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Purchasing and cost overruns in ETO projects

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Preface

This master thesis has been conducted during the spring 2020 as the final stage of a Master's of Science degree in Logistics at Molde University College and it has been written as a collaboration between the College and Møreforsking Molde AS.

We would first like to thank our supervisor Sergei Teryokhin from Molde University College and co-supervisor Kristina Kjersem from Møreforsking Molde AS for their valuable contribution. Their deep knowledge and professional guidance throughout the process has led to good discussion and valuable insights. The difficult situation with COVID-19 did not stop you, and the confidence you gave us through mails, skype-meetings and written feedback has been incredibly valuable in a challenging process.

Furthermore, we would like to thank the employees at the case company for their willingness to help us by attending interviews and giving us valuable information. We appreciate the opportunity they gave us by participating in the research.

Molde, 02.06.2020
Vetle Terland Nilsen and Kristian Granberg

Abstract

The purpose of this thesis was to see how a shipbuilding company can prevent cost overruns in future projects by improving their purchasing activities. Therefore, this research aims to generate a better understanding of the role purchasing has in projects. Both the literature and our empirical findings reveal that there is a research gap regarding delayed purchasing, and how delayed purchasing affects the total cost of projects.

The main finding in our research is that shipbuilding companies need a better overview on their purchasing costs and that their low-cost supplier strategy may not be the optimal solution. There are many unexpected costs related to the suppliers and one cannot look at the purchasing price isolated, but must include costs as production, outfitting, service, etc. Also, there is no efficient system for evaluation of the suppliers at the end of the project. The practice of evaluation is too person dependent and the production is not enough involved in the process, which gives poor data and does not facilitate improvement in future projects. Furthermore, they experience challenges that arise from a premature agreement with the customer which leads to adjustments and rework later in the process. This complicates the purchasing activities and makes the planning more difficult as components could be delayed. Delayed components affect the whole project since the production needs to reorganize the workers to keep the project on schedule. In this way, they transform delayed purchases into cost overruns. We have also discovered challenges with communication between certain suppliers and case company. After the contract is signed, the suppliers must send a monthly progress report, but too often the purchasing department must use a lot of resources to request the documents. At the same time, there are often delays connected to other important documentation the supplier has to send, which often may stop the progress of the project, again resulting in cost overruns.

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List of Abbreviations

ATO	Assemble-To-Order
CE	Concurrent Engineering
CODP	Customer order decoupling point
ETO	Engineer-To-Order
GA	General Agreement
MTO	Make-To-Order
MTS	Make-To-Stock
OSV	Offshore service vessels
PD	Purchasing Department
PO	Purchasing Order
Production	Production Department
RP	Research problem
RFQ	Request for quotations
Spec	Building Specifications

1.0 Introduction

Norwegian shipyards are building offshore service vessels (OSV's) and other specialized ships as fishing, ferries, and cruise ships (Semini, Brett, et al. 2018). OSV's are developed to support marine operations, often for high-value offshore oil and gas installations. There is no optimal design for these vessels as the scope of use them is varying, making it more challenging and complex to build compared to other transport vessels. OSV's are smaller vessels compared to other cargo ships and operate closer to the shore with shorter trips, but with a higher frequency. Despite the shorter trips, the vessels must be able to deliver regardless of weather conditions, so it is important that they can be maneuvered under harsh conditions and master the sea (Adland, Cariou and Wolff 2019).

Since the cost of labor in Norway is high and working with hull requires a substantial number of working hours, most Norwegian shipbuilding companies have outsourced parts of the building process. For Norwegian shipyards to stay competitive, the steel-related tasks have been moved to Eastern European countries such as Poland, Ukraine, Lithuania, and Romania where the labor cost is relatively lower. Outsourcing steel related work to larger yards gives increased economy of scale, which result in lower total costs for shipyards in Norway (Semini, Brett, et al. 2018). Most Norwegian yards are now focusing on outfitting the hulls with engines, machines, and other advanced technologies as well as commissioning and testing the complete vessel. These tasks require advanced knowledge and expertise in procurement, integration, project management and coordination, which count for 60-80% of the value of the ships (Sriram, Alfnes and Arica 2013). The global competition from low-cost countries has led to a decline in profit margins for most of the Norwegian shipyards (Mellbye, Nellemann and Jakobsen 2016). However, Norwegian shipyards can still compete on this market due to their ability to build tailor-made solutions (Mellbye, Zhovtobryukh, et al. 2015) .

