who is doing it and how inputs and outputs are handled and distributed. Figure 2 illustrates the symbols used for the process maps.

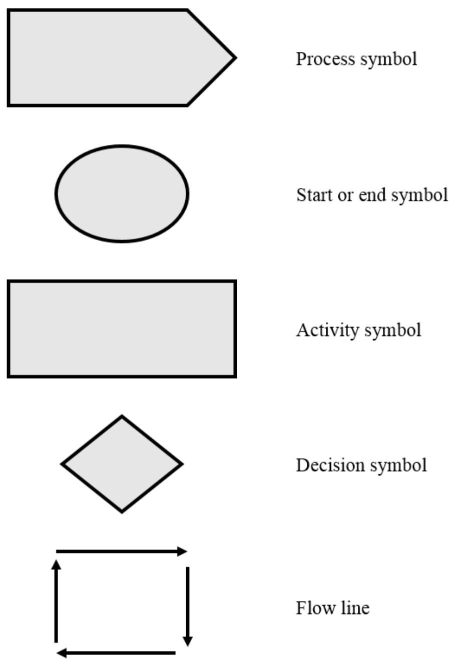

Figure 2 - *Traditional process map symbols (Westcott, 2013, pp. 380).*

A few years ago, the work tasks for each department was documented in an activity checklist. This list was used by the researchers to first make a process map draft for each department before each workshop. Then the participants got to comment on the mapping and make changes to it. Therefore, each process mapping session took about one hour as there were mostly minor changes that needed to be made for each department, see table 1.

Table 1 - *The conducted process mapping at the company.*

No. of participants	Department	Date of workshop	Duration of workshop
7	MEK-Design	19/02/2019	1 hour
4	EL-Design	21/02/2019	1 hour
4	Production	27/02/2019	1 hour
1	Installation	08/03/2019	1 hour
6	Application	14/03/2019	1 hour
4	Purchasing	20/03/2019	1 hour
3	Sales	28/03/2019	1 hour

2.2.4 Affinity-Interrelationship Method

According to Alänge (2009), the affinity-interrelationship method (AIM) is an appropriate tool to gather qualitative data by using a step-by-step approach to unveil root causes to existing problems. The method is based on the two management tools: the affinity diagram and the interrelationship diagram, and it is used to identify problems on a high level.

The purpose of using AIM was to identify and define challenges that may occur within each department when handling a project. Every session has been conducted with each department separately, and participants have been the head of the department along with employees, see table 2. One of the group members of this master thesis was the moderator of the session, and the other was a participant. As each session included several members from each department, the workshops managed to capture as many challenges as possible that might occur during their daily work.

Table 2 - *Workshops conducted at the company.*

No. of participants	Department	Date of workshop	Duration of workshop
7	MEK-Design	19/02/2019	3 hours
4	EL-Design	21/02/2019	2,5 hours
4	Production	27/02/2019	2,5 hours
1	Installation	08/03/2019	2 hours
6	Application	14/03/2019	3 hours
4	Purchasing	20/03/2019	3 hours
3	Sales	28/03/2019	3 hours

Before each workshop started, the purpose of the master thesis and the workshop was presented to assist the participants in understanding the objective of it. Since the group members of this master thesis have used AIM before, it took about two to three hours to follow the steps given by Alänge (2009). The first step is to come up with a question for the whole group to answer. The question asked for each session was “What are the biggest challenges regarding lead time in your department?”. In the second step, participants got to talk about how they felt about the decided question. Then the brainstorming started where everyone got to write down reasons on post-it notes that could answer the main question. All participants had the opportunity to explain and clarify what they meant. After that grouping of similar problems was made three times until a final layout was achieved. Each participant got to vote on what issues they felt were most important, and after that, a concluding sentence could be written that answers the main question. Before the end of the session, participants, along with the moderators took 10 minutes and reflected on all data that had been gathered. After each workshop was done, the group members of this master thesis reflected on what was said during it, and all data were sorted and documented.

2.2.5 Semi-Structured Interviews

A semi-structured interview is built up by a set of specific questions that are asked by the interviewer. However, participants can elaborate on exciting subjects that come up during the interview (Bryman and Bell, 2015). The purpose of the semi-structured interviews was to collect further data on the processes within different projects to be able to better understand and map the current processes as accurately as possible, while at the same time create a better understanding of the issues that arise in each of them. To gain insights regarding the whole process of a project, the objective was to interview several stakeholders within different departments that are connected to the entire delivery process of a project. Each person interviewed is considered to have detailed knowledge about planning, delegating and performing tasks for projects. In Table 3, a list of the interviewed persons is presented, and when they were performed. Before each interview, the purpose of the meeting and the thesis was introduced to assist the interviewee in understanding the objective of the meeting. A form with semi-structured interview questions were constructed and handed to the person that was going to be interviewed before all meetings.

Table 3 - *Interviews conducted at the company.*

Person	Department	Date of interview	Duration of interview
A	MEK-Design	27/03/2019	1 hour
B	EL-Design	27/03/2019	1,5 hours
C	Application	03/04/2019	1,5 hours
D	Installation	03/04/2019	1 hour
E	Purchase	08/04/2019	1 hour
F	Production	08/04/2019	1 hour
G	Sales	08/04/2019	1 hour

The interviews were conducted by both group members conducting this study, where one was the interview leader, and the other could fill in with follow up questions if needed. No notes were taken during the interviews as they were recorded. After each meeting, the recording was transcribed and summarized to gain a clear view of what was said during the meeting and to make it easier to go back to the data when analyzing it. Each interviewed person was given the option to be anonymous, and after each meeting, the researchers reviewed the questions and answers to see if improvements could be made to both the questions and the overall process of the meetings. Furthermore, if some data was unclear or if some data was missing, a follow-up interview was scheduled to fill in the gaps.

2.2.6 Quantitative Data Collection

In order to establish how long time it takes for a project to be delivered, data from previous customer project has been collected. According to Bouma (2000), researchers must first identify and define the basic concepts involved in their research. Otherwise there is a risk that the data collection is performed in a wasteful and unproductive way. Therefore, data were collected at the end of this research as it was determined necessary to strengthen the results of this master thesis and to prove if the studied company have any challenges with long lead times. According to Bryman and Cramer (2004), a single variable is not enough to analyze. Therefore, data has been collected on the total lead time for projects, the total amount of working days in each department, the pending time between the departments and how long work took at each department on a project. In total, data were collected from 21 customer projects which included a mix of A, B and C-systems as well as new projects and reconstruction projects. Even though data has been collected in detail, it cannot be presented at the same level of detail. Therefore, data should be summarized in tables of graphs (Bouma, 2000). The data is presented in tables with the average and median total lead time, the number of working days in each department, the pending time between departments and the uptime in each department. Furthermore, data is also presented in the analysis in three Gantt charts to illustrate how differently the project flow can be.

2.3 Reliability and Validity

Reliability is about how the results from, for example, qualitative research can be replicated if the study is conducted again (Bannigan & Watson, 2009). The main issues with qualitative research are that it can be subjective, hard to duplicate and difficult to generalize since the scope is too specific and that there is a lack of transparency in how the research was conducted (Bryman & Bell, 2015). To ensure that the prerequisites for gathering empirical data can be replicated, the interviews and workshops have been conducted in a neutral environment. It should be noted that qualitative research is affected by some subjectivity (Bryman, 2012). To reduce subjectivity, data has been collected through different methods such as interviews, workshops, quantitative data collection on previous projects and observations. Interviews and workshops have been conducted with several employees from various departments. By doing so, the collected data can either be confirmed or disregarded by others. According to Eisenhardt

(1989), the results might only be applicable in a few situations. However, the engineer to order industry can be considered to be a large industry, the findings from this master thesis can be generalized to other organizations with similar structures that operate in different environments.

2.4 Ethical Considerations

There are some ethical aspects to consider while doing qualitative research. According to Easterby-Smith et al. (20015), four major guidelines that should be followed:

1) Ensure that the company accepts the research.
2) To establish transparency, continuously give information about what the aim of the study is and how the research is progressing.
3) If there is any confidential data, make sure that it is protected and give the opportunity to those included in the study to be anonymous.
4) To avoid misconducting research, do not draw to generalizing conclusions.

The research was accepted with the CEO after the two semi-structured interviews where the problem definition and research questions were established. After each interview and workshops, the gathered data were constructed into process maps, text and tables by the group members of this master thesis and sent out to the participants so that they could either confirm it as accurate or disregard it as inaccurate. Every participant has been allowed to be anonymous and quantitative collected data, such as earnings, has been left out of the thesis. To avoid drawing to generalizing conclusions, several data collection methods have been used to get a better grasp of how processes operate within customer projects. Since the report will not provide an implementation plan of the intended improvements, the potential ethical employee impact of these improvements has not been taken into account.

3 Theoretical Framework

In this chapter, the theoretical framework for this master thesis will be presented. It is the basis for the analysis, and the covered subjects will be Engineer to Order Organizations, Organizational Design, Project Management, Project Interconnectedness and Business Process Reengineering. Two cases have been chosen and described in the Organizational Design chapter. These cases are selected to strengthen further the aspects, both advantages and disadvantages of changing an organizational structure.

3.1 Engineer to Order Organization

ETO organizations mostly produce one-of-a-kind products where every project generates a unique product or service. One-fourth of all manufacturing companies in North America is an ETO-firm, and the number is growing, mainly because of customers being more demanding (Grabenstetter & Usher, 2014). It should be noted that operating in this type of environment means exposure to high uncertainty when it comes to product specification, demand composition, supply and delivery lead times (Adrodegari et al., 2014). This is supported by Kristianto et al. (2015) who states that many failures in ETO environments are caused by demand uncertainty, high level of customer involvement during product design, and product customization as production control becomes more difficult. Designing and building complex products and systems to customer specifications often translate into long lead times and heavy engineering. Another challenge for ETO organizations is that they will not receive payment for a project until it is installed and running (Dallasega et al., 2015). Further characteristics of ETO's is that the product volume is high while customer demand is high which means that the product range is wide involving a high number of customized products, increasing the costs (Mello et al., 2017).

Therefore, it is of fundamental importance for these types of companies to consider their whole supply chain and on-site installation to avoid long waiting times. Also, non-physical delivery of drawings, technical solutions or simple decisions from engineering can put the planned due date at risk. Thus, short lead times and active synchronization between customers, engineering, manufacturing and installation are crucial for ETO organization as the most critical success factor is the capability to deliver project orders on time (Dallasega et al., 2015)

3.1.1 Engineer to Order Complexity

The major problem that impacts the performance of an organization is delays. In large engineering projects, delays and rework are common as they need refinements during implementation, which affects costs and lead times. Production and engineering activities demand extensive coordination effort. An example of this is when engineering reviews must be handled by manufacturing since the engineering work is not finalized before production takes place (Mello et al., 2015).

Changes in the project by manufacturing, installation and customer is something that further adds to the complexity. At the installation site, there can be short-term problems that can occur that needs to be handled immediately. In manufacturing, there is often changes in time schedules due to technical or logistics issues during the order process. However, most changes are caused by the customer before and during the order process. This leads to bottlenecks in terms of capacity and adds to the complexity of project management (Dallasega et al., 2015).
Furthermore, for ETO organizations, uncertainties play a vital role, and it can vary substantially from one project to another. It is recognized as one of the major factors for causing delays in projects. On-time performance is therefore undermined as the uncertainty makes it difficult to predict the outcome. Many studies have been made trying to identify the various sources for uncertainty to find techniques to reduce it. When it comes to ETO supply chains, coordination from project management has been pointed out as one of the most frequently used elements to handle uncertainty (Mello et al., 2015).

Regarding these customer changes, all functions within the entire supply chain must be aligned and coordinated. The missing alignment and transparency between departments usually create inefficient processes as manufacturing produces parts that are not needed on-site yet, while installation stands still due to parts not delivered in time. Furthermore, installation and production are not able to continue their work because of missing information or drawings from the engineering department. This is very common in the ETO environment as the design and development of technical solutions is executed almost in parallel with production, assembly and installation (Dallasega et al., 2015).

3.1.2 Engineer to Order Supply Chain

During a project, organizations are responsible for performing varied tasks such as design, engineering, procurement, logistics, manufacturing, assembling and commissioning. The ETO supply chain can be divided up into two main flows, physical material flow and information flow. The material flow involves manufacturing, assembly and installation and the information flow involve planning, design, engineering and procurement (Mello et al., 2015). The interdependency between material and information flow increases steadily as products are moving from design to production. Therefore, any changes that occur in the later stages of a project have a higher impact on the efficiency of production. Consequently, managing the material and information flow requires a systematic approach to identify, analyze and coordinate among those involved in the project (Mello et al., 2017).

The supply chain for ETO organizations is based on low volume with high variety of products. Therefore, ETO supply chains usually serves niche markets with none or few competitors and customers, willing to pay a premium price for products that fit their specific needs and the product differentiation is decided in the design phase (Mello et al., 2015). This means that each customer order requires some reengineering work, either by changing an existing design or developing a new one (Dallasega et al., 2015). The end products are individual. However, there is still room to use standard components. Successful ETO organizations are those who can understand their customer requirements and translating them into specifications at the product and component level, while at the same time integrating standard components and subsystems into the total end product (Mello et al., 2017).

In ETO supply chains, there is typically no inventory of finished products that could satisfy a specific customer need immediately, thus making the customer exposed to the total product lead time. Whereas the high degree of customization also affects the delivery lead time. The more customized a project becomes, the longer the lead time since more activities need to be performed after the order is received. Therefore, it is crucial to be able to perform tasks and changes in a short amount of time to be able to handle the customer need. Lead time reduction is also considered to be one of the most critical factors for improving the delivery performance for ETO organizations (Mello et al., 2015).

3.1.3 The Need for Supply Chain Coordination

According to Mello et al. (2017), supply chain coordination can be defined as "*the act of managing dependencies between entities and the joint effort of entities working together towards mutually defined goals".* With this in mind, coordination plays a vital role in the decision-making process to maintain order and stability to the system. To achieve total coordination, the supply chain requires that all decisions are aligned to reach the overall objective of a system (Mello et al., 2017). Essentially, three major phases require coordination for an ETO organization. Those are: tendering (sales and marketing), product development (engineering) and product realization (production). Coordinating these processes requires specific coordination structures that can be used in situations with limited standardization and no repetitive orders. Research shows that organizations usually fail to coordinate among functional interfaces across several business units. Some common coordination problems are inadequate structures, poor communication, lack of external support, poor cooperation, unclear responsibilities and an organizational structure that inhibits coordination (Mello et al., 2015). Often, departments within the ETO environment are in control of their budget and planning. Therefore, errors made in the engineering department is mostly discovered later in the supply chain, sometimes even in the installation phase. If this happens, then the defective components must be engineered, produced and installed again. However, it should be noted that communication between departments becomes complex as they represent activities at different levels of detail. Engineering is focused on making drawings, manufacturing is focused on producing components, and products and the installation department is focused on performing their on-site tasks. Consequently, one job may require more than one component and one drawing can specify more than one component, adding to the complexity (Dallasega et al., 2015).

3.2 Organizational Design

According to Burton and Obel (2018), organizational design is a significant factor that drives and determines an organization's performance and how people work together. All organizations have a management structure that determines relationships between different activities and members but also assigned roles, responsibilities and the authority to carry out the organization’s various tasks. These activities must therefore be coordinated to obtain the goals of the organization. Structure and coordination are thus the fundamental choices in organizational design and must therefore specify the fit between the structure of the organization, and the tasks supposed to be coordinated, for it to work in coherence.

Burton and Obel (2018) state that the fundamentals of organizational design are to *“investigate the information flows that are essential for accomplishing the organization's objectives, and to examine what these information patterns imply for the organizational structure”.* This means that the underlying theory of organizational design is to structure the organization so that the information-processing capacity is in balance with the information-processing demand. This implies that the more significant task uncertainty, the greater information-processing is required. Furthermore, the more interdependence between sub-tasks, the more information-processing capacity is needed. Therefore, uncertainty and interdependence create the need for information processing in the organization. To balance the information-processing demand and capacity, you may, therefore, increase the information capacity with more excellent communication, either by hierarchical or lateral coordination.

The form of organizational structure defines relationships between members of a project and the relationship towards other projects. A structure also defines the authority, where each member of the project is located, and the lines of communication, supervision, coordination and collaboration among its members (San Cristobal et al., 2018).

Organizational structures can be ranged from pure functional structures with departments to project-based organizations without any coordination across project lines. In between, there are versions of matrix structures; functional, balanced and project matrix structures. These are characterized by low, balanced or high authority of the project manager in regard to the functional manager (Hobday, 2000). The three generic types of structures that are most common are the functional structure, matrix structure and project structure. There is no definitive answer to which structure is the most efficient and useful to all types of projects, since every project is unique and require different management approaches. Therefore, it is crucial to tailor the structure towards the organization regarding the organizational environment and project characteristics (San Cristobal et al., 2018). This is supported by Aubry and Lavoie-Tremblay (2017), who concludes that context is of importance when engaging in what type of organizational design is preferred. Since organizational design takes time, there is no general ideal model to copy. Context, history and identity of an organization must be taken into consideration, which requires a collective effort to enact what is found inside and outside the organization. Burton and Obel (2018) state that there is no best way of organizing and therefore, the structure should be designed to fit the particular circumstances. There is no ideal structure, and each structure has different pros and cons. There are advantages and disadvantages of the three general organizational structures.

3.2.1 Traditional and Project Structure

In traditional structures, various teams consist of a stable hierarchical form. This type of structure does not suit organizations which require coordination between a diverse mix of personnel with different expertise. The functional structure advantages are that there is no need to negotiate and compete with other departments for resources and the departments become effective since the employees work in the same area. The disadvantages are that specific projects may not have all the specialists needed to work on the project. Team members may have other responsibilities in the department since they may not be working full-time on the project (San Cristobal et al., 2018).

In the project structure, project managers have a high level of authority, which gives robust project control, but also full responsibility for the performance of the project. Personnel is assigned to the project, usually on a full-time basis. This develops a strong sense of project identification and a good understanding of the project goals. Project structure is therefore more common in large organizations that handle huge and valuable long-term projects, and that can absorb the cost of maintaining this type of structure (San Cristobal et al., 2018). The disadvantages are that a pure project structure is costly and utilize resources inefficient since several resources man be duplicated on different projects. There are limited opportunities for knowledge sharing and professional growth since team members are dedicated to one project at a time.

3.2.2 Matrix Structure

The issue of interrelationships between departments, individuals and projects is recognized and well known. One suggested solution is coordinating activities among projects in a matrix structure (Laslo & Goldberg, 2007). The matrix structure is a combination of traditional structure and project structure. The structure combines a functional design and horizontal project teams. In this type of structure, several functional areas is set up along the horizontal axis and several projects along the vertical axis that use the resources from the functional areas to complete project activities (San Cristobal et al., 2018). According to Laslo and Goldberg (2007), the matrix structure is the primary organizational mean for maintaining an efficient flow of resources in multi-project environments. San Cristobal et al. (2018) further states that the matrix structure advantage is that it enables dynamic allocations of specialist, which can be fully leveraged by working on multiple projects. Employees can therefore change from project to another without making the changes permanent. The matrix structure also enables sufficient information flow, which allows team members to share information readily across the unit boundaries. Therefore, strong project coordination and better control are highlighted as an advantage. San Cristobal et al. (2018) further states that the matrix structure is commonly used by organizations who operate in complex and dynamic environments, and in highly innovative organizations where the results of the project are entirely new products or technologies. In an organizational matrix structure, project managers share responsibility with unit managers, and sometimes they compete for the same resources. Laslo and Goldberg (2007) describe that conflicts among the project and functional managers substantially limits the matrix effectiveness. Reporting relations can be complicated, and some team members might report to a department manager while working for one or more project managers. Therefore, according to San Cristobal et al. (2018), a high level of communication and cooperation is required between pragmatic unit managers and project managers. Often, it is necessary to decide whose authority, project or functional manager, will be dominant or whether their jurisdiction will be equivalent.

According to Tonchia and Cozzi (2008), there are two types of matrix structures, namely a lightweight matrix and heavyweight matrix. These types differ in terms of where authority resides, either in the function or in the project. In the lightweight matrix, the authority is still retained by the functional manager, and the project manager plays a side role, coordinating, allocation, using and managing the resources for the project. In the lightweight matrix there are some issues ascribed to the role of the project manager, who is responsible for the resources without having the authority to delegate priority, and therefore risks becoming a coordinator/facilitator. In the heavyweight matrix, the authority is aligned with the project manager and the functional managers are in charge of supplying the resources to the project, while preserving a minimum of performances in the function (productivity technical updates etc).

3.2.3 A Chinese Construction Case Study

As stated earlier in this chapter, selecting an appropriate organizational structure is difficult since many variables need to be considered. A case study of a company operating in the Chinese construction industry shows that a move from a traditional functional structure to a functional matrix structure is beneficial (Woo, 2008). In the functional matrix structure, a full-time project manager was employed to oversee a construction project. This structure involved decision-making, made by the project manager, in areas including personnel and project workflow through the project, but the functional managers still had authority over the project manager. The case experienced both positive and negative outcomes. The positive findings were that they experienced better utilization of resources, reduced project length and better communication. The most important outcome of the functional matrix structure was that communication and coordination improved. Where the project manager became a coordination point for information flow throughout the project. Furthermore, the company estimated that they were able to save, on average, 30 days of lead time for each project (Woo, 2008).