The Norwegian shipbuilding industry constructs tailor-made solutions to meet customers' needs and each project is therefore different. From the literature perspective these are characterized as engineer to order (ETO), meaning that the customer is involved from the design stage all the way to testing the final product. The production approach can be characterized by low production volume, high customization, and the decoupling point is located at the design stage (Gosling and M.Naim 2009, Olhager 2010).

According to Wikner and Backstrand (2018), customization can be described from two perspectives, *a process perspective* and *a content perspective. A process perspective* is about how customized products are developed, while *content perspective* is more about different aspects of the actual customization. From a supply chain perspective, customization is when the customer has a specific set of requirements that need to be fulfilled (Wikner and Backstrand 2018). The customization in the shipbuilding industry is high, and every component purchased must be customized to fit each specific vessel. These detailed specifications and new configurations at the design stage complicate the purchasing process (McGovern, Hicks and Earl 1999) making it more challenging both for the purchasing department (PD) and for their suppliers.

Norwegian Shipyards experience challenges of controlling their cost, and often experiencing cost-overruns in their projects. Further, cost overruns are normal due to unexpected events, and it is difficult to control and prevent (Olawale and Sun 2010). The shipbuilding industry operates in a challenging environment with consistent uncertainty and a high level of specification from their customers. This is something that needs to be considered when investigating the cost overruns. In this environment everything needs to be planned down to the last detail, and their purchases must harmonize with this plan. The level of specifications is especially challenging for the PD, the slightest deviation on these specifications or from the plan could have a significant negative impact on the overall performance of the project.

Purchasing has received increasing attention in the supply chain because it plays a connecting role between external suppliers and internal organizations to create and deliver value to its customers (Chen, Paulraj and Lado 2004). Further, Held (2010) describes the importance of developing competence in the field of supplier integration since 60-80 percent value-added in shipbuilding projects are procured from external suppliers. According to Rahman, et al.(2017) shortage and delays in materials supply is an important factor for delayss in the construction project. Poor materials procurement and inventory management were found to be the most significant reason for delays. There are several suppliers involved when a yard is building vessels varying from standard products suppliers to highly complex system suppliers. Additionally, there are nearly no long-term contractual agreements between suppliers and shipbuilding companies. For a long time, the

purchasing strategy was to encourage strong competition between different suppliers and using short-term contracts (Held 2010).

The ETO environment is categorized by high complexity and long lead time, and the continuous dialogue with the customer during the project results in change in the original design. To solve such flexibility while reducing the lead time, ETO companies apply several strategies like, supply chain integration, information systems, and concurrent engineering, but none of these have solved all the problems (Strandhagen, et al. 2018). Continuous changes by the customer, lead to adjustments for PD, which complicates their tasks (Vaagen, Kaut and Wallace 2017). However, both the literature and our empirical findings reveal that there is a research gap regarding purchasing, and how purchasing affect the total cost of projects. Therefore, in this thesis the purpose is to better understand how one can prevent cost overruns in ETO projects by improving the purchasing activities. Since the suppliers of components stand for most of the value added in constructing a vessels, it is important to identify the potential savings the purchasing has on the total costs in ETO projects.