However, there were also some negative experiences of the functional matrix structure. The employees found the new structure confusing as they had to report to both the head of their department and the project manager, and if they were involved in different projects, it was even more confusing. They also experienced power struggles between project managers for resources, mainly when employees worked on more than one project at once. Senior management had to step in to solve these struggles by implementing a maximum resource allocation at different functions for the project managers. Furthermore, the company also had to make clear documentation about authority, responsibility and the reporting structure to explicitly ensure the role of the project manager and the functional manager. Even though this is somewhat outside the scope of a matrix structure, the company felt that it was necessary to ensure accountability for both the project and functional manager (Woo, 2008).

3.2.4 The Renault Case

Renault underwent a massive organizational change from 1960 to 1989. During these years, they transformed from a traditional functional organization to working with autonomous project teams. The transition was divided up in three different phases (Midler, 1995).

Phase 1, the functional organization:
In 1960, Renault had a functional organization which was divided into powerful skill-based departments with no direct link between them, see figure 3. Each project was managed on a case to case basis where the CEO was the link between the departments. For few non-diversified products, this approach was suited, but as the demand for more sophisticated products grew, during the 1970s, the company had to change their way of working.

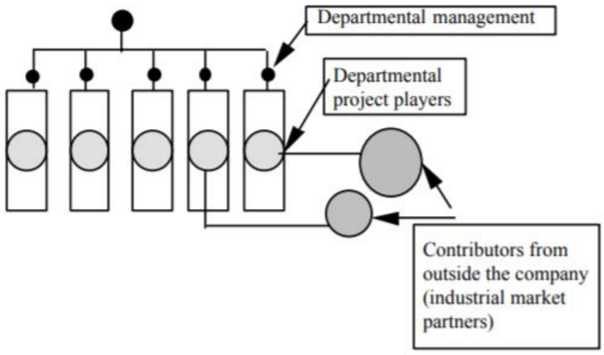

Figure 3 - *The functional structure at Renault (Midler, 1995).*

Phase 2, centralized project coordination:
At the beginning of 1970, the organizational structure changed, as seen in Figure 4, by implementing a project manager as a project coordinator. Which meant that the head of the operational division had to look at problems related to projects. However, communication remained vertical between each functional department. The status of the appointed project coordinators was low, and their competence was not fully confirmed yet. This type of matrix structure can be likened to a lightweight structure. Project managers main tasks were to gather information for the department managers as they had no power to make decisions (Midler, 1995). Furthermore, in this phase, project management tools such as planning, budgeting and return on investment criteria were implemented to make sure that the project portfolio was coherent with the global strategy of the organization. However, this project coordination system failed in terms of time, quality and cost control as matching the department strategies with a project coordinator, with no power, was an ineffective process.

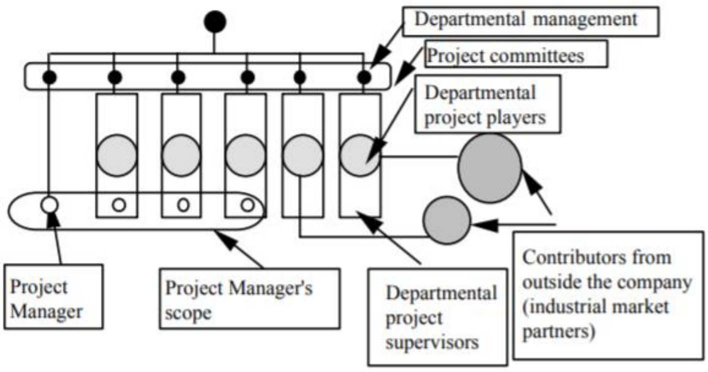

Figure 4 - *The project coordination structure at Renault (Midler, 1995).*

Phase 3, empowerment and autonomy of the project management structure:
In the late 1980s, the company decided to create project directors. The innovation of this was not in the management structure but the power and autonomy given to the project manager role. Project managers were given a strong status to drive projects and teams of experienced personnel were built around them. The project structure also surrounded the project director with departmental project supervisor in production, purchasing, sales, quality and planning. The structure was operating as a strong matrix structure and is illustrated in figure 5 below.

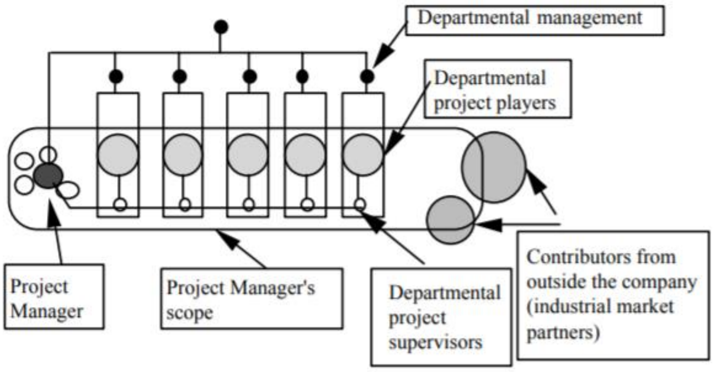

Figure 5 - *The project director structure at Renault (Midler, 1995).*

By implementing this type of organizational structure, the project roles became more evident, cross functional communication increased as projects were scheduled and coordinated horizontally instead of being performed sequentially, and the project management teams contributed to an enhanced partnership with both internal and external suppliers (Midler, 1995).

3.3 Project Management

What distinguishes a project from other activities within an organization is that it has a beginning and an end. Which means that it is temporary, and it will sooner or later finish, either by achieving its objectives, passing the schedule, running out of finances or that the organization closes it down. Managing projects means dealing with variables that can be influenced as it is impossible to manage them if no variation is allowed. Furthermore, managing means taking decisions and act accordingly to the constraints of the environment, i.e. control, plan and execute. The typical variables that can be controlled for projects are time, quality, cost and resources (Tonchia & Cozzi, 2008, pp. 3). Mossalam and Arafa (2016) states that project success is measured by product or project quality, budget compliance, timeliness and to what degree customers are satisfied. The two most important things in project management to consider is stakeholder management and communications management. Therefore, the project manager should possess the skills of being able to manage change, forecast, leadership and have a broad knowledge of the project, in-depth knowledge is, however not required. By having these skills, the manager will be able to make sure to reach the objectives of a project while keeping it within the budget for both time and cost (Tonchia & Cozzi, 2008, pp. 6). For a project to be appropriately completed, both planning and execution must be implemented well. The monitoring mechanism for this is controlling, which ensures that right actions are used to avoid undesired discrepancies between the plan for the project and its execution. Thus, communication plays a vital role in planning and the most challenging part for the project manager to plan is to determine who needs what information, when they will need it and how it will be handed over to them as there are few formal tools and techniques available to support the communications area for the project manager. The project manager is fully responsible for overcoming these difficulties to guarantee that each project moves along according to plan. It is up to the project manager to identify problem areas that harm completing projects and develop solutions to accommodate them (Globerson & Zwikael, 2002). To achieve this, it is vital for participants to understand their roles in the planning process. If the roles are clear, it will reduce the number of changes required in the planning stage. The major players involved in projects are project managers, line managers and senior management. In a project, the project manager is responsible for achieving the goals and objectives of it, set major milestones, ground rules and assumptions, define requirements, determine the time, cost and performance constraints, operating procedures, policies for administrative work and how reporting should be handled. The line manager is responsible for making a detailed task description of how to implement the objectives, requirements and milestones of the project. Make a comprehensive scheduled plan and allocate resources that support both budget and time constraints. The line manager is also responsible for identifying areas of risk, uncertainty and conflicts that will assist the decision making for the project manager. Senior management is responsible for acting as a negotiator when disagreements occur between line and project managers. Furthermore, they should provide clarification of critical issues and be a communication link with customers (Kerzner, 2017, pp. 519).

3.3.1 Stage Gates

When companies recognize the need to begin developing processes for project management, the starting point is usually the stage-gate process. The stage-gate process was created because the traditional organizational structure was designed primarily for top-down, centralized management, control, and communications, all of which were no longer practical for organizations that use project management and horizontal workflow (Kerzner, 2017). By using gates and transparent rules for passing defined stages, management of the engineering process and stakeholders in the ETO process should become clear in terms of configuration management (Kristianto et al., 2015).

For managing the gates, gatekeepers must be authorized to evaluate the performance to date against predetermined criteria and to provide the project team with additional business and technical information, see figure 6. It is necessary for the gatekeeper to make decisions and therefore needs the mandate to do so. The most common decisions are; proceed to the next gate based upon original objectives; proceed to the next gate based upon revised objectives; delay making a gate decision until further information is obtained; cancel the project (Kerzner, 2017).

There are significant benefits in terms of stage-gate processes since it provides a structure for project management, standardization in planning, scheduling and control by forms, checklists and guidelines, allowing for a structured decision-making process (Kerzner, 2017).

Figure 6 - *Stage gate model (Conforto & Amaral, 2016).*

3.4 Project Interconnectedness

The complexity about project environments which require many decisions in design, planning and management are not only exposed to a large variety of decisions, the interrelationship between them are often undefined and dynamic. Which means that there is a causal link between them, and one choice will influence another one (Karni & Kaner, 2008). The theories on project management are based on the perspective that a project is treated as a single event, where the project has either history or future. Furthermore, projects are somewhat similar and are therefore also treated as a common phenomenon. However, from an organizational perspective, projects are one of their most important characteristics (Engwall, 2003).

A classic issue, in organizational theory, is the environmental impact on projects, where external factors heavily influence the internal processes of an organization. The internal behaviour of an organization is shaped by complexity, uncertainty, changes, allocation of authority and availability of resources. Thus, in an environment with multi-projects, the linkage between them and the parent system is of importance. Projects should be seen as an open system, both in time and space, and not a lonely and closed one as has been addressed in project management theory before, since projects are subjects to variation, and they have less in common between them as previously thought. However, research shows that a project is closely connected to its organizational history and environment. It determines to what extent a project construct structures, knowledge, procedures, values, experiences and ideas from the organizational situation. Throughout the entire project, there will continuously be booking of resources. Therefore, there will usually be negotiations between the project manager and the different individuals involved in the project to reach the total goal of it. Thus, whether the project will be a success or not is determined by the results of the negotiations between the project manager and other key stakeholders rather than particular project management techniques or skills (Engwall, 2003).

3.4.1 Multiple Project Environment

The multi-project environment is complex, and managers need to take fast decisions while allocating resources efficiently and at the same time have a clear focus. For organizations that handle many projects simultaneously, management is exposed to numerous challenges and the project manager must handle projects with different scopes, time schedules and complexities. The most common problem in this environment is resource conflicts and throughput times. Additional pressure is put on the organization if the balancing of these projects is inadequate, leading to poor information quality and long lead times. Further challenges are interdependencies and interactions between projects as well as project overloads. This may cause an overload of information, which may cause project managers to lose sight of relevant details or being unaware of inaccuracies, leading up to poor decision making for each project (Caniëls & Bakens, 2012). Therefore, the ability to manage multiple projects is a key competence for competitive advantage in a dynamic modern environment (Araszkiewicz, 2017). A study made by Spalek (2012) showed that 72,9% of companies operating in an ETO environment requires handling their projects more efficiently. From a project management perspective, this can be challenging as unexpected events in one project can affect the performance of a concurrent project. Yaghootkar and Gil (2012) conclude that organizations who handle multiple projects perform poorly if they have project- or function-based structures. They recommend a matrix-based structure to guarantee effective negotiations of project priorities and resource allocations between the functional managers and the project manager. Furthermore, there is a limit on how many projects a project manager can handle at the same time, based on the available resources. It can therefore be helpful if some procedures and routines, even though it is challenging in ETO environments, are standardized, as projects workers usually know what to do and how to carry out the work. However, too many or too few procedures can become troublesome for those involved when the pay-off and effort are not balanced (Caniëls & Bakens, 2012).

For ETO organizations, project management and production planning should be well-known methods to optimize the scheduling of activities, project sequences, and monitoring the project status. According to Adrodegari et al. (2014) case studies shows that a few years ago, when business for ETO organization were blooming, projects and planning of activities were managed by a few experienced people within the company, and some inefficiencies related to cost were tolerated. Today, the demand for more customized products has increased as well as the need for shorter lead times and lower prices. Therefore, time and cost efficiency are a fundamental factor that allows companies to stay competitive and make a profit. Project management and planning has become essential processes as it can aid organizations to optimize the allocation of resources, minimize cost, plan for corrective actions and maximize delivery (Adrodegari et al., 2014). One crucial aspect is capacity planning, and it refers to the problem of coordinating demand with resource availability in the medium term. To adequately perform planning of multiple projects, they must be considered simultaneously at all planning levels, while at the same time consider that those levels have different objectives, constraints, degrees of aggregation and flexibility with capacity. For instance, these objectives can be the optimal timing of operations, optimal resource management and the robustness or stability of the plans for all levels (Hans et al., 2007). Carvalho et al. (2015) suggest that an aggregated plan is used, which encompasses a time frame of 3 to 18 months and focuses on the optimal workforce for each period in the planning horizon. A capacity planning system can quickly analyze the impact of potential new orders in the capacity plan, which makes it easier to determine reliable due dates and price quotations in the order acceptance phase. For ETO organizations, these decisions are crucial, and they are related to setting essential milestones for each project (Carvalho et al., 2015). For the intermediate milestones, the construction of a rough cut plan is suggested as it helps to set priorities for each project and it considers that changes may occur, which gives the project manager the opportunity to consider what work to release what best suits the overall planning for the multiple projects in motion (Hans et al., 2007).

3.5 Business Process Reengineering

Business systems are made up out of processes, and processes are a collection of activities that results in an output. With time, processes develop, which means that they need to be redesigned or replaced by another process (Bhaskar, 2017). One of the most popular change management processes is Business Process Reengineering (BPR). It can bring considerable solutions to organizations, and it has arisen as a solution for companies to develop their competitive advantage and to enhance their performance (Goksoy et al., 2012). Organizations that do not adapt to their environment will have trouble staying competitive, e.g. they must be able to change. Since change is a continuous process, it forces companies to adjust their way of working, so it follows the requirements of the marketplace (Bhaskar, 2017). Therefore, BPR involves reinventing and overturning old processes while radically designing new ones (Goksoy et al., 2012). It is a cross-functional approach, and it requires support from all departments within the organization. According to Mohapatra (2012, pp.51), the focus for BPR is on redesigning processes, so they work towards the strategic direction of the company. As seen in figure 7, BPR is used to continuously improve an organization's process.

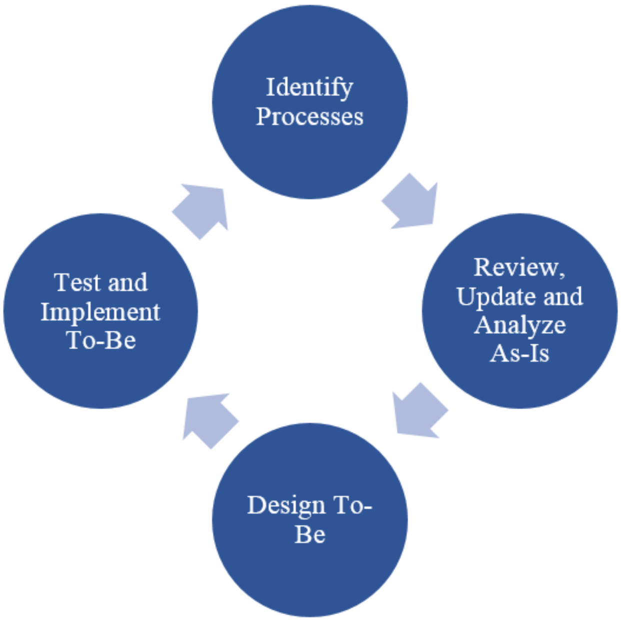

Figure 7 - *The business process reengineering cycle (Mohapatra, 2012, pp.52).*

When conducting BPR, the company first determines what it must do, and then it decides how it should be done. Therefore, they must ask themselves: Why do we do what we do? Why do we do it the way we do? And should it even be performed at all? By asking these simple questions, it forces people to look at their embedded rules and assumptions that compose the way they handle their business (Goksoy et al., 2012). Often, it turns out that these rules are wrong, obsolete or even inappropriate. In reengineering work, nothing is taken for granted. For example, companies that start working with BPR must guard themselves against the assumption that most processes already have a function. Merely looking at a particular process and try to find ways to improve it assumes that the process must be checked. However, the process might not even be required (Bhaskar, 2017).

For BPR to be successful, some requirements need to be fulfilled. First, there should be a clear understanding of customers, markets and competitive directions for the company, and they should be aligned with the business strategy and vision. Second, there should be a high commitment from management. Third, it should be founded on already proven analytical approaches. Forth, there should be a project leader, or team, that can evolve from developing and implement new processes (Goksoy et al., 2012). According to Bhaskar (2017), there are three types of companies that initiate BPR. The first type is the company that finds themselves in trouble. They can even be in a situation that can be termed as a crisis. These companies have no choice but to look over their processes. The second type is companies that are not yet in trouble, but management recognizes that trouble is on its way. At the moment, everything is fine, but new competitors are entering the market, or there are new technological breakthroughs that change customer behaviour. The third type of company to initiate BPR is the one that is in its best shape. They have no visible difficulties at the time, but management are ambitious, and they see an opportunity to further extend their competitive advantage over their competitors. It should be noted that BPR is not about fine-tuning processes by making small changes. It is for companies willing to go the extra mile to achieve substantial performance improvements (Gunasekaran & Kobu, 2002). There can be several reasons for a company to start reengineering its processes. According to Mohapatra (2012, pp.45), if the answer is yes on one or more of the following questions, then the company should consider BPR.

1) Is competition outperforming the company?
2) Does conflict occur regularly in the organization?
3) Is there a need for a lot of meetings? (Can indicate a lack of clear directions).
4) Is there excessive use of unstructured communication?
5) Have the processes stopped returning substantial business results?

3.5.1 Challenges with Business Process Reengineering

Several BPR implementations has been successful. However, these projects require significant changes in business processes that may lead to instability and failure. Studies show that 70-85% of all BPR initiatives fails. The major reasons for failures are: management commitment and leadership are not sustained, unrealistic scope and expectations, expecting results to early, lack of redesigning expertise of related activities and lack of partnership between internal information technology (Goksoy et al., 2012).

3.5.2 Understanding Processes

The objective of BPR is processes and not organizations. There is often confusion about organizational units and processes because departments, divisions and groups are used to specific people within the organization. Since organizational lines are drawn on organization charts and processes are not. Processes are often invisible and not managed as people recognize the departments and not the processes of which all of them are involved in. This means that they tend to be unmanaged as people usually are put in charge of departments or groups, and no one is responsible for the whole process (Gunasekaran & Kobu, 2002). Discussing what a process is can be confusing as people have different perceptions on what a process is. Therefore, it must be established what constitutes a process, how they can evolve, and how various processes relate to each other. Also, characterize what works well in a process versus what does not work well needs to be established (Bradford & Gerard, 2015).

By their very nature, processes consist of several levels. It can vary from just a few steps producing a minor output for an internal customer or a long complex process that consists of many steps that produce a major product for a customer. The entire operation of a company can be a process with a lot of different levels and steps (Bhaskar, 2017). Furthermore, it is important to understand that between every step of a process there will be some waiting time as it will involve some movement from one area to another and responsibilities will transfer from one person to another (Bhaskar, 2017). To understand how processes work and how they relate to each other, process mapping is a beneficial tool, within BPR, to use (Goksoy et al., 2012)

3.5.3 Cross-Functional Integration

According to Wheelwright and Clark (1992), not all projects need cross-functional integration. If product designs are stable, customer demand is well defined, interfaces between functions are clear and well established and lead times are long, then an organization may be more effective with a moderate amount of coordination through processes. However, in markets with more dynamic markets and technologies, more intensive cross-functional integration is needed as it is crucial for effective development.

When individual design engineers work together with different marketers or process engineers to solve common problems, that is when cross-functional integration that matters occur. Hence, to be effective, cross-functional integration must be more than just a schedule that links the time for activities in each function, it must also support activities for cross-functional interaction. Cross-functional integration occurs at the working level, and it is founded on close linkages in time and communication between individuals and groups working on closely related problems. A critical element is the communication pattern between upstream and downstream groups of the organization. According to Wheelwright and Clark (1992), there are four different modes of communication, which is illustrated in figure 8 below:

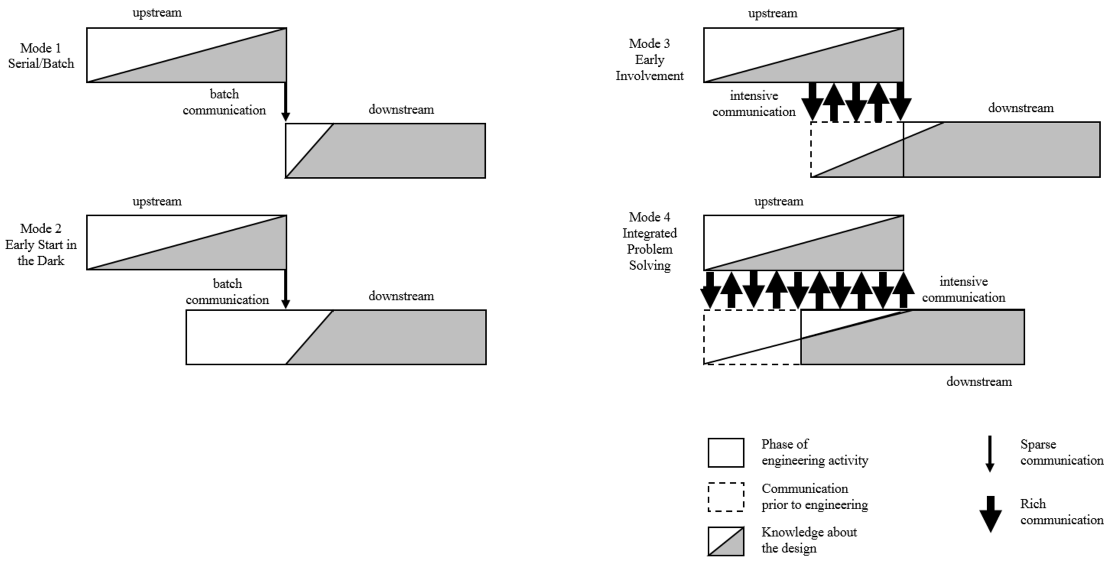

Figure 8 - *The four modes of upstream-downstream interaction (Wheelwright & Clark, 1992).*

The first mode is called a serial mode of interaction, which is a classic relationship where the downstream group waits to begin their work until the upstream group is done with the design. The completed work is then handed over in a one-shot transmission of information. In the second mode, called early start in the dark, links the upstream and downstream groups, but it continues to use a one batch way of communication. This type of interaction usually occurs when the downstream group faces a deadline that they feel cannot be met without an early start of the project. In this way, the downstream group might be surprised when the work is handed over as the design might not look like they previously thought it would. In the third mode, which is called the early involvement mode. In this mode, the communication is starting to move towards real integration as the upstream and downstream people engage in an interactive pattern of communication. The downstream group develops insights about the emerging design as they are interacting with the upstream group during the design process to gain feedback. However, even though the downstream group are involved in the design process, they wait until the design is done before solving their tasks. The pattern of communication does not only occur earlier than in mode one and two, it also involves two-way communication of preliminary and incomplete information. In the last mode, called integrated problem solving, the upstream and downstream groups in the organization are linked in time and in the pattern of communication.

The downstream engineers not only participate in preliminary and ongoing dialogue with their upstream counterparts, but they also use that information to get a jumpstart on their work. This changes the downstream work in the early phase of the upstream design, and it also changes the pattern of communication between them. For the mode to be effective, the communication between the departments must be rich, intense and bilateral (Wheelwright and Clark, 1992).

3.6 Summary of Theory

As stated in the introduction, organizations must take actions to improve their operations, regarding performance and strategic positioning, to stay competitive. However, for a company to choose the right reorganization, it is essential to tailor it after their circumstances.

In this thesis, literature about companies operating in an ETO environment is added, where the customer is exposed to the total lead time and the focal company exposure to high uncertainty. It is therefore of importance for these types of firm operating under these circumstances to consider their whole supply chain. Because of the exposure to high uncertainty for both customers and the focal firm, it is relevant to also look at the organizational design and more precisely the organizational structure since this is a significant factor that needs to be coordinated to obtain the goals of the organization. Also, the relationship between organizational structure and processes is vital for the performance of the organization. Changing the organizational structure also affect the processes, since processes must be redesigned to fit the strategic direction for companies. Thus, both theoretical aspects are essential in this context.

By adding the project interconnectedness and the multi-project environment scenario, it creates a more complex dimension into the environment that needs to be managed. Therefore, project management literature is added to the theory to be able to analyze what is expected from a project manager, and how to manage the organizational structure for the multi-project ETO environment. By collecting theoretical data from project management, organizational design, business process engineering and project interconnectedness, see figure 9, a framework for analyzing a company operating in an ETO environment is possible.

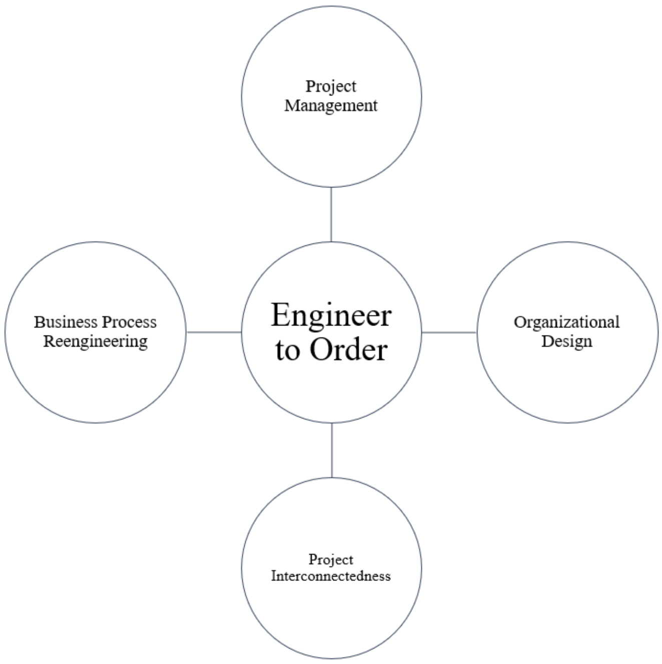

Figure 9 - *Theoretical framework for this master thesis.*

4 Company Description

In this chapter, the studied company and its history are presented. The company's role in the value chain and the corporate group in which the company is part of is also described. The information come from the company's catalogues.

4.1 Jensen Sweden

The business that is currently being conducted in JESW's 2100 square meters premises originates from a company called Metric Interconveyor. The company's main activities consist of sales, development, production, installation and service of complete conveyor and sorting systems for the laundry industry. The company Metric Interconveyor started in 1971, in Borås, as a supplier for the clothing industry. In the late 1970s, the company chose to shift its focus from the clothing industry to the laundry industry. About ten years later, the founder sold the company to a local investor. In connection with the establishment of Jensen Groups expansion plans, Jensen Group acquires Metric Interconveyor for its group. In 1997, the company moved into the present premises in Viared and in 1999 the company changed its name to Jensen Sweden. JESW currently has about 75 employees and possesses expertise in project design, hardware and software development, system installations. The company had sales of SEK 145 million during the financial year 2017.

4.2 Jensen Sweden as part of the Jensen Group

Jensen Group is a global company that had a turnover of EUR 318 million in the last financial year, which was an increase of 11% compared with the previous year. The company was founded in 1937 on Bornholm in Denmark, by a single entrepreneur named Jörn Munch Jensen and had a total of 1520 employees at year-end 2017. Just before the turn of the millennium, several companies are acquired in connection with an expansion phase. This expansion makes the Jensen Group the first supplier of complete automated laundry solutions in the world. The company's product portfolio today includes all parts of the washing process, which includes washing areas, the logistics that move the textiles, finishers, feeders, defects, folders and software technology to monitor the process.

Figure 10 - *World map of Jensen Group's operations.*

Jensen Group's business idea is to *"assist industrial laundries worldwide to provide cost-effective textile services to its customers."* The goal the company communicates is to offer the best possible solutions in the heavy laundry industry to a global market. The company emphasizes that the laundries supplied by the Jensen Group have the highest resource efficiency in the entire industry. Jensen Group has a decentralized business strategy with over 40 countries in its distribution base, which creates proximity to its customers. Figure 10 illustrates the local facilities that make up the group.

In Sweden, there are two different departments, one of which is located in Solna and one in Borås. The department in Solna is referred to as Jensen Sverige and is a sales and service center

(SSC), while the business in Borås provides engineering, development, production, installation and service. JESW is part of the growing business area finishing technology and specializes in systems for garment transport and garment sorting.

4.3 Product Description

Hotels, restaurants, hospitals and other county councils are examples of activities that send their own or rented clothes to industrial laundries. They expect to get their clothes back in a particular order, in the right quality and of course in the correct number. In some cases, the garments are personal and will be returned to the right person after washing with thousands of other clothes. The laundry industry's garment handling involves processing everything from simple T-shirts and hospital clothes to overalls where each type has its specific requirements for the process after washing. Examples of such processes are tunnel cleaning to get the clothes smooth, inspection and repair, sorting and automatic folding of the garments. JESW's Metricon is an automated system for efficiently transporting and controlling the clothes through these processes. The traceability of the garment through the system is done by reading the built-in chip or bar code of the garment and gallows. You can thus check each garment and communicate with the laundry's database so that they, in turn, can keep track and invoice their customers. Metricon is scalable both in terms of capacity, typically between 400 - 6000 garments per hour, and functionality. It is also designed for the specific building it is installed in. Which makes each system unique, and although it is made up of mostly standard components, the variant flora has grown over the years. JESW are selling A, B, and C systems. A-system is less complex PLC based transporting systems and delivered to the customer without any hanger or garment ID. B-systems are also a PLC-based system but are used with hanger or garment IDs together with communication with the garment database. C-systems are a more complex sorting system that is controlled by the PC-based monitoring system Metricon Plus.

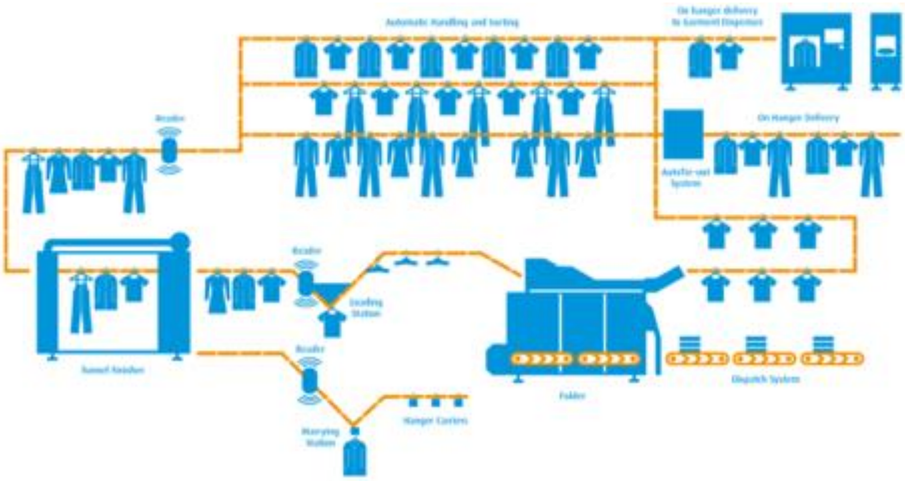

Figure 11 - *Sketch of the Metricon system.*

5 Empirical Findings

In this chapter, the overall structure of JESW will be presented along with how each department operates to complete a customer project.

5.1 Overview Jensen Sweden Current Structure

JESW handles a project as illustrated in figure 12, where each department manage themselves with their own functional manager. Currently, the CEO is the functional manager for the sales department and MEK-Design, and the software manager is also a functional manager for EL-Design. There is no middle manager between the functional managers and the CEO. The main functions consist of the sales, MEK-Design, EL-Design, production, installation and start-up department. The support functions consist of field application engineers (who also is responsible for the start-up process), purchasing, MEK-Development, EL-Development and Software Development. MEK-Design also supports the sales department by allocating quotations drawers. These quotations drawers are consistently working with quotes only.

When there is a project handover from the sales department, which is made at the D10 meeting, where all the functions are represented. By that time, a resource from MEK-Design, EL-Design and Field Application Engineers has already been allocated to the project and participates at the meeting as representatives from their function. The production manager, installation manager and representatives from the purchasing department are also present at the project handover.

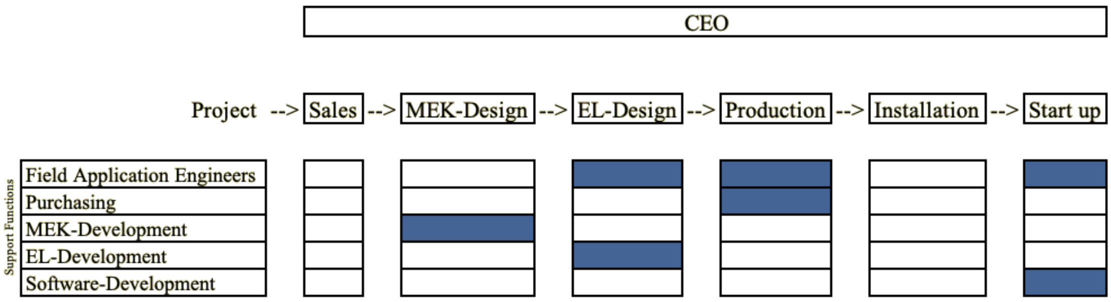

Figure 12 - *Organizational Structure of JESW.*

The Sales department is responsible for, making quotes, receiving orders and the overall contact with the SSC. The sales team are divided into the responsibilities of certain countries. There are currently four people working in the Sales Department. The MEK-Design department consists of two teams, quotations and order writers. The quotation workers make all quotation layouts. The order drawers then take on the specification and are responsible for making the precise layout of the entire system. The EL-Design department is responsible for creating the electrical drawings and layouts. After the drawings are verified, EL-Design generate all their outputs through E-plan. The production department is primarily working with sub-assembling of parts, which are later sent as modules to the installation site. Installation of a system on site can be made all over the world. JESW are working primarily with their own installation staff, however, sometimes subcontractors are being used. Field application engineers (FAE) are responsible for the start up process of the system on site and ensures that the quality of the system is what the customer demanded before system handover. FAE is also working as a support function where they quality check EL-Designs work and configure the Metricon system. The purchasing department makes all the purchasing of parts for the production. MEK, EL and the software development department make project specific product and system developments to meet the customer demand.

5.2 Jensen Sweden Project Supply Chain

Figure 13 illustrates how a project flow through JESW. At first, JESW gets an offer where they analyze it, calculate the cost and time, and MEK-Design assists with making a first conceptual layout for the system. Then they hand over a quote on price and when the system can be delivered. If it gets accepted, an order is placed, then the sales department plans the project for MEK and EL-Design. They design the system and hands over their specifications to production and the FAE. The FAE need to make sure that the electrical specifications are correct so they can prepare their software for when EL-production are done. Production holds meetings every week with all involved departments to give updates on ongoing and upcoming projects. The information is handed over to the purchasing department who places purchase orders to suppliers to ensure that all materials are available upon production. Purchases can also be made on preliminary specifications to ensure that material is ready when production is about to start. Then MEK and EL-production can begin, they perform their work in parallel. When EL-production is done, the field application engineers configure their software with the electrical components for the system. When production and configuration have been performed, the material gets sent to the customer site to be installed. The installation department installs the system according to the installation plan, and when the hardware is set up, the field application engineers can begin to start up and test the system to make sure it runs correctly. The installation team is still at the sight as well, as support. When the system behaves according to customer requirements, it can be handed over to the end customer.

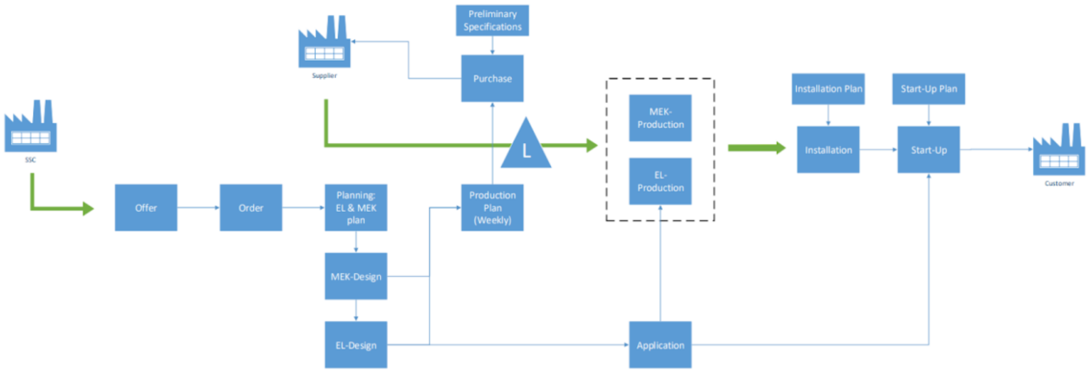

Figure 13 - *The project supply chain at JESW.*

5.3 Project Data

During 2017, 90 projects were commissioned, and in 2018 a total of 82 projects were commissioned, which represents about half of all customer requests. 21 project samples have been investigated to have a better understanding of the total lead time between different projects. For JESW, there has been an overall customer demand stating that A-systems should be delivered within 6-8 weeks, B-systems should be delivered within 8-10 weeks, and C-systems should be delivered within 16-20 weeks after an order is received. As the data in table 4 are stating, the average total lead time of the samples conducted was 23 weeks for A-systems, 26 weeks for B-systems and 29 weeks for C-systems. Therefore, there is an incentive to further investigate and improve the total project lead time at JESW.

Table 4 - *Overview of the collected for project lead time and revenue for JESW.*

	Number of Projects	A-system	B-system	C-system
Project samples 2018	19	7%	16%	77%
Total projects 2018	82	14%	11%	75%
Project samples 2017	2	0%	100%	0%
Total projects 2017	90	10%	9%	81%
Average total lead time (weeks)		23	26	29

In table 5, the average and the median number of working days in each department for projects are stated. Which is counted from when a project handover has been made to the department, the starting date, to the point that the department has made their final touch at the project, the end date. When looking into the average and median number of working days in the different departments, the numbers differentiate. This differation represent the difference in terms of workload for each department, depending on what type of project is being conducted. There is however, no supporting data for knowing when specifications were handed over to EL production from EL-Design and therefore, no information about average and median working days. Also, the time from a customer request to JESW made their first quotation and eventually get an order can differ from two months to up to a year.

Table 5 - *Overview of average and median working days in the departments.*

Working days	MEK-Design	EL-Design	MEK Production	EL Production	FAE	Installation	Start up
Average	33,3	22,3	26,2	No info	101,5	10,8	23,2
Median	21	6	21	No info	49	8	5

From looking into the number of working days, an interesting aspect is the average and median up-time in the different departments, see table 6. The information is gathered from the actual number of hours the various departments put into the project relative to the number of working days.

Table 6 - *Overview of median and average up-time in departments.*

Up-Time	MEK-Design	EL-Design	MEK Production	EL Production	FAE	Installation	Start up
Average	45%	62%	41%	No info	15%	249%	117%
Median	40%	68%	32%	No info	7%	244%	110%

When further investigating average and median days pending between the different departments, see table 7, it is also clear that this data differs. This because in some projects there is a negative amount of time between the departments, meaning that the next department starts before the previous department made its project handover. What also can be concluded is the fact that there is a lack of coordination between the department. In the best-case scenario, there would be an average and median of zero days pending between the department for a project to be in total synchronization between departments.

Table 7 - *Overview of average and median pending time between departments.*

Pending days between	Sales & MEK-Design	MEK & EL-Design	MEK-Design & MEK Production	EL-Design & EL Production	EL-Design & FAE	Production & Installation	Installation & Start up
Average	23,7	-4,47	2,53	No info	-20,1	21	-3,4
Median	20	0	3	No info	2,5	5	-2

Overall, the average and median project data reveals that there is room for improvement in terms of total project lead time to meet the customer demand better.

5.4 Processes at Jensen Sweden

In this chapter, the processes that a customer project must go through will be presented. At the end of this chapter, a map for all processes is presented.

5.4.1 Sales Department Process

The sales process starts with an inquiry from customers, usually from the SSC, see Appendix A. The first thing that is determined is if the inquiry is within the expertise of the company. If it is not, then the inquiry is closed. If it is within their expertise, then the process for verifying the project begins. In the verification process, a new project number must be created for the project. Then the sales team starts checking and filling in a project check sheet. The project check sheet is a checklist to fill in data for how the customer wants the system to be delivered. The data can, for example, be on what type of gallows the system contains, different lengths of the system and what capacity it should be able to handle. When all information has been gathered, a conceptual layout can be created, and the mechanical design team does it. When this is done, the sales team starts to fill in an internal project checklist about what is included in the project. Which is done to ensure that they have enough information about it to calculate the right price and lead times for delivery. When this is done, a verification meeting is held with all departments that are going to be affected by the project. This meeting is held to ensure that JESW can handle all the requirements that the customer is demanding. There might be some development of new features of software or hardware if so, the development teams need to confirm that they can develop it. If the project gets verified, then the offer process can start. However, it is very unusual that it gets verified at the first meeting. Some data can be wrong or insufficient, there might be that they figure out that the system is not able to perform the way the customer wants because of certain restrictions on the structure of the building. This can go on for a while until the project can be verified as more and more information is surfacing. But once the project is verified and all internal departments are in agreement, then the offer process begins. However, if a project does not get verified on the first time, then no new verification meeting is held.

In the offer process, when the project has been verified, there are usually some changes to the drawing as new functions or restrictions is added to the system. A motor list is created, it is not always mandatory to make a motor list at this stage. Therefore, this step is sometimes skipped. A pre-calculation for the project is made, this is for the most part based on similar projects that have been done before. When that information is gathered, the sales team have a pretty good guess on how much the system will approximately cost. When that is done, a functional description is created, this is a text that describes how the system is going to work and this is needed together with the conceptual layout to understand the total behaviour of the system. After the functional description is done, an offer to the customer can be made, and it consists of a conceptual layout, functional description and specification on what is included within the offer. If the offer is accepted, then a contract can be signed with the SSC, if it is not accepted, then either the project gets cancelled, or additional work has to be made to satisfy the customer need. Usually, there is a need for multiple offers as there is a mismatch between what the customer wants and what is included in the offer. So, it takes a few rounds of negotiations with the customer and changes and updates has to be made before all is in agreement. The type of changes that has to be made varies, but usually, there is something small that has to be changed in the drawing or that the customer wants to change some specific product. When all parties have agreed on the system and its features, then a contract is signed between the customer and the SSC, and JESW receives an order from the SSC. When the order is received, the registration process can begin.