1.1 Relevance of the study

Various research and literature has been written about ETO-projects and shipbuilding industry. Most of the available research that focuses on purchasing, focuses on how early involvement of purchasing reduces costs. Furthermore, the literature also suggests the industry to procure more standardized components to reduce costs and reduce lead time. Even though early involvement has been a primary focus in the literature, there are still problems with information-sharing between project participants leading to purchasers making decisions without enough information. The most important factors to achieve a successful project are keeping the schedule, and delivering the project on time. This applies especially in the shipbuilding industry, and most of them are therefore practicing time-buffers when planning their purchases. As stated by Yeo and Ning (2006) time buffers are frequently used in projects to protect the agreed schedule and prevent delays. Another important factor in this industry is to avoid cost overruns. The shipbuilding industry operates under small margins and these cost overruns could result in deficits in their projects. The sources for cost overruns vary, but since 60 – 80 percent of the value added in shipbuilding projects are purchased from external suppliers, and the customized purchasing stands for a high percentage of the total cost (Held 2010), in view of the

findings, delayed purchasing are worth investigating. Furthermore, findings from the literature presents poor material purchasing as one of the most significant reasons for delays (Rahman, et al. 2017). Tailor-made solutions are the way Norwegian shipyards can compete, therefore it is important for the shipyards to focus on other factors to save costs. How the purchasing contributes to cost overruns is not well documented neither in theory nor in practice. As other similar companies, Company X lacks an overview over these numbers and have no mechanism helping them to avoid these significant cost overruns. One source for these cost overruns could be delayed purchasing, but this subject has not been given enough attention in the research field. Based on previous research within this field and available literature, there is a research gap regarding how delayed procurement affects projects and the total costs of projects. Along with results from a previous thesis (Magnussen and Aarra 2019), our findings show the lack of both data on the actual cost of delayed purchasing, and a mechanism to help improve this issue.

For our thesis, we have performed a case study focusing on sources to delayed or improper purchasing, and how this affect cost overruns. The starting point of this research is based on a master's thesis written in 2019 that made interesting findings about planning of purchasing activities. A secondary gap in the same thesis was about delayed purchasing affecting the results in other departments. We consider this topic highly relevant because of the role purchasers have during a project, and the potential of saving cost. To our knowledge, there is no previous research documenting how delayed purchasing affects the cost overruns. The purpose of this research is to analyze purchasing activities in ETO environment, and how ETO-projects can reduce cost overruns by addressing delays in their purchasing activities.

1.2 Research problem

The purpose for this thesis is to investigate how improvements in purchasing activities can be used to prevent cost overruns. This thesis will focus mainly on the PD and investigate how delayed or improper purchasing lead to cost overruns. This has given us the following research problem (RP):

RP: How can ETO projects avoid cost overruns by improving their purchasing activities?

To further help the RP, we had to develop an understanding about the environment in which a shipbuilding company operates. ETO projects differ from other types of projects by being more complex, limited standardization and a higher product specification from the customer. Our ambition is therefore to discover why these projects often are experiencing challenges with cost overruns. This has given us the following RQ1:

RQ 1: What are the major reasons for cost overruns in ETO projects?

As earlier described, we have not discovered any research related to how delayed purchasing affects the cost overruns nor delayed purchasing in ETO projects. Despite this, we believe that a better understanding regarding delayed purchasing and the main reasons why this is happening could help Company X improve their purchasing activities and thereby reduce their cost overruns. Based on this reasoning, we have developed the following RQ2:

RQ 2: What are the main reasons for delayed purchasing in ETO projects?

At the last RQ we have the objective to further investigate different solutions to improve the purchasing activities. This is because 60 – 80 percent of the value added in shipbuilding projects are purchased from external suppliers, and that the purchasing stands for a high percentage of the total cost. Therefore, the following RQ 3 is developed:

RQ 3: What solutions can be applied to improve the purchasing activities?

The RP and all three RQs were developed based on empirical findings as well as a relevant literature. Our empirical data show that Company X lack an overview over supplier related costs and have challenges with evaluation of the suppliers. The practice is too person dependent and the PD are receiving poor data which makes it difficult to improve the purchasing activities in the future projects. The production is not properly involved in the selection and evaluation of the suppliers and their opinion does not influence the outcome. As a result, the production department stopped reporting the discrepancies and the PD are therefore missing valuable