In the registration process, when an offer is accepted by the customer, the project needs to be registered internally as JESW have ten days to send out an order confirmation. First off, project awareness information is sent out to all departments stating that a new order has been received and what type of order it is. Then it gets registered in XAL and planning for the project starts. EL-Design is planned by the sales team, and the other departments must plan for the new project and report to the sales team when they can deliver their parts. Then a compiled calculation can be made of lead times and costs as this is the last thing that is done to the calculation. Usually, the customer has added some features, and that is why a compiled calculation must be made. When this is done, then JESW can offer a delivery date for the project, and an order confirmation can be sent to the customer. After the confirmation is sent out, then a D10 meeting is set with all departments that are going to be involved with the project. At the meeting, the prerequisites for the project is presented and the internal checklist, order and layout is reviewed to see if there are any questions from the other departments and if something needs to be changed. After the D10, all stakeholders have been informed, and the project is ready to be designed.

5.4.2 Mechanical Design Department Process

In the final project design process, MEK-Design is present at the D10 meeting, where they receive sales specification, customer specification, and a quote layout, see Appendix B. The specifications need to be complete, especially for smaller projects where MEK-Design has less time to work on the project. For larger projects, there is scope for more flexibility, which means that MEK-Design does not know precisely how the project should look, but then they have more time to find information. MEK-Design has hopefully received a lot of information about the building already, but often a site visit is needed, which is done as soon as possible. Here the MEK-Design can have a more consistent look at the building. Which is especially important if the project is a reconstruction of an existing system, and a temporary installation layout is required. Make a temporary layout is not always done but occurs during remodeling when making a temporary solution so as not to stop the customer's production. MEK-Design always do a site visit on reconstructions except if the reconstruction is a smaller project. Site visits are not always done at new constructions. Which is because they usually rely on the drawings that come in from the SSC, and sometimes, the building that the system is going to be installed in is not built yet.

The primary steelwork drawing is made for C and some B systems but not for A systems. The steelwork drawing includes an IPE beam system with a platform, which is called a primary beam. It can vary in time how long it takes to do the primary beam drawing since sometimes it is JESW who both draw and deliver the primary bar system, but sometimes it is another supplier who does the job. In those cases, MEK-Design must put in more time on the administrative job for the steelwork drawings. So even though MEK-Design does not make those drawing, they must always be active to ensure that the drawings are on time with the correct quality. After the drawings are made, approval from the customer is required to be able to make the specifications and motor list for the system. When an approval needs to be received from the customer, is entirely dependent on how the planning for MEK-Design looks ahead, and when a resource has a time slot available. Which means that sometimes the approval needs to come in only after a couple of weeks, and sometimes immediately (two to three days). As stated by MEK-Design

"In a perfect world we would like to get back an approval right away, but it is difficult to get it".

In the mechanical specification process, when the customer has approved the layout, MEK-Design makes the specifications and motor list. MEK-Design has started working on the motor list in the final project design process, in parallel with the design work, but it is completed in the mechanical specification process. It is an advantage that the motor list is made as early as possible since the purchasing department needs it to be able to make their purchases as early as possible. The specifications that are handed over to other departments consist of the Bill of Material (BOM) list, and production and installation also gets a layout of the system. The installation department also get a steelwork drawing. The steelwork drawing includes a detailed installation drawing with instructions for how to mount a particular type of beam suspension or a certain station that is sent away for the installation.

5.4.3 Electrical Design Department Process

The electrical design process begins with a D10 meeting, see Appendix C. EL-Design needs the internal checklist and functional description to be able to proceed with the project after MEK-Design is finished. The Internal checklist consists of information about the software communications, what kind of sorting hanger that the system is supposed to use if the system is going to use barcode or RFID code. There is a functional description for larger projects, there EL-Design gets information about how the system is supposed to work, exactly. The functional description contains more detailed info of the system. That information is also included in the internal checklist. However, the functional description is more detailed. Without the functional description, EL-Design does not know how the system should work, and then do what they feel is most appropriate for the project as they possess a lot of knowledge on how it probably should work.

After the D10 meeting, EL-Design starts with completing the EL-layout. MEK-designs layout is loaded from CAD to EL-Designs “E-Plan”. After that, all electrical drawings are made. The electrical drawings include all steering for the system, PC cabinets and EL cabinets. These are then left over for control at the application department. If the application department approves the drawings, EL-Design runs its outputs, from these drawings in E-plan. Then FAE gets an IO/def which is a configuration file that they build their software on. Then EL-Design makes labels, the specifications run into XAL, from the E-Plan. XAL generates productions based on the data. After that, all tag files are made for cables. The electrical documentation is made into a pdf file that is stored in vault.

5.4.4 Purchasing Department Process

During the handover at the D10 meeting, the purchasing department receives information about what mechanical production articles, with long lead times, they need to purchase on a preliminary basis, see Appendix D. Preliminary data for MEK-production is added manually into XAL by the production planner. This is done on all projects, and it is the beam and aluminum profiles that are purchased this early. Orders for preliminary data for EL, on the other hand, are rarely made. For EL-production, it is decided whether purchases must be made on the preliminary requirement basis during the production planning meeting. The EL-Design department is after MEK-Design in the supply chain and can sometimes be done with their specifications the same day the system is to be delivered, and it is on those terms then decided if purchase on preliminary requirements is needed. Usually, this occurs when the EL-Design has been affected by changes by the customer in a later stage. Purchases need, however, all the data necessary from EL-Design at least before the purchase lead time and production start. When the actual requirements are specified, the preliminary requirements are manually removed in XAL and replaced by the real requirements.

From MEK-Design, the production planner gets a motor list and BOM-list. The motor list is needed as a complement to the BOM-list since the BOM-list does not include article variants, which the motor list has information about. Therefore, the BOM and motor list complement each other. The BOM-list from MEK-Design is entered manually in XAL. The specifications from EL-Design are added into XAL via E-plan directly. Hence no direct handover from EL-Design is made to purchases. Based on the documentation available in XAL, a demand run is made. The demand run is not made after a specific routine, and it is done when there is time for it. Based on the demand run, purchasing requirements are created. Thus, it is the projects that JESW has in orders that generate a net requirement, which purchases are based on. Purchases are made after receiving project data from MEK and EL-Design.

If new articles are supposed to be manufactured, the purchasing department makes a request from suppliers, unless the developers themselves have found a supplier. The developers have usually done this if there are more "complicated" articles already in the development phase. In that situation, purchasing negotiate prices and lead times. Then "article care" is done in the system where lead times, prices and batch sizes are determined. After that, a quote request is made.

When a purchase is made, an order confirmation is received, which is entered into the system with time and price. Subsequently, the material is delivered to the goods reception and reported from there. The purchase department also get spare parts requirements from the spare part department. These requirements are also inserted into XAL and included in the demand run.

5.4.5 Production Department Process

In the goods receiving process, goods must be received at JESW before production can begin, see Appendix E. When goods arrive from suppliers, there is a visual control of the quantity. The purchase order is needed to ensure that the right quantity and articles have been received. The goods are unpacked, and a quality check is performed. However, this is not done on all shipments, it depends on if the supplier is trusted or not. If everything is in accordance with the purchase order and the delivery note, then the goods are registered in XAL, the delivery notes get filed and controlled against the supplier invoice. The goods are considered received, and the mechanical and electrical production process can start when the design departments are ready.

Before the specifications can be handed out to the mechanical production, an inventory check is performed every Monday between the production manager, purchase manager and the production team leaders. To ensure that all material that is needed for a project is available before production is started. If everything is available, the production specifications and pack documents can be handed out to the production personnel. The production specifications consist of the BOM-list, mechanical layout, motor list and the order confirmation. All parts are produced in accordance with the specifications. Then a quality control is performed before they are packed. To keep track on how projects are progressing in the production area, daily meetings are held every morning to keep everyone informed on where to put their focus for the day. When all material for a project has been packed, then a delivery specification is created for the shipping process, and production is reported as finished.

The electrical production process is performed in parallel with the mechanical production process. What is needed to start this process is a confirmation on if it is going to run on a PC or PLC system. Furthermore, an electrical specification from EL-Design is needed and the final delivery date. When this information has reached the electrical production team, they can start to make the electrical and pulpit cabinets. The PC or PLC is set up so that FAE can test the software configuration. If the configuration is not okay, then they must rebuild the cabinets and PC/PLC. If the configuration works, then sensors and brackets can be made, and other components that are needed is picked in accordance with the picking list and configured if needed, this can, for example, be barcode readers. When everything is set up, picked and configured, quality control is performed to ensure that everything is up to the customer requirements. A delivery specification is created for the shipping process, and here should also the picking list be included, then all material and components are packed and ready for shipment. Then the electrical production team reports the order in XAL as ready for shipment.

In the shipping process, a delivery specification is issued to the transportation company where they receive information on price and delivery time. Price and time vary depending on how much JESW want to ship and where they want to send it. If the price and lead time are acceptable, then the freight gets booked. The production manager contacts the installation team and the customer to let them know when they can expect the material to be delivered. Usually, shipments are sent abroad, and then a proforma is needed for the transportation company to use at customs. Then the truck gets loaded, and information is handed over about where to send the invoice. The material gets shipped, and a waybill is handed over to the installation team so they can monitor the shipment. When the invoice arrives, it gets controlled, and the shipping process is completed.

5.4.6 Installation Department Process

Installation is part of the offer process when JESW receives an inquiry from a customer, but they are not involved until the verification meeting in the process, see Appendix F. At the meeting they get information about the scope of the project and what features the customer is demanding. Then the conceptual layout is made, and installation makes an installation plan based on that layout and the internal checklist, sometimes a site visit is necessary for being able to finish the installation plan. However, it depends on whether the project is new or if it is a reconstruction project. If it is a reconstruction project, then a site visit is almost always done, if it is a new project then usually no site visit is needed as the building is generally empty and the SSC provides a finished drawing of the building layout. After this step, a pre-calculation is made as a basis for the sales department when they make an offer to the customer. What is handed over to the offer process is the pre-calculation, the installation plan, time estimation and cost. This need to be adjusted for local rules as well. Furthermore, since there is a short amount of time in the offer process, the installation department makes a projection for the cost of work, which is normally based on 40% of the total material cost. If there is no special demand for the project, then this projection is usually close to the truth. It should be noted that this only works for C-systems, for A and B-systems it is not as accurate, but those projects do not take much time to calculate for the offer process. When the pre-calculation is done, the installation team hands over an installation plan and startup costs to the sales team that can be used in the offer process.

If the offer turns into an order, then the hardware installation process begins. Then installation is present at the D10 meeting to get information on the project and possible updates and changes that have occurred during the offer process between the sales department and the customer. After the meeting, apart from getting information on the project progress, then installation is not involved in the project until it has been produced and is ready for installation. The next step in the installation process is when the system has arrived at the customer site. If the project is in Europe, then the team has 11 days to finish the installation. If the project is in the United States, then they have 18 days to finish it. Which means that it is crucial that all material has arrived at the site when the installation is about to begin, if the material is late by a few days then nothing can be done, and more people are needed to be able to finish the installation on time. First, at the site, a risk assessment is done on the building and the material that has arrived to ensure safety for everyone. Then the material is checked, in accordance with the delivery specification, to make sure that everything that is included in the order has arrived, there is some organizing of the material as well since there is a lot of material arriving at once to the site. When everything has been checked and organized, then the system installation can begin. First, the beams are set up, then parts from the mechanical production are installed followed by the parts and computers from the electrical department. When that is done, the system is connected with the customers air, electric and network supply so the hardware and I/O can be tested to make sure that everything is set up in the right order. Here is also the customer database integrated with the network, and it includes information about what type of clothes that are going to go through the system. This information is needed to install the system correctly. Then the motors are started to make sure that they have been set up correctly, this is important and a critical task, since if the motors are set up in the wrong way the whole system will crash. Then the software can be prepared, FAE does this, but installation is involved as support if there must be some changes on the system to make it behave properly. When the software is prepared, then the hardware installation is completed, and the startup and commissioning process can start.

In the startup and commissioning process, installation is more involved as support in this process as there might be a need for changes when the application department tests the network, scanners, motors and frequencies. Furthermore, before they can start positioning, then they need to have made sure that all motors are working and that they are installed in the right direction. After everything has been positioned in the right way, then the system can be tested by doing a production run to see how the whole system behaves. Usually, the customer provides 500-1000 garments to test the system with. When the system is running as it should, the first education can begin where installation is educating the customer personnel responsible for maintenance while FAE is educating the operators. This usually starts at a Monday and both the installation and FAE is staying on site until Friday to educate the customer team and to make sure that the system behaves correctly. When the system is up and running the system is handed over to the customer.

During the support and follow up process, installation is not that much involved in this process. But there might be some corrections that are needed for the system after it is handed over or that the customer maybe comes up with some new features that they want to be added. Then they must be able to offer support if there are minor changes since the warranty time is two years for a newly installed system or feature. But for the most part, a few weeks after the system has been installed, the project is closed for the installation team. Then an economical follow up can be performed. However, in the current business system, it is not easy to make a follow-up report as it does not support it. But it is performed to the extent it is possible. The after calculation is compared to the pre-calculation that was made in the offer process to see how well the installation team did base on their initial offer. However, this is not done properly, so it is hard to know how well they have performed in the end since all data is not available in XAL. Furthermore, whether an installation goes good or bad is decided by luck in the end.

5.4.7 Field Application Engineers Department Process

FAE starts work on a project as they get invited to the verification meeting in the offer process. Which is the first time they get information on what the project is about and how it looks, see Appendix G. Mechanical design has usually created a conceptual layout. Based on the layout and the internal checklist, FAE asks relevant questions to understand the functions of the project better, and they might request additional information if it is needed. The functional description describes how the system is supposed to behave, so first, they research similar projects that have been done to see if something is useful from them. Former checklists can be found in previously saved emails. However, it requires some detective work as there is no structured way to save old projects, so they have to go through a lot of old emails to find the information needed. It could also be that some software has to be developed, so the software department has to be contacted. When data has been collected, a calculation is made on how long time it will take to configure and start up the system. Which is handed to the sales department as a basis for the offer process to the customer.

If the offer is accepted, an order is created. FAE is invited to the D10 meeting to get information on what has been ordered by the customer and if some changes have been made from the offer process. What is covered in the D10 meeting is the layout of the system and the internal checklist. If changes have been made, the functional description has to be updated, this is done between the sales department and FAE. After the D10 meeting, there is some waiting time as the project must be designed. When the mechanical design is done with the motor list, it is checked to see if the capacities are right. It is the same for the electrical layout and I/O-def. It is a control stage for FAE to ensure that it is according to the specifications. Then the electrical production makes the computers, and when they are done, FAE can setup and test the computers. This can be done when time is found for it when the configuration of the Metricon starts, then FAE is fully involved with the project. As the previous steps can be done by different persons, but from the configuration of the Metricon, then it is the same person who is involved for the rest of the project. Then the customer is contacted to get information on what type of database they have and how our system is going to communicate with it. Sometimes this is described in the functional description, so there is no need to contact the customer. Then the M-label printing is fixed, which is what should be written on the labels, and the compatibility is tested. Manuals are updated, or training material, this is always done as it is important to have descriptions on how to operate the system. When the manuals are updated, the application process is done, and the startup process can begin when the hardware installation has been completed.

When a date is set for the startup and commissioning process, a flight and hotel are booked. Usually, FAE flies and arrives on a Friday, especially if it is a new system. If it is a reconstruction project, then there might be a need to arrive on a Thursday. All startup work is performed during the weekend as the customer wants the system up and running on Monday. When arriving upon the site, a risk assessment is performed. Usually everything is installed, if installation is running behind then FAE helps to finish it. When the installation is done, then the Metricon's that has been configured back home is installed. Then the testing starts, software, IO/def, network, scanners, motors and frequency get tested to ensure that everything runs according to the customer requirements. All sensors are tested to ensure that everything will be sent to the right place and that they send the correct information to the PC or PLC. For the scanners, all bar codes are tested to ensure that they work correctly and can be read. The scanners should be set up with the right distance so they can read the barcodes properly. Then the scanners get positioned and checked to ensure that they can understand the barcodes and send the gallows to the right place. When everything is set up, the system needs to be tested. As mentioned in the installation process, the customer provides clothes and then, for the most part, the sorting is tested. To make sure that clothes will get sent to the right place. If it is reconstruction project, then they want production up and running on Monday, if it is a large new system then testing is performed on Monday and throughout the week to look for disturbances and deviations in the system. During this week, FAE performs education with the operators on how to start and close the system. Usually, they get to do it themselves and FAE functions as a backup to give directions. When the operators can handle it themselves, FAE is available for the rest of the week to act as production support as there might be a need for some smaller changes on the system. When the system is working as it should, it can be handed over to the customer who signs a confirmation with the SSC. After the system handover, an installation report is made. Usually, it consists of some points, and then a meeting is held to discuss and follow up on the positive and negative aspects of the project. The configuration files that have been used onsite is stored as they might be useful for future projects.

In the support process, the customer usually wants some minor changes to the system. Then FAE is available as the customer usually discover some minor issues on the system when they have left the site. It can either be minor changes or the customer might find that they want another set up on the system so it will be more efficient. The warranty is two years so after the system has been set up, and FAE needs to be available to help with problems that might occur.

5.4.8 Process Summary

From the process description, it can be concluded that creating a system for JESW is rather complex, as there are many factors to consider from a customer request to installation and startup. Figure 14 gives an overview of how a project flows through the whole organization, from start to completion. In the next chapter, the identified problem areas for these processes will be presented.

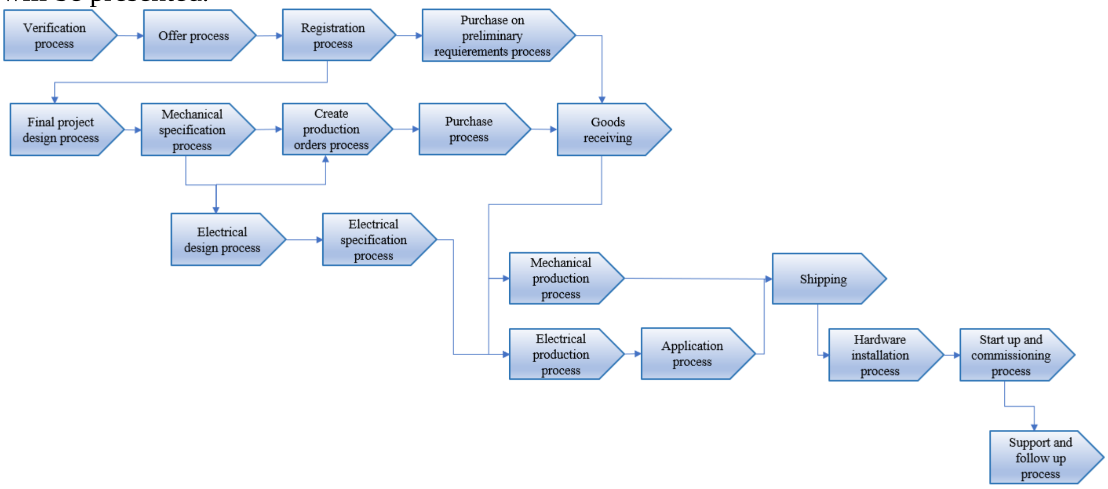

Figure 14 - *Overview of the processes at JESW, from a customer request to delivery.*

5.5 Identified Problem Areas

In this chapter, the identified problem areas for each department that have been discovered during the AIM workshops will be presented.

5.5.1 Sales Problem

Overbooked resources in the offer process are the largest challenge for the sales department. As of now, the offer process cannot be prioritized since JESW is project driven and not offer driven, and therefore, it is hard to get offers ready in time. EL-Design rarely finds time to make their offers ready, while MEK-Design does it a little bit better, according to the sales department. Furthermore, the internal information amongst departments is insufficient as the sales department must chase for information about expected workload, costs and delivery dates from each department, and therefore, it is also difficult to prioritize offers. Complexity is added since during the offer process, information from the SSC can also be insufficient as their demand and specifications can be unclear. Since resources are overbooked at JESW, there is a short amount of time to find out what the customer need is, and offers may, therefore, be calculated on inadequate information.

The information flow in general at JESW is inadequate, either information is missing, or not enough is done to require the information needed, this goes for most departments. Another complexity is that after the offer process, the person who made the offer for a particular department might not be the one who works on the project if it becomes a customer order. Furthermore, the sales department believes that there are too many meetings for spreading information. After the D10 meeting, when an order has been received, everything should be crystal clear on what should be done and when a project should be complete. Also, the sales department expect other departments to ask questions at the D10 meeting about what they need to know to be able to finish their tasks in the upcoming project. However, now there is a lack of commitment at meetings as many from other departments come unprepared, and they are therefore missing out on important information. As stated by the sales department *"what needs to be clear is what is expected from us and what we expect from others, which is not the case now"*.

Late customer changes after the D10 meeting is a problem for JESW. There are some different definitions about orders between the sales department, SSC and the customer. As stated by the sales department *"After an order has been signed, then you as a customer should know what you have bought. But the SSC and the customer might just perceive it as they have picked a supplier and that the real work to find out what they want is after the order has been signed".* Which according to the sales department *"then we have a real mismatch between them and how we work here at JESW".*

An essential aspect for steering projects is defining who is in charge of what. For a project to run smoothly throughout the whole organization, the right resources should be put at the right place at the right time. The sales department must manage projects both officially and unofficially, which further creates unclarity about the roles within JESW. When they are officially in charge of a project, it is because the customer requires an assigned project manager for it. Which means that the sales team must work with tasks that is not related to the sales process, they must drive projects and plan other departments because *"if we don't do it, who will?".* Furthermore, there is no feedback on project success/failure. This since no one is in charge of giving feedback after a project is completed. Consequently, there is no information on how a project actually went when it comes to cost, quality and time, or as stated by the sales department *"we do not consider that at all after the project is done, in the end, the only way we know that we are performing well is to look at the results on the bottom line at the end of the year".*

5.5.2 Mechanical Design Problem

All type of layout changes after the D10 meeting, from customers, affects MEK-Design the most. Which is because it generates rework of drawings, which then affects their planning. Changes may occur for various reasons, as stated by MEK-Design *"the customer sometimes does not know what they have bought, and the SSC does not know what they have sold".* After the final project design process, the customer needs to approve the layout. The layout is therefore sent to the SSC, who sends it to the customer, who then can be of another perception of how the system should work. In that case, the layout has to be redrawn from the beginning. Feedback on approval can also in this situation be delayed, and in that case, the mechanical specifications cannot be made until the customer has approved the layout. This causes problems for MEK-Design as their time slots for making the mechanical specifications have already been planned before internally. If the customer has not approved the layout, then the mechanical specifications usually are made anyway, since the resource is planned to do so, in the hope that the customer will approve the layout without adding any changes.

In several quotes, the drawers often must search for information about the project as they are not sure what needs to be done and who is supposed to do what. However, it is expected from quotation drawers in MEK-Design that they should receive all information before they should start drawing on an offer. As stated by MEK-Design *"there is often just a quick unofficial meeting where we go over the offer with the sales department. However, even if it is difficult to make a perfect layout during the offer process as information is inadequate, it still needs to be sufficiently detailed so that it will not be chaos for us if it becomes an order".* Furthermore, after the D10 meeting, all information for a project should be ready. However, MEK-Design may lack the necessary information about the project. Therefore, they must find information, either by themselves or ask the sales department. They think that the information is scattered in many places and hence is difficult to find. The problem is that MEK-Design also experiences that all the facts are not available when they search for information. Also, In the quotation phase, the drawers do not have as much information yet as they do in the final project design process, where they might do a site visit. Which means that the reality of the building often does not look like they thought during the quotation. Therefore, changes can be made when they are working on the drawings for the placed customer order. It may also be that the customer has made some changes with the facility that MEK-Design has not received any information about, or that the construction drawing on the building does not correspond to reality. These inaccurate specifications that MEK-Design has to work on, both in the quotation phase and the order phase, leads to rework and longer lead times.

MEK-Design states that they are affected by the fact that there is no clear project manager to turn to when needed. There is no control over projects at the moment, as there is no function for planning and steering them. Which means that MEK-Design must spend time trying to find people at JESW that has information about an ongoing project. Often, they turn to the sales department, since there is an unclear role distribution about who should do what, and who owns specific tasks.

Since the way of working method and design layouts are not standardized, it can create discussions about layouts between MEK-Design and the sales department. According to MEK-Design, the sales department does not always have the same views about the layouts as MEK-Design has. It also means that it can create discussions back and forth when it comes to layout changes, both internally and externally.

5.5.3 Electrical Design Problem

Several quotes and calculations may be required before the order is accepted. When the sales department receives an order, the calculations are compiled into one order calculation. However, only to the extent that the calculation is compiled to the project price. EL-Designs work is based on the latest quote. The latest quote, therefore, needs to be up to date, but this is not always the case as the information about the project is spread over different quotes, and they are not compiled in one place. Which makes it hard to keep track of the quotes since an order might be accepted on the 14th quotation and a quotation can contain information from several previous projects. EL-Design, therefore, needs to go into superoffice, which is JESW customer relationship management (CRM) tool and go through all the quotes to get information about what has been sold. It is therefore difficult to find this information and EL-Design may, therefore, have to work on several different calculations and spend a lot of time researching old projects and new quotes. Furthermore, during the D10 meeting, information about the project should be handed over, but the information on the internal checklist and functional description are often insufficient. As stated by EL-Design *"the internal checklist is maybe complete seven out of ten times on reconstruction projects and the functional description is almost never found"*. Furthermore, the D10 meeting takes a lot of time according to EL-Design as most of the information handed out at that meeting is general, and the electrical design is just a small part of the meeting. A challenge for EL-Design regarding the D10 meeting is that it is held relatively early into the project. Since EL-Design does not start working at a project before MEK-Design is done, a lot of information obtained at the D10 meeting is lost.

One of the main problems for EL-Design is the feedback from other departments. Partly, EL drawings are not updated after the installation has been made. If EL-Design wants to see how the layout is designed, they cannot rely on existing drawings of the current system. Because during the installation phase, changes may have occurred, which then does not correspond to existing EL-Design drawings. It may also be that the customer has made some changes with the electricity. Which affects EL-Design in the next stage if the customer wants to make a reconstruction of their existing system. Often, MEK-Design is doing site visits at reconstructions to look at the existing facility. However, this is not made for EL-Design to see how cables, for example, are covered physically. If the electrical drawings were correctly reported back to EL-Design, they could see how the wires were drawn. Furthermore, EL-Design does not measure their performance in any way, so they cannot say how good or bad job they have done for the year or if their planning is solid.

Tight planning is a problem when deviations occur, this is because employees at EL-Design are 100% covered in their planning, which means that they have no room for deviations. Deviations occur because of customer order changes or errors. It is a challenge to find time for rework as the whole department is tightly planned. Therefore, project work could start before MEK-Design are done, to buy time, since EL-Designs planning states it is time to do so. To handle deviations, the planning for EL-Design is hedged with safety time or the department have to work overtime. Tightly planned resources in the department give no extra allocated time to work with improvements. The only focus their resources have is to start working on a new project. If a project is delayed in EL-Design, they sometimes release working orders for production anyway *"sometimes we know that we are delayed, then we release some preliminary work for the production department so that they have something to do. However, this usually creates extra work for them and for us when changes are made"*.

No quality control is made when EL-Design hand over their drawings and specifications to electrical production, which means that errors are first noticed in production. On the other hand, the drawings and specifications can be correct, but the staff in production has no clear information on what needs to be done, so they have to ask EL-Design. In either case, the problem is that it can take 1-2 months before the drawing and specification are going to be produced in production, which means that when errors or questions occur, it is time-consuming as information about the project has most likely been forgotten. Also, EL-Design can be affected by errors handed over to them from other departments, for example, if the motor list is wrongly specified.

5.5.4 Purchasing Problems

There is a lack of production planning. As production planning is designed now, the only available information for purchase is the production delivery date and when the design departments are supposed to be done, but the purchasing department has no idea when production must start in order to be done in time. Therefore, the purchasing department does not know when the material should be delivered so that the production can begin. Furthermore, a project is not reported as finished until the whole customer order in production is completed. Which results in items having an inventory level in the business system for several months when it has been used, causing a material shortage for other projects in production. Wrong inventory levels are one of the biggest reasons for deviations, and it can also be caused by the production team as they use the material for one project that was planned to be used on another. Also, the purchasing department has little overall knowledge about what projects are ongoing and in what stage the project is in. The information flow between departments is insufficient, and changes in the project are uncontrolled. Changes occurring in later stages may force the purchasing department to purchase extra material. In that case, there is no direct follow up on and control of the purchases.

Purchasing gets its data from MEK and EL-Design at the same time as production. Which means that the purchasing department has no time to make sure material is ready before production starts unless purchasing has been made on preliminary requirements. Therefore, lots of material is purchased on preliminary data, that is not yet confirmed by the customer. As stated by the purchasing department *"there is no understanding for the whole supply chain for internal and external customers when work is performed in this way. Information for purchase needs only gets delivered when something is done or when something is missing"*.

5.5.5 Production Problems

Even though there are weekly meetings where inventory levels are checked before the start of a project, the control of material before the project start is insufficient. Furthermore, there is no close check on what should be done and what is expected to be done before production starts. If a project is started in production and they discover that parts are missing, the project is put on hold, waiting until the parts arrive, yet new projects are started so that the workers always have something to work on. Late deliveries in production mean that when parts arrive, they must be prioritized, which in turn makes it difficult to perform tasks in the right order.

Consequently, more projects are run simultaneously, which makes it harder to keep track of what projects that have the highest priority.

It is hard to down prioritize projects, or as stated by the production manager *"it is easy to know which project to prioritize, but hard to know which project that has to be re-planned. That is up to the management team to decide as we do not have the mandate to make those top-level decisions."*

Changes on drawings can be made by design after they have been produced. Which means that the drawings that were handed over to production were wrong, as well as the specifications along with it. The production department is also affected when the customer makes changes after handover. Furthermore, if the material specification is wrong, then the wrong material can be sent out to installation sites. If that happens, extra deliveries must be booked, and it is time-consuming because it will be noticed at the site and then the matter must be prioritized.

The steering of projects does not work well as there is no project manager in charge. If there are some questions about the project in the production, it is hard to know who to turn to, except possibly the sales department, *"in the end, most questions and such goes back to the sales department as they are the closest thing to a project manager we have".*

5.5.6 Installation Problems

The most problematic deviation for the installation department is wrong deliveries from production to installation site. According to the installation team, this occurs because of incorrect specifications from MEK and EL-Design are handed over to production. As installation is mostly dependent on the production department, it is crucial that they deliver correct parts to the customer site, especially since some deliveries can take a few weeks.

Another deviation is when installation arrives at the installation site, and the customer has, for example, decided to put in a new ventilation system or a sprinkler system. As stated by the installation team *"in about half of the projects we install, there is usually a ventilation system, sprinkler system, wall or some other equipment at the site that we did not even know existed. Sometimes this can have been put up just right before we arrive at the installation site"*. Consequently, the Installation team has to adapt to the new site environment and therefore need to come up with new solutions and do rework at the site.

As stated by the installation team *"We try to prioritize the projects we think fits the overall planning, in the weekly production planning meeting. But more clear steering from the sales department is probably necessary as they know what projects can be put on hold and which projects that need to be escalated. As of now, they can tell us before the meeting, which projects are more important, but that does not work at all because then we do not know which projects that should be down prioritized".* Consequently, when a project is prioritized, another project will have to be moved, which causes problems as every department is always planned up for 100% of their time, and overall project planning gets an unfortunate result. *"It is strange that no one from sales takes that call, often it is sorted as best as possible by us in the meeting and in the end, no one is satisfied with the result".*

5.5.7 Field Application Engineer Problems

Communication is seen as the largest challenge for FAE. It is often unclear what is expected of the project and who should perform tasks. Even though all information is supposed to be given at the D10 meeting, the functional description and the internal checklist are rarely filled in correctly, resulting in incomplete information on what has been sold. Therefore, similar old projects must be researched, or they must ask around to get the correct information, and some sense of what is needed to be done. However, if a project had 20 quotations before becoming an order, it is not easy to find the information needed. Furthermore, in the application process, information from MEK and EL-Design can be wrong or inadequate, then work must be double checked to make sure that everything is correctly specified after what is expected of the system. Manuals can be missing, and information can be wrong in the manuals. There can also be missing information on special functions, and there is usually no manual on how to set it up, so a quick solution must be made on site.

FAE only know when the electrical production is supposed to be done and when the project is expected to be shipped. So, they must make sure that everything is ready before shipment. However, as communication and information are inadequate between departments, computers can arrive late for their department, sometimes as late as just a few hours before shipment. As stated by the application team *"planning in regards to other departments is non-existent. The only thing we plan is when we travel and if we are at the office or the customer site"*.

It is not clear who is responsible for a project, so it is difficult to find information about specific features for it. Furthermore, there is no feedback for knowing if a project was successful/unsuccessful. As stated by FAE *"we have a follow-up process, but we usually take up some points, together with the installation team, on what went good or bad. But no one really follows up on the discussed issues. For example, if too much material arrived at the site, we just state in the follow up documentation that we delivered to much material. However, we do not follow up on why there are material leftovers"*.

5.5.8 Problem Areas Summary

Based on the empirical data, the main identified problem areas for JESW areas are collected and displayed in figure 15. These are the main causes for long customer project lead times, that was identified during interviews and workshops. The matrix shows the identified causes of problems and the departments which are affected by them.

		Deparment							
Nr	Problem	Sales	MEK-Design	EL-Design	Purchase	Production	Installation	FAE	Total
1	Lack of Information	■	■	■			■	■	5
2	Late customer changes	■	■	■		■			4
3	Unclear Responsibillities	■	■			■		■	4
4	Lack of Planning				■	■		■	3
5	Incorrect Specification			■			■		2
6	Lack of Project Prioritization					■	■		2
7	Project Driven	■							1
8	Lack of feedback			■					1
9	Lack of Standardisation		■						1
10	Purchase on Preliminary requirements				■				1

Figure 15 - *The identified problem areas for long customer project lead times.*

6 Analysis

In this section, suggestions for improvements that affect the project lead time will be presented. The analysis is divided up in two parts. The first part, chapter 6.1 Engineer to Order, the environment in which JESW operates in will be established alongside with the problems they are facing because of this. In the second part, suggestions on how to solve the main identified problem areas will be presented.

6.1 Engineer to Order

JESW is operating in an ETO environment where the customer is affected by the total supply and delivery lead-time during the phases tendering, engineering, production, installation and start up see figure 16. There are two main flows at JESW that need to be coordinated, the physical material flow and the information flow. The physical flow consists of deliveries from suppliers to production and shipping from production to the installation site. The information flow permeates the whole organization, where all different departments need to be coordinated and synchronized. Therefore, for delivering projects effectively, JESW must consider their entire supply chain since all problems related to it will affect the customer project lead time. In figure 16, all problems related to the supply chain with their underlying root causes are presented.

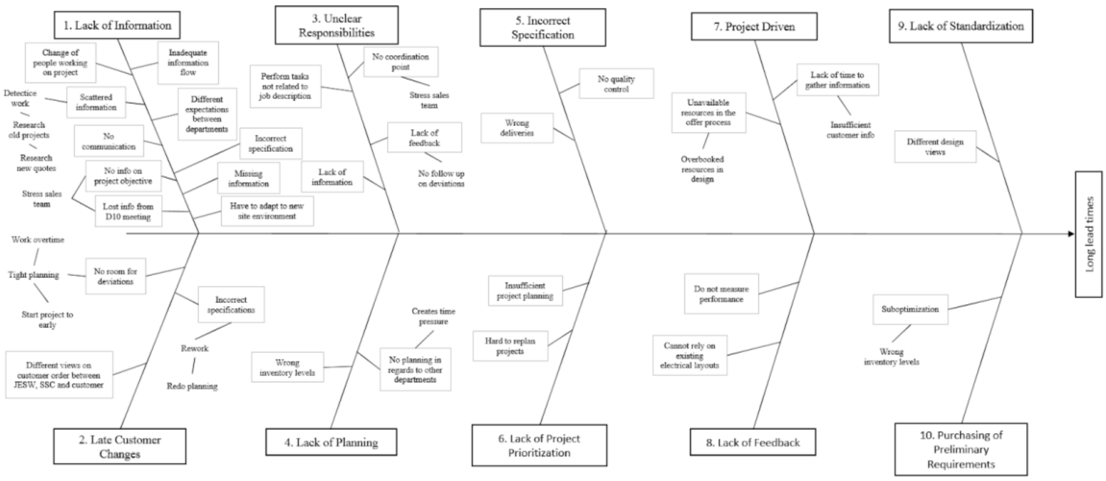

Figure 16 - *Root cause analysis for the identified problem areas at JESW.*

Problem 1 relates to lack of information. Which is a result of a combination of inadequate information flow, incorrect specifications, that information is scattered or missing. At the beginning of a project, the objective is too vague, and as there is a lack of communication between departments, their expectations of the project vary. Problem 2 is late customer changes, they can happen for several reasons, but when changes occur, it puts pressure on the planning for a project as resources at each department are booked at full capacity. Which means that there is almost no room for deviations in their planning. Problem 3 is identified as unclear responsibilities, and this leads to employees getting unofficial roles within the company and therefore perform tasks that are not related to their job description. As no one is responsible for a project, there is no coordination point to turn to, and information is lost between departments as well as there is no feedback on performance for projects. Problem 4 is lack of planning, which is not performed in regard to other departments, which creates time pressure for others down the supply chain. Each department is responsible for their planning. Problem 5 is incorrect specifications, and they occur as there usually is no quality control on drawings and specifications when work is handed over between departments. Which in combination with late customer changes, can lead to wrong deliveries, both within JESW and to the customer site.

Problem 6 is lack of project prioritization, and it is in regard to planning, the project planning is seen as insufficient, and even though it is possible to prioritize a project, it is hard to know which other projects that have to be moved behind. The ones making those decisions do not consider themselves having the mandate to make those decisions. Problem 7 is that JESW is project driven, which means that projects get prioritized before making offers to customers, the sales department considers that the information from customers as insufficient and they do not have time to gather all of it. Meanwhile, resources for making offers are often overbooked, especially in the design departments. Problem 8 is lack of feedback. EL-Design can for example, not rely on existing electrical layouts that have been performed for other projects as the customer or the installation team might have made changes on them, without notifying the electrical department. Furthermore, performance is not measured within JESW, so there is no way of knowing how well a project went, other than if it got delivered on time. Problem 9 is lack of standardization, in the design phase, the sales department and the design department might have different views on how to draw a layout for a project as there are no standards set up. Problem 10 is purchasing on preliminary requirements, to meet due dates, the purchasing department must take chances and purchase material on preliminary specifications for projects to get the material in house on time for production. Furthermore, as inventory levels usually are wrong, extra purchases are made to be on the safe side. These problems can be related to the fact that JESW is operating in a highly complex and uncertain ETO environment that needs to be managed to be able to reduce the customer lead times. Consequently, these ten identified problem areas will be the focus of the analysis of this thesis.

As stated by Adrodegari (2014), operating in an ETO environment puts exposures to high uncertainty when it comes to supply and delivery lead times. Therefore, designing and building complex systems to exact customer specifications often translates into long lead times and heavy engineering (Dallasega et al., 2015). It is of fundamental importance for companies operating in this environment to consider the whole supply chain (Dallasega et al.,2016), both for physical material flow and the information flow (Mello et al., 2015). Since the customer is exposed to the total delivery time from engineering to installation on site, lead time reduction is therefore considered as one of the most critical factors for improving delivery performance for ETO organizations.

One major problem that affects the performance of ETO organizations is delays. Delays and rework are common, especially in production and engineering, and therefore need extensive coordination effort (Mello et al., 2015). Changes that cause delays and reworks, often caused by customer changes both before and during the order process, but also errors made in departments that are discovered in later stages ad further complexity to processes. Rework put extra pressure on departments in terms of capacity and project management (Dallasega et al., 2015). It is therefore hard to predict project outcome as these uncertainties are causing delays in projects (Mello et al., 2015).

Changes cause uncertainty, and in the end, project delays. Therefore, changes need to be aligned and coordinated within the whole supply chain in all functions. Missing alignment and transparency between departments are pointed out as a source that creates inefficient processes. Coordination, therefore, requires specific coordination structures. It is pointed out by (Mello et al., 2015) that common coordination problems are, poor communication, poor cooperation, unclear responsibilities and an organizational structure that inhibits coordination. When it comes to ETO supply chains, coordination from project management has been pointed out as one of the most frequently used elements to handle uncertainty (Mello et al., 2015).

Consequently, because JESW operates in an ETO environment, departments are stressed with more uncertainties caused by late customer changes and incorrect specifications. Which generates rework and delays in departments, ultimately affecting the total customer lead time. Because of JESW natural ETO strategy, some of the identified problem areas like lack of information, unclear responsibilities, late customer changes and incorrect specification can perhaps be seen as general challenges for all organizations operating in an ETO environment and therefore a symptom of that chosen strategy. However, neither the less, the identified problem areas need to be targeted for improving lead times. JESW has not utilized an organizational structure that exhibits their coordination and information flow, which could be a factor for reducing the total delivery time and improving JESWs company performance.

6.2 Organizational Design

As for now, JESW is built on several departments that a project must go through to be delivered. All departments have a functional manager, except for the sales department and MEK-design who operates under the CEO. There is no employed project manager, instead the sales department sometimes has to take that role. However, that role is often unofficial. When a new customer order is sold, a D10 meeting is held between all departments to spread information about the project. After the D10 meeting, the expectations and functionalities of the system should be clear. However, as stated in the root cause analysis, lack of information is seen as one of the major issues at JESW as most departments are unsure about what the objective is for a new project.

As departments experience that there is information missing at the D10 meeting. The sales team have an unofficial project manager role, as they must perform tasks not related to their job description. Which means that when information is missing, most questions come back to the sales department, even though they have handed over the project and not been involved in the project for a while, since most departments experience that there is no one else to turn to when problems occur. Another problem found in the root cause analysis is that there is a difficulty to prioritize projects. Projects get prioritized over making offers and when a project needs prioritization over others, no one at the weekly production planning meeting experience that they have the mandate to make those required prioritize decisions.

Planning in regard to other departments is also considered as a problem, and since most departments are planned for 100% utilization, there is no room for deviations. Therefore, late customer changes affect the planning for the design, which further affects the planning for production. For MEK-Design, customer changes frequently occur which affect their work. Which is because they need customer approval before they start making specifications. However, if the customer approval is not handed over in time, MEK-Design must begin to make their specifications even though the layout is yet to be confirmed by the customer. Which also affects EL-Design as they might have to start working on layouts not yet confirmed by the customer. Since planning is tight at JESW, preliminary layouts and specifications can be released to production, to save time in the production phase as well. Which will cause problems when the customer changes occur. It should be noted that even though most departments believes that there is lack of information, planning and that the project objective is unclear, the installation department perceives the coordination for projects to work well, as they believe that everything is clear what they should do for a project and they know exactly when they are supposed to go out on installations.

According to Burton and Obel (2018), structure and coordination is the fundamental choices when deciding the organizational design. San Cristobal et al. (2018) further states that the organizational structure should define the relationship between members of a project towards other projects. The underlying theory of organizational design is to structure the organization to be able to handle information processing as the greater the task uncertainty, the greater information processing is required (Burton & Obel, 2018).

According to Hobday (2000) the three most common organizational structures are the functional structure, matrix structure and project structure. The functional structure does not suit organizations which require coordination between many employees who have lots of different expertise. In the project structure, project managers have a high level of authority where personnel are assigned to a project. This structure suits large organizations. According to Laslo and Goldberg (2007), the matrix structure is the primary organizational structure for maintaining an efficient flow of resources in a multi-project environment. Also, the matrix structure is commonly used by organizations operating in complex and dynamic environments. Furthermore, in the matrix structure, two different approaches could be used, either the lightweight or heavyweight matrix structure. In the lightweight structure the project manager is more of a coordinator with no authority over functional managers whereas in the heavyweight matrix structure the project manager has authority over or equal to the functional manager (Tonchia & Cozzi, 2008). Either way, the main positive effects of a matrix structure is that it achieves strong project coordination and better control (San Cristobal et al., 2018). Which is strengthened by Woo (2018), who concluded that a Chinese construction company were able to reduce their project lead times by 30 days by transitioning from a traditional structure to a functional matrix structure. The main reason for this achievement was that the functional matrix structure improved communication and coordination. However, there were also some negative aspects of this transition as employees found it confusing to report to both the functional manager, and the project manager, and there were also power struggles between these two over resources. Therefore, management had to document and delegate power to each function (Woo, 2018). This is confirmed by Midler (1995), in the Renault case, where it was concluded in the second phase of their organizational transition, that having a project manager who only acts as a coordinator with no real power to make decisions results in poor outcomes for a project in terms of time, quality and cost. Consequently, it turned out to be an ineffective process. Therefore, they implemented more clear roles and authority. This increased the cross-functional communication as the project got coordinated horizontally instead of sequentially. Furthermore, the project manager contributed to an increased partnership with both internal and external suppliers (Midler, 1995).

It could be argued that JESW has a functional structure, even though there are some attempts to achieve coordination between departments as there is a D10 meeting to align all departments for a project. However, this type of one batch information transfer is not enough for every department to understand the expectations of a project, especially as it can take several months after the D10 meeting before work on a project is started in some departments, which results in lost information. After the D10, the general culture at JESW is that every department is run by themselves where resources are allocated to fit their planning with the overall planning. This means that every department is resource efficient, but projects can suffer from long lead times, hence the statement that JESW has a functional structure.

Furthermore, as departments are in need of a better coordination point, the authors suggest that JESW should move from their current structure and implement a matrix structure, as it is suitable for organizations operating in complex environments. Employing a project manager would also enhance the coordination and information flow between departments. By doing this transition, JESW should be able to utilize their resources better, improve communication between departments and reduce the lead time for projects. In figure 17 below, it is suggested how the new matrix structure should be set up.

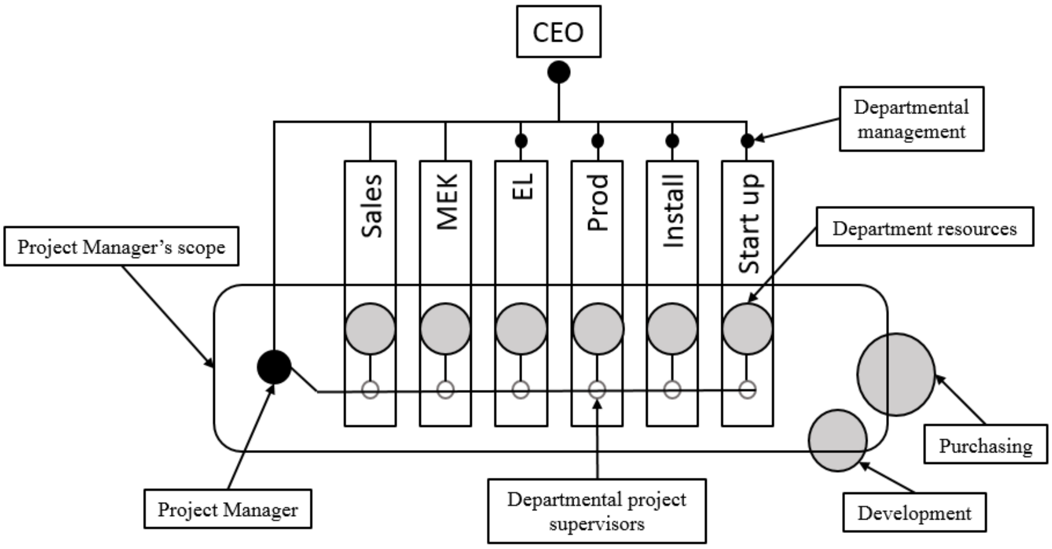

Figure 17 - *New organizational structure for JESW.*

In this organizational structure, the project manager will have the authority to make decisions about the project flow and projects will be planned horizontally instead of being planned sequentially, as it is now. It is essential that the project manager has the authority over functional managers in terms of planning. Otherwise, the project flow is going to be inefficient, as shown in the Renault case. The project manager would also be able to assist during the weekly production meeting and make decisions on which projects that need to be prioritized and which can be pushed back as the project manager will have overall knowledge about the status for all active projects. Which will create control for projects when someone is responsible for driving them forward as the role will be clear for everyone within the organization.

In the collected project data, it is clear that coordination amongst projects is insufficient as projects are waiting for a long time between departments. Implementing this organizational structure, it should create a prerequisite for achieving cross-functional integration between departments, where information can be transferred more efficiently, leading to enhanced communication between departments and better utilization of their resources. As JESW operates in a complex ETO environment, the matrix structure in figure 17 is suitable to improve coordination, which could decrease lead times for projects. If JESW is able to better coordinate their projects, working on preliminary data might be eliminated and the waiting time between departments will be decreased. Consequently, a strong matrix structure with a project manager could solve the perceived difficulties in lack of planning, unclear responsibilities, lack of information and lack of project prioritization.

6.3 Project Management

From the empirical data, it can be concluded that all departments involved in a project attend the D10 meeting, to gather project information. After the D10 meeting, all project requirements should be clear on what the objective of the project is, but it rarely is. This because the conceptual layout, internal checklist and functional description are rarely filled in properly, even though it should be. Which is supported by EL-Design, who states that the functional description is filled in for about 30% of the times. Which is an essential aspect as internal checklist and functional description together explains how the system is going to operate. As the responsibilities are unclear, there is also a perception of a lack of project prioritization. During the weekly production meetings, those attending experience that they have no mandate to prioritize which projects that should be done first, and which should be moved as prioritization might be needed because of late customer changes or that they have received a new critical project. The planning is also insufficient as there is no planning performed in regard to other departments, or so it is perceived. For example, to be able to manage their planning in each department, they start working on a project even if the layout and specifications have not yet been confirmed by either the customer or the previous department. When changes in planning occur, it will affect the planning for all departments down the supply chain. Furthermore, no one is really in charge of making follow-ups on projects, even though installation and FAE has a follow-up process, it is mainly for themselves to discuss what went good or bad in a project. However, no one acts on what is pointed out as project deviations on those meetings. Which is further proved by sales who states that no one is following up on how a project went, as they only know the total years project success by looking at the economic results at the end of the year.

According to Tonchia and Cozzi (2008, pp. 3), managing projects is about managing the variables that can be influenced. It means taking a decision and act accordingly to the constraints of the environment, i.e. control, act and execute. The most critical variables to control and influence in a project is time, cost and quality as they are the metrics for process success (Mossalam & Arafa, 2016). To achieve this, the project manager should possess skills in handling changes, communication and manage stakeholders for being able to achieve the objective of a project. Furthermore, to be able to plan and execute a project, the mechanism for this is control as the project manager is responsible for a project to move as efficient as possible according to time and budget. It is also up to the project manager to identify problem areas and come up with solutions and implement them (Globerson & Zwikael, 2002). To achieve effective planning for a project, the roles need to be clear as it will reduce the number of changes required in the planning stage. Therefore, the role of the project manager is to set major milestones, ground rules, objectives, operating procedures, policies for administrative work, and how the reports should be handled for projects. The project manager should also make a detailed plan and allocate resources to support the budget and time constraints. The functional manager is responsible for executing the objectives, requirements and milestones for the project. The functional manager is also responsible for identifying uncertainties, risks and conflicts to assist the decision making for the project manager. Senior management should act as a negotiator between the project and functional manager if conflicts occur between them (Kerzner, 2017, pp. 519). Furthermore, when organizations recognize the need to develop processes for project management, a stage-gate model should be implemented. As by using gates and clear rules for passing defined milestones, the stakeholders working in departments will know what is required of them for the project to pass the gates. Furthermore, the gatekeeper should have the authority to make decisions regarding if the project is ready to move on, or not. The major benefit in having a stage-gate process is that it will provide a structure for the project manager, and it will standardize the planning, control, checklists and guidelines for a project. Which will lead to a more structured decision-making process (Kerzner, 2017).

In the previous chapter, it was stated that a project manager is needed at JESW for enabling a heavyweight matrix structure. JESW are operating in an ETO environment, and a project manager is needed as the company need someone responsible for handling the overall planning, feedback and improvement work. From the empirical data it can be concluded that a project manager is needed to plan, prioritize and take responsibility for the project objective. Even though it could be stated that JESW handles projects rather well, since they never missed a project delivery deadline, a project manager could possibly solve many of the problems that departments are experiencing at JESW, which would improve the lead time for projects. By implementing stage gates between departments and processes, it enables the project manager to ensure that no department hand over unfinished work. For example, MEK and EL-design should not be able to start work before the functional description, and internal checklist is filled in as it is an essential aspect for them. Which could also explain why so much rework is needed for projects. By implementing stage gates, it would assist the project manager in clearly define what is expected from each department as they would know what they should hand over, and the department who receives the information would know what they should expect. Which would cause better communication between departments and planning would be synced better. The stage gates should be seen as milestones, and the project manager decides what should go through these milestones and what should not. Which would create more effective planning for projects, and this should theoretically reduce the number of rework and replanning for projects, as has been stated as a problem in the empirical section. Which would also enable the project manager to be able to handle feedback as the stage gates would force problems to the surface. Since the project manager is going to be responsible for driving change and development of processes, improvement work can be implemented on problem areas as the project manager is responsible for making lead times better for the projects. Furthermore, as stated in figure 17 in the previous chapter, the project manager should have authority over the functional managers. When roles are clearly defined, the project manager also has a mandate to take prioritization decisions on projects in the weekly production planning meeting. Which is logical as they would have a lot of overall knowledge about the projects who are ongoing, and which are coming in. The proposed gates that the project manager should handle is illustrated in figure 18 below.

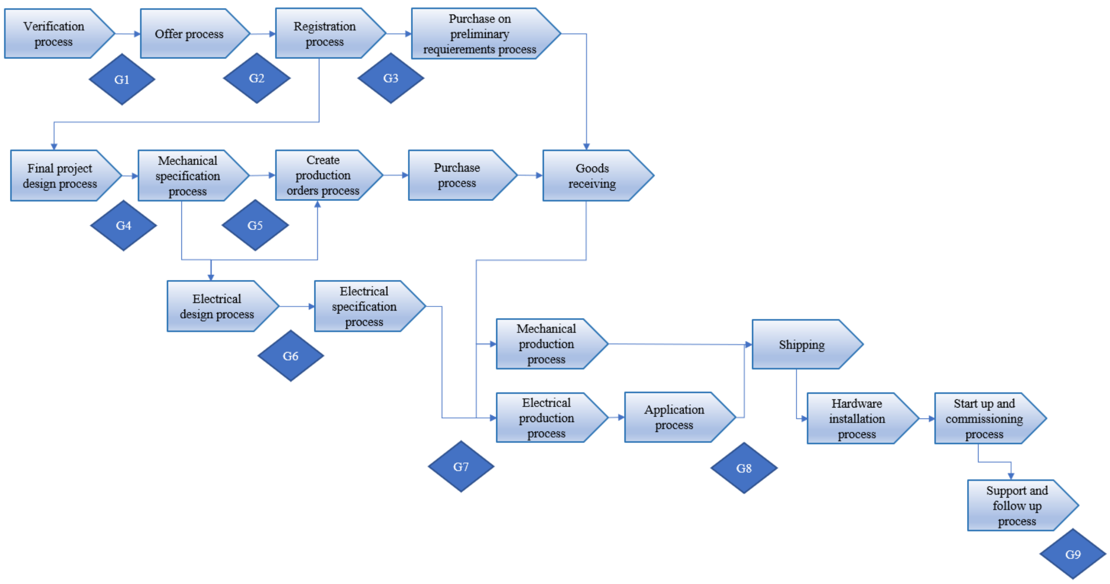

Figure 18 - *Stage gates, where the project manager decides if the project is ready for the next process.*

6.4 Project Interconnectedness

Looking at data from table 6, it reveals that the uptime is insufficient and the pending between stations are long, which results in too long lead times in regard to the customer demand. However, there can both be internal and external reasons for why the lead times are insufficient. From the problem analysis chapter, it can be concluded that JESW is affected by external factors like late customer changes and lack of information from SSC. But also, from internal factors like the lack of mandate to prioritize and, more importantly, down prioritize projects. Altogether, JESW has a complex product, and an extensive process chain, see figure 14, which leads to uncertainty in the organization since changes in projects occur regularly. JESW also lack a project manager and has a functional structure, which may hinder the information flow and collaboration between departments to function efficiently. However, processes are quite standardized and repetitive, regardless of what type of project JESW are executing. The major difference in the processes is the amount of work that needs to be performed for each project as reconstruction projects require more time for design and new system require more time in production.

Looking at the uptime in departments and pending time between departments, it is clear that those are affected by both internal and external factors. However, 82 projects were commissioned in 2018, which naturally affect the project lead times. As JESW handles multiple projects, planning and resource availability is affected negatively when changes occur, and rework is needed in design or production.

In figure 19, an authentic project is visualized through a Gantt chart, displaying a quite coordinated and synchronized project. The data reveals that there can be a long sales process until the order is received. In the root cause analysis, an identified problem is that JESW is project driven and focuses resources on actual order, leading to unavailable resources in the offer process because of overbooked resources in the design departments.

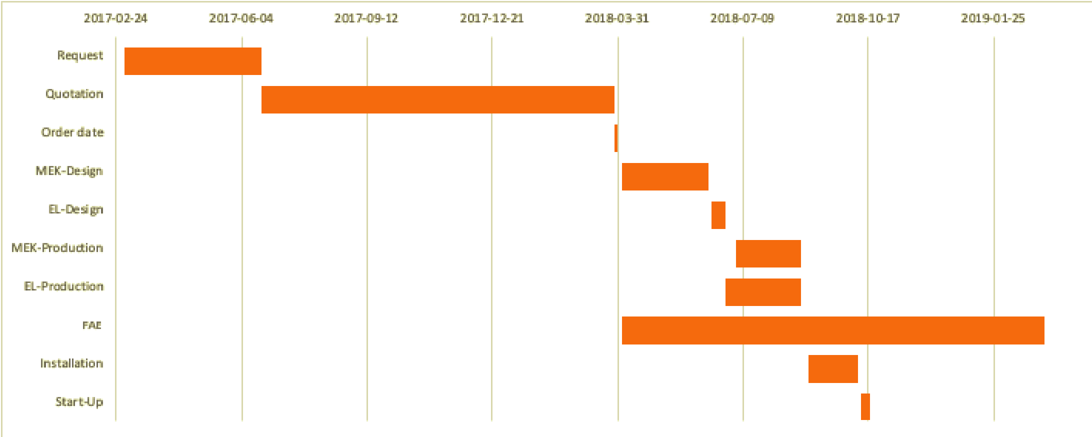

Figure 19 - *Gantt chart displaying a project.*

On the other hand, as seen in figure 20, the project data reveals that there is a lack of coordination and synchronization between the departments, which creates pending time. After the order is received, it takes several months until the MEK-Design department starts working on the project. After the MEK-Design department is finished, it takes time until EL-Design starts work, which creates the need for the electrical department to start production on preliminary requirements before the design has specified what is required. This problem can be connected to a lack of planning that is the root cause of no planning in regard to other departments, which then creates time pressure for other departments.

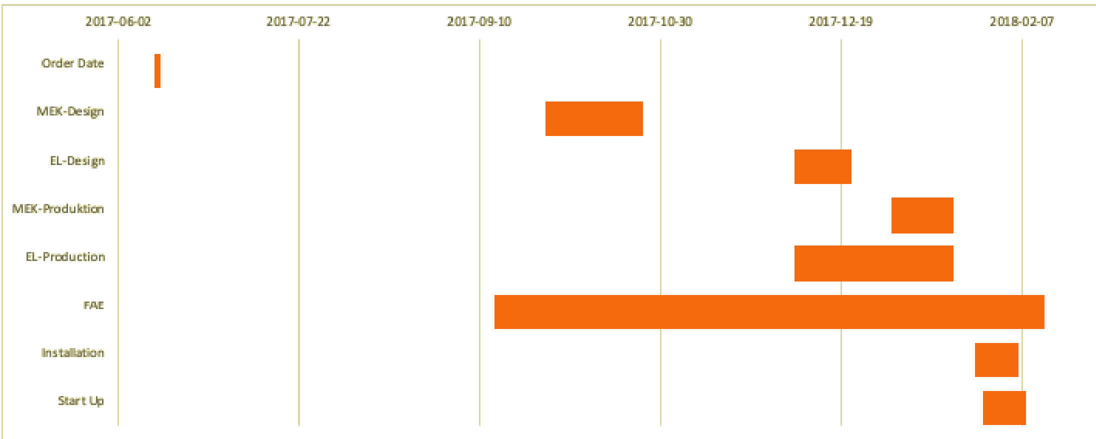

Figure 20 - *Gantt chart displaying a project.*

In figure 21, it can be concluded that all departments except installation and startup are started early, by working on preliminary requirements. Which raises the problem of incorrect specifications and therefore rework must be made if customer changes occur.

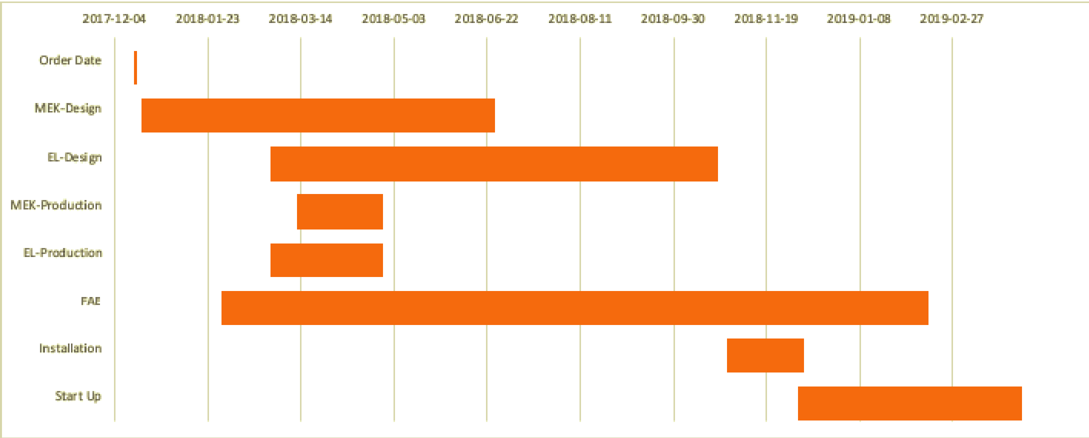

Figure 21 - *Gantt chart displaying a project.*

Consequently, the data reveals that there are different types of deviations that need to be managed. Both the fact that in some projects, there are a lot of pending time between the departments, which result in poor project lead times. In some projects, departments start early, working on preliminary requirement, which leads to incorrect specifications and rework. Overall, the causes of planning problems are many and dependent on external factors as well as the fact that new customer orders can change the overall planning. Therefore, the fact that JESW is in a multi-project environment can be seen as a root cause for several root causes.

According to Engwall (2003), theories on project management are based on the perspective that a project is treated as a single event, with neither history nor future. A classic issue is an environmental impact on projects where external factors influence the internal processes of an organization. Caniëls and Bakens (2012) state that multi-project environments are complex, and to be able to handle many projects simultaneously, management is exposed to numerous challenges. The most common problem in this environment is resource conflict and long lead times. Therefore, it puts additional pressure on the organization if the balancing of these projects is inadequate, as it leads to poor information quality and long lead times. Therefore, as stated by Arazkiewicz (2017), the ability to manage multiple projects is a key competency for competitive advantage. Furthermore, Yaghootkar and Gil (2012) state that an organization that handles multiple projects perform poorly if they have a project or function-based structure, and they recommend a matrix-based structure to guarantee effective negotiations of project priorities and resource allocations between the functional managers and project manager. However, there is a limit in how many projects a project manager can handle at the same time, and it is therefore helpful if processes and routines are standardized. According to Adrodegari et al. (2014) for ETO organizations, project management should be well-known methods to optimize the scheduling activities, project sequence and monitoring the project status since it aids the organization to optimize allocations of resources, minimize cost, plan for corrective actions and maximize delivery in multiple projects.

Consequently, the lead and up times at JESW are insufficient. However, this is also a consequence of dealing with multiple projects simultaneously. Without a multiple project environment or external impacts, projects could have been treated more like lonely events and these problems that JESW are affected by might not have occurred, in regards to lack of planning, lack of information and incorrect specifications. Dealing with multiple projects might put a greater demand on a project manager, since planning, resource allocation and maximize delivery in projects becomes a big challenge. On the other hand, since all projects go through the same processes and steps, having standardized processes, which JESW has, will help the project manager. The collected project data reveals that introducing a project manager is a necessity to reduce lead times. Furthermore, it also becomes evident that JESW is hindered by their current functional structure as departments work in silos where work is either pending between departments, which affect the next one, or that departments start work too early, which means that they might be working on not yet confirmed specifications, which leads to rework and further pressured schedules. From the collected project data, it can be concluded, from a multi-project perspective, that changing the organizational structure from a functional to a matrix structure and implement a project manager is needed to better coordinate the project flow for JESW.

6.5 Business Process Reengineering

To introduce a PM function that manages the overall capacity and planning that can push projects through stage gates has been established in the previous chapter. Which in itself could be considered as a process change and should favour several of the identified problems established in the root cause analysis like planning, information sharing, feedback, unclear responsibilities, incorrect specifications and project prioritization.

From the previous chapter 6.2, there has also been established that JESW is in need to change their structure to better cope with their multi-project ETO environment. Changing the structure can in itself, be seen as a major change. However, to achieve cross-functionality, more is required than just implementing a project manager. In chapter 6.2, it is also stated that changing structure also requires changing processes, and by doing that, achieving a cross-functionality by a more drastically process change.

In appendix A, B and C the process maps for the sales department, MEK-Design and EL-Design departments are shown. In chapter 5.4, there is established that within the sales process, preliminary MEK and EL layouts are made by the help of MEK-Design. However, after the order is received, MEK and EL-Design are working sequentially after each other by themselves, based on one batch information transfer. The lead time from receiving an order until MEK-Design starts working on the project is average 23.7 days, and they are working on average 33,3 days on the project. During this time, after the final design process, they must wait for customer approval before they can start the mechanical specification process, which slows down their work. After that, EL-Design is working on the order for 22,3 days on average. It can also be concluded that the offer process can last up to half a year wherein extreme cases requires up to 14 offers until a customer order is approved.

For these three departments, sales, MEK-Design and EL-Design, several problems can be derived, which further affects the sequentially following departments. Primarily, the completion of MEK-Design affects the when purchasing department can purchase materials on correct specifications for production. As for now, it is standard for the purchasing department to purchase materials with long lead times on preliminary requirements, for the production to be able to finish their assembly before shipping. Buying on preliminary requirements can, however, lead to rework and replanning and high inventories. To reduce lead times and manage the root cause problems, process changes in sales, MEK and EL processes could be required.

Organizations must adapt to their changing environment. Since a change in a continuous process, it forces companies to adjust their way of working, so it follows the customer requirements (Bhaskar, 2017). BPR involves reinventing and overturning old processes while radically designing new ones. BPR is a cross-functional approach and therefore requires support from all departments within the organization. There are different types of companies that initiates BPR. One type is the one that is in its best shape. That type has no visible difficulties at the time, but management are ambitious, and they see an opportunity to further extend their competitive advantage over their competitors. BPR is not a fine-tuning tool, but it is for companies willing to go the extra mile to achieve substantial performance improvements (Gunasekaran & Kobu, 2002). There can be several reasons for a company to start reengineering its processes. Lack of unclear directions and unclear responsibilities but also excessive use of unstructured communication is an indication that BPR can be necessary. Also, to gain a more integrated communication between departments, mode three and mode four, visualized in figure 8, is suitable to handle a greater flow of information (Wheelwright & Clark, 1992).

As it has been established in the above sections, JESW is facing lots of challenges. During projects, employees perceive that customers make late changes, specifications are incorrect, that there is a lack of information and projects are prioritized over offers. Therefore, the authors of this study argue that reengineering the processes at JESW is needed for better adoption of their multi-project ETO environment. It could be argued that many of the problems established in the root cause analysis derives from the offer process, and therefore reinventing and overturning old processes could be required.

The perceived problems could relate to the fact that the offer process is inefficient as it can require up to 14 tries before an offer gets accepted. Since almost half of the offers turn into an order, the authors suggest that the processes from MEK and EL-Design is integrated with the processes for the sales department. Which could solve a lot of identified problem areas for JESW as the departments could be more cross-functionally integrated and the need for searching for information would most likely be reduced significantly. In Figure 22, a suggestion for a new offer process is illustrated.

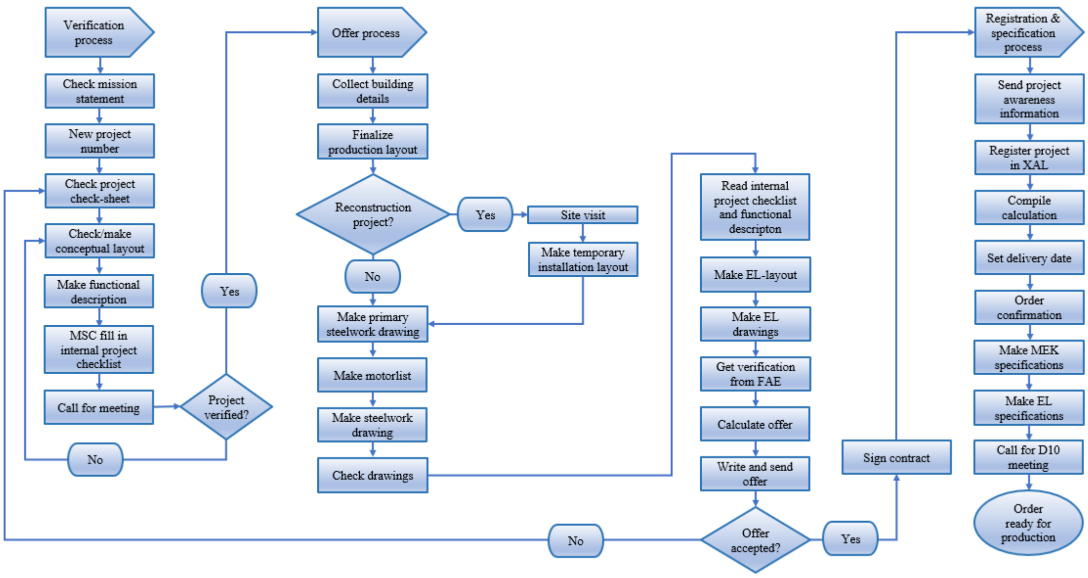

Figure 22 - *Process map over the suggested new offer process.*

In this process, some changes have occurred. The verification process should remain the same as it is mainly a process for gathering information from the SSC to get an overall understanding of how the system is desired to operate. Furthermore, in the verification meeting, all departments that need to be involved is attending the meeting to give their opinion on if they can handle the system requirements, which is the first information meeting for the project. Also, in the verification meeting, the new project manager is involved.

In the offer process, the change drawing task along with the make motor list draft and make pre-calculation task has been removed, see appendix A. Instead, the offer process should start with the final project design process, see appendix B, and then continue with the electrical design process, see appendix C, since the calculation for the offers should be more accurate as more information has been gathered about the customer requirements.

Furthermore, the registration process has been extended with the mechanical specification process, see appendix B, and the electrical specification process, see appendix C. The mechanical and electrical specification process should be performed directly after the order has been received since all necessary information has been collected now during the offer process.

Consequently, these process changes will remove the pending lead time, from a customer perspective, of average 23,7 days between the sales department and MEK-Design, see table 7, the average 33,3 working days in MEK-Design and the average 22,3 working days in EL-design, see table 5. Which is a total lead time reduction of average 79,3 days.

By doing these process changes, JESW should become more cross-functional integrated, see figure 23. Cross-functional integration occurs at the working level, and it is founded on close linkages in time and in communication between individuals and groups working on closely related problems. Sales, MEK-design and EL-Design department are going to work together in the same process, and solving a common problem, namely the quotations.

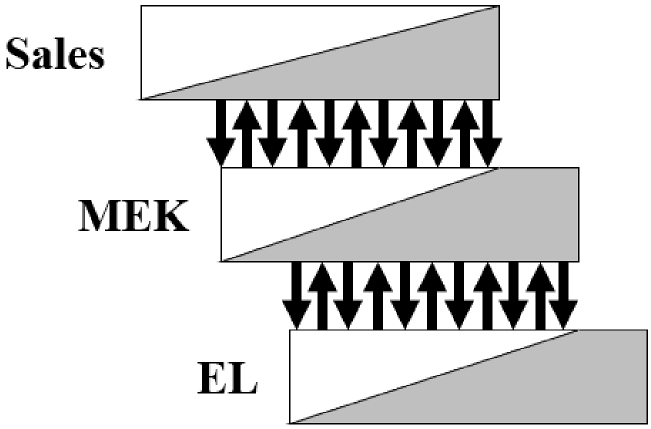

Figure 23 - *Cross-functional integration for JESW.*

Also, since some processes have been removed. The process map of JESW has changed. Which leads to fewer processes needed to be managed by the intended PM, and therefore fewer gates need to be monitored.

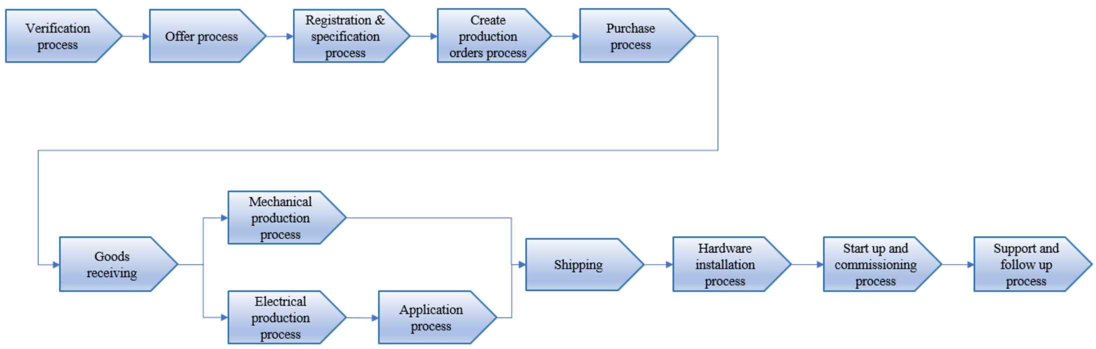

Figure 24 - *New process map for JESW.*

7 Discussion

The purpose of this study is to understand how the flow of projects works today for a company operating in an engineer to order environment and to develop improvements that can increase the total throughput for every type of project.

The approach chosen was first to get an idea of how the processes at JESW works. The processes at Jensen Sweden chapter 5.4 provides an overview of how projects flow through the organization. Understanding the project flow made it easier for the authors of this study to know how things work. The workshops and interviews provided further knowledge about how the processes operate and what type of tasks that are performed in those processes. After establishing the processes, problem areas were identified by using the AIM method, to further investigate where suggestions for improvements could be identified. As this thesis is limited only to investigate potential improvements, no implementation plan is suggested. To complement the processes and identified problems, a data collection was made over authentic reported projects, to back up the data collected from the workshops and interviews.

First, it could be discussed if there has been enough interviews and workshops to handle a strategic thesis of this size, as many departments are involved, the data collection can be too scarce. When doing interviews and workshops, there is a risk that the authors draw too general conclusions. The workshops were followed up by interviews to strengthen the claims made regarding the processes and problem areas and to further understand them. In the workshops and interviews, there is a risk that information might not surface if the people attending do not want to share all the details. There can also be subjectivity by the invited participants that affect the results of the workshops and interviews, and their subjective reflection of the environment might not reflect the actual truth. Which is also a factor which might reflect the analysis or a factor that highlights certain problem aspects that is not the common nominator in the organization.

Furthermore, the execution and setting of the workshops and interviews could also affect the results as the general atmosphere could affect what people are willing to talk about. The general attitude towards the study also has an effect on the result, as some employees did not want to attend the workshops if they would have attended, other problem areas might have surfaced.

Also, if these workshops were conducted at any other time or by anyone else, the result might have reflected other problem areas. Another aspect is the level of experience in conducting interviews and leading workshops, as it plays a vital role in the quality of the gathered data. Which is strengthened by the authors who experienced that workshops and interviews went better as the thesis progressed. Furthermore, the project data collection could be questioned, as only 21 samples were used. If other project samples would have been used, there could have been a different result in terms of project lead times, and therefore, the analysis of this report might have been different. Since the samples represent 41% of the turnover, it is argued that if another sample size had been used, there would not have been too much of a difference in the result. Therefore, the authors are comfortable by the fact that the project data collected is representative for the project lead times.

Second, it takes several years to see the benefits of a large restructuring of an organization. While changing the structure and processes, it could be argued whether the goals in the analysis are realistic. It most likely is possible to implement a project manager at JESW that could improve the total throughput for projects as there would be someone who is in charge of driving them forward. However, it could be argued if a project manager can handle 82 projects per year or if a project manager is needed when a new offer process is suggested since the cross-functional integration might work better now between the sales department, MEK-Design and

EL-design. Therefore, one suggestion would be to try out the new offer process first for A-systems as they are the smallest projects and would generate data faster than other systems.

The authors of this thesis were able to conclude how much time could be saved by moving the design processes into the offer process. However, they were not able to conclude how much longer the offer process will take. It can be established that the offer process will take longer as the workload will increase, but on the other hand, perhaps the process will be more effective since more departments are working cross-functionally. Consequently, it could be argued that the information loss between the offer process and design processes will not have the same effect anymore as information is used shortly after it is gathered. Therefore, the overall performance regarding lead times for a project would most likely decrease. Furthermore, as the focus of this thesis has been to give suggestions on how to improve the total throughput for projects. Future research is needed in order to establish whether the suggestions are adequate or not for JESW.

8 Conclusion

As the purpose of this study is to understand how the flow of projects works today for a company operating in an engineer to order environment and to develop improvements that can increase the total throughput for every type of project. The authors argue that JESW is in need of changing their processes to handle the total lead time for projects better as this is what the customer is exposed to.

By establishing how the processes and supply chain is set up today at JESW, areas for improvements were identified. The main challenges are lack of information, late customer changes, unclear responsibilities, lack of planning, incorrect specification, lack of project prioritization, project driven, lack of feedback, lack of standardization and purchase on preliminary requirements.

The authors of this thesis argue that these problems can be derived from the current structure at JESW and by changing it to a heavyweight matrix structure, several identified problems can be dealt with. By adding a project manager who has the mandate to prioritize, handle the overall project planning, feedback and control through stage gates, it will ensure responsibility of the total throughput for projects.

Furthermore, as the offer process has been integrated with the final project and electrical design process, and the registration process has been extended with the mechanical specification and electrical specification process. It can be concluded that these process changes will support a more cross-functional integration, supported by the matrix structure, which will enhance communication between departments. By doing these process changes, it will remove the pending lead time, from a customer perspective, of average 23,7 days between the sales department and MEK-Design, the average 33,3 days in MEK-Design and the average 22,3 days in EL-design. Which is a total lead time reduction of average 79,3 days per project.

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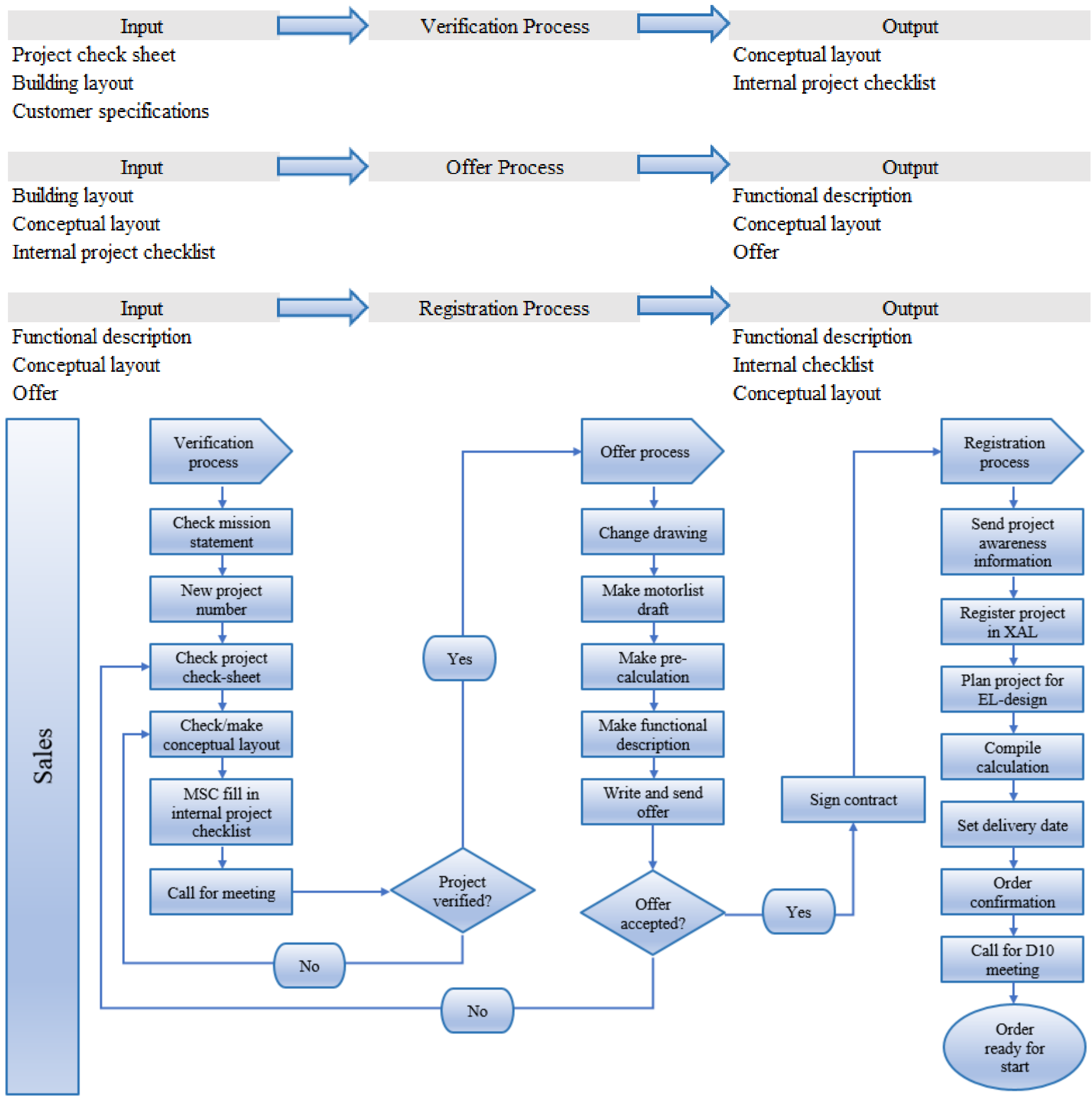
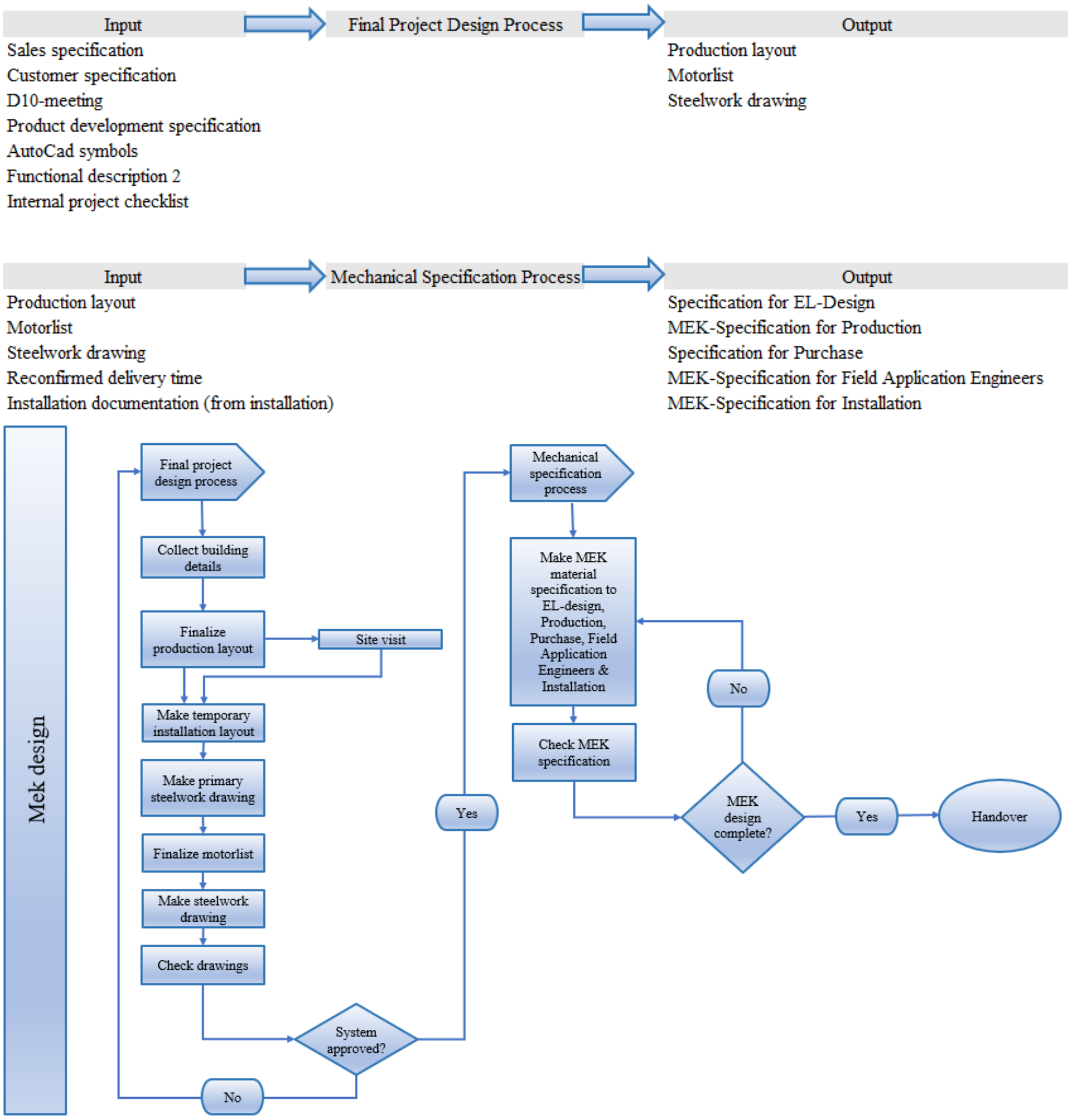
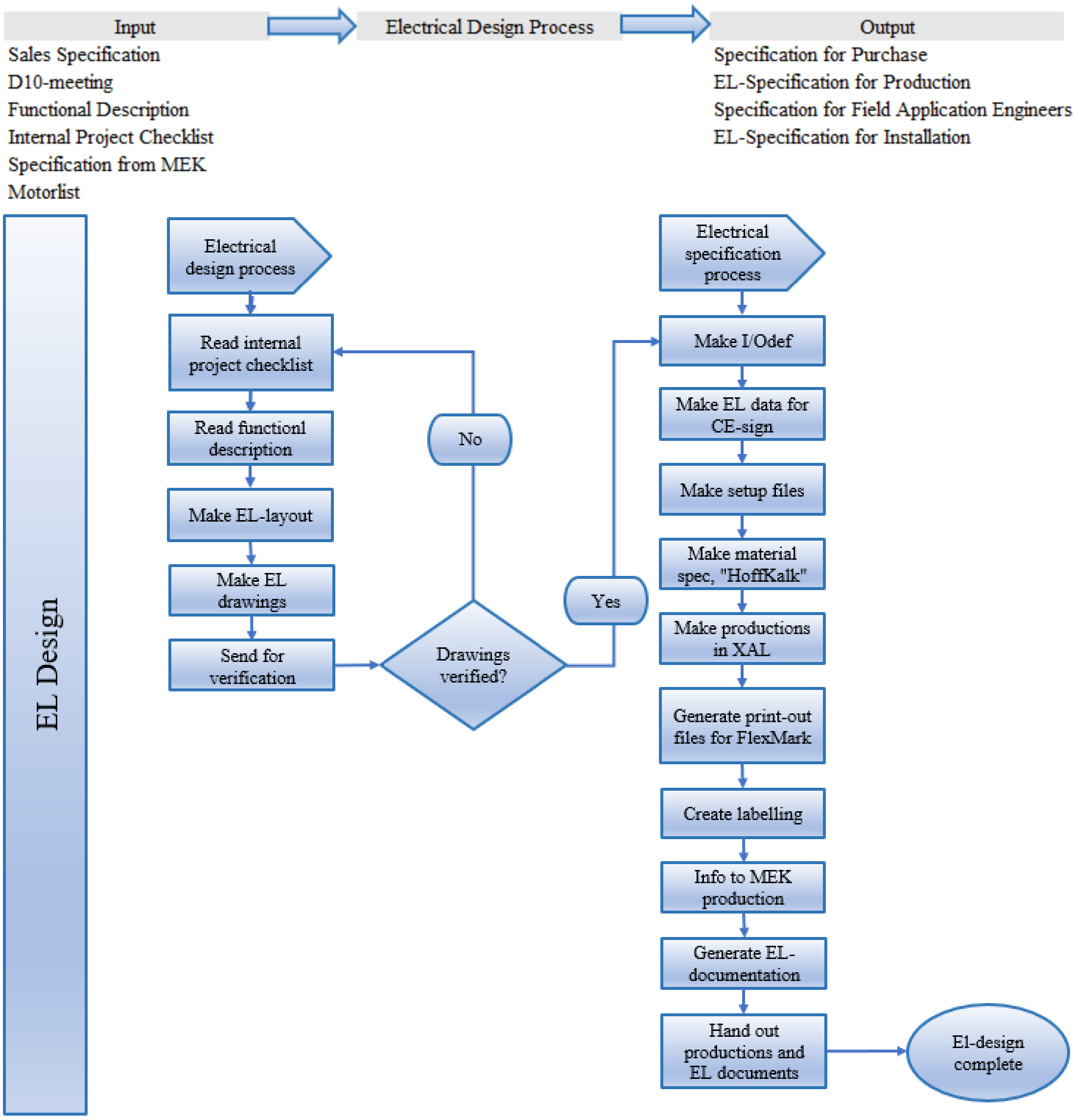
10 Appendix



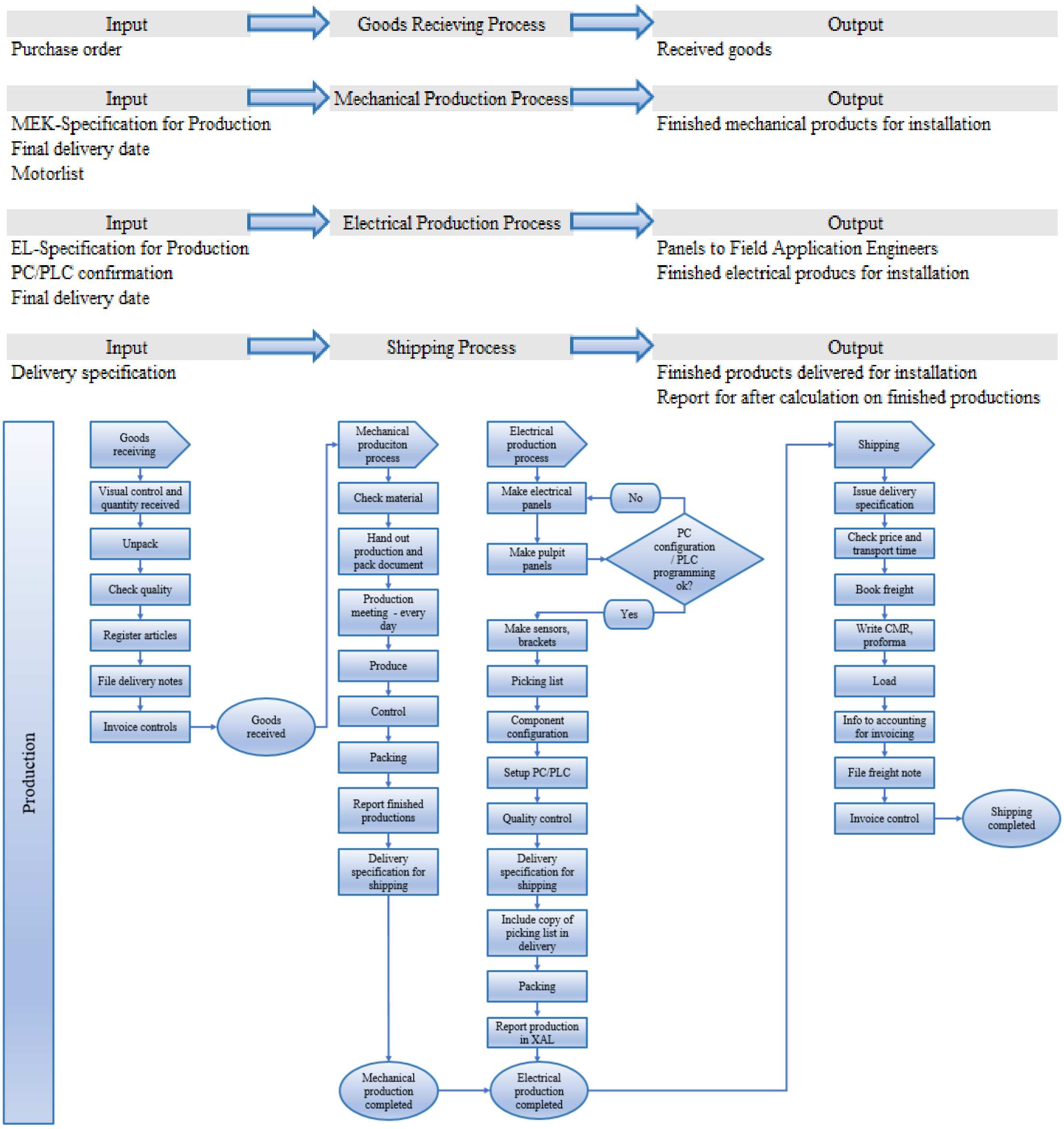
Appendix A - Process map for the sales process with inputs and outputs.



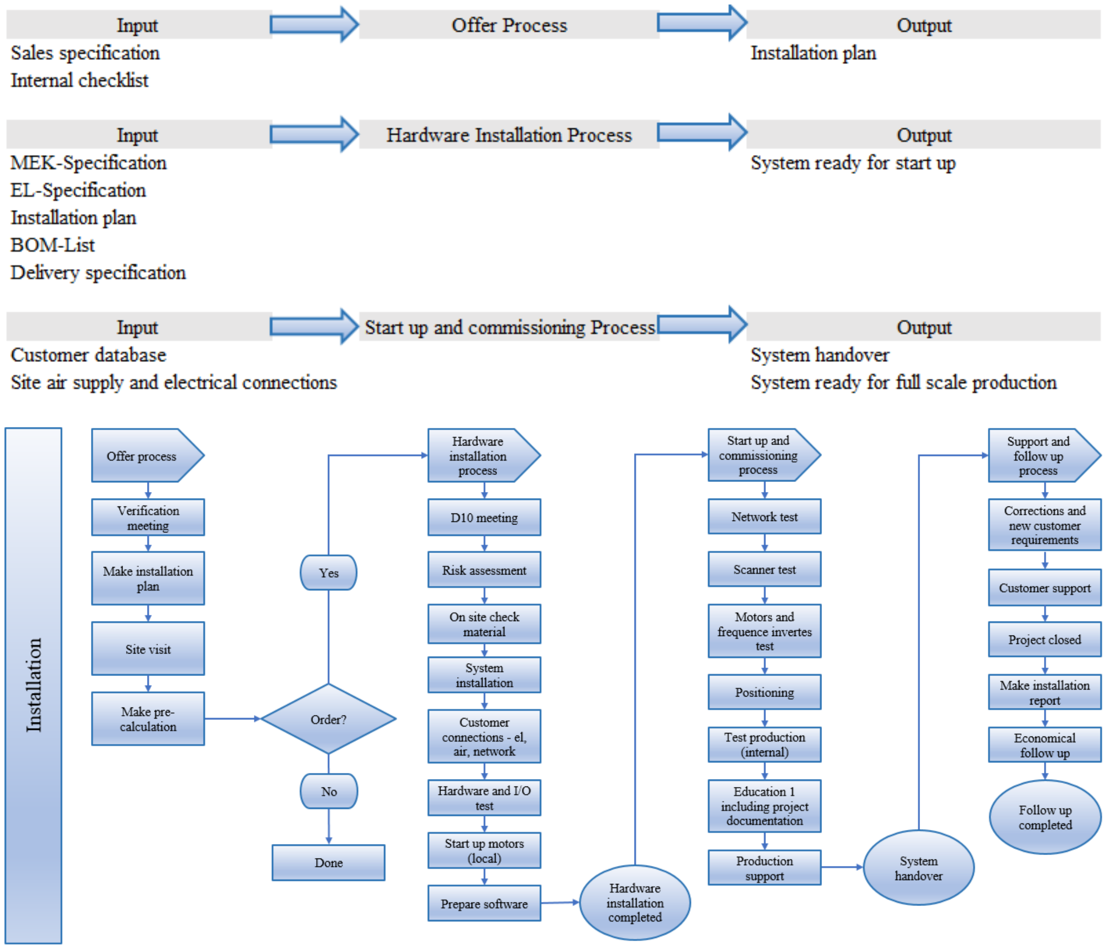
Appendix B - Process map for the mechanical design process with inputs and outputs.



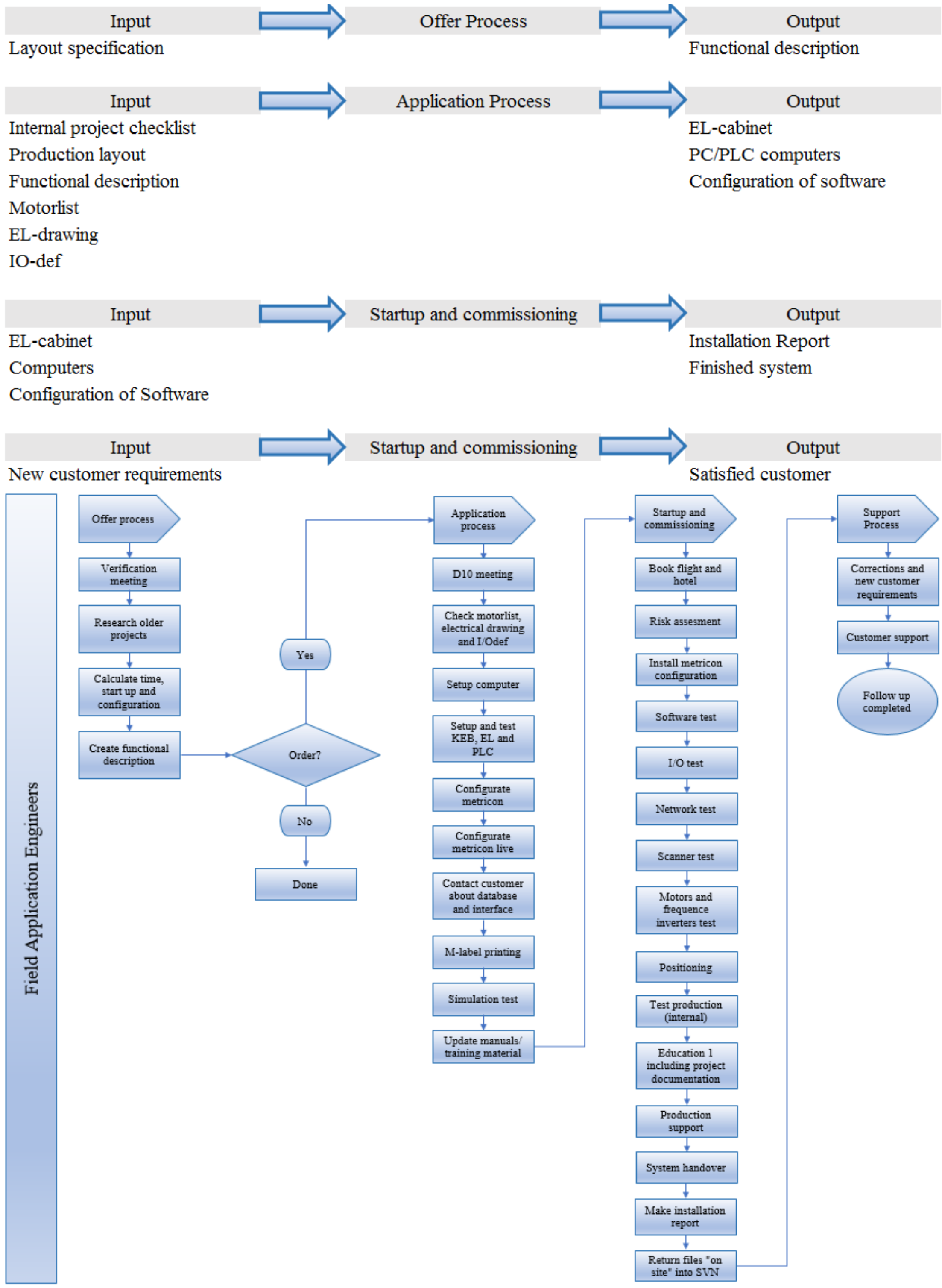
Appendix C - Process map for the electrical design process with inputs and outputs.



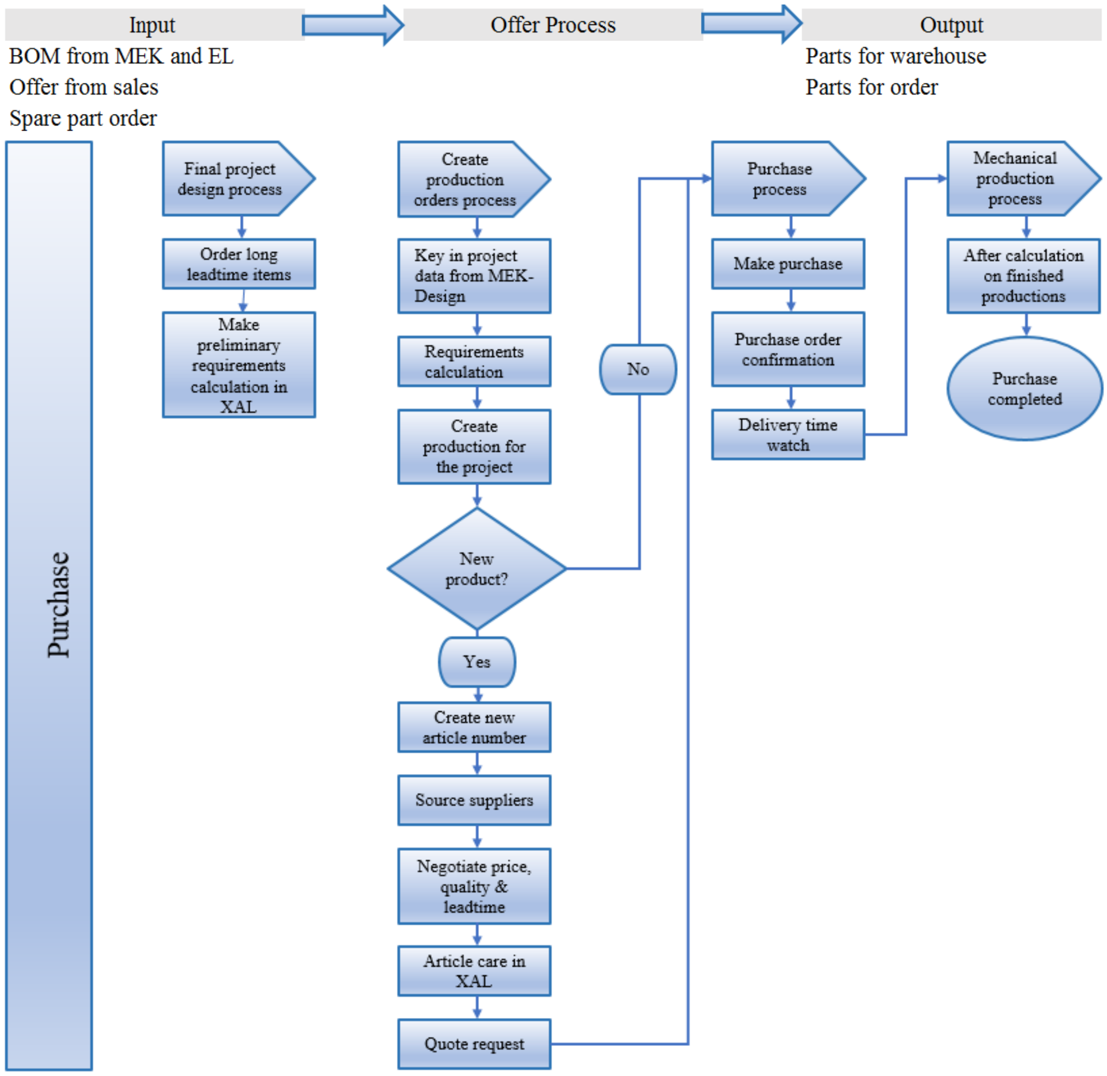
Appendix D - Process map for the production process with inputs and outputs.



Appendix E - Process map for the installation process with inputs and outputs.



Appendix F - Process map for the field application engineers process with inputs and outputs.



Appendix G - Process map for the purchase process with inputs and outputs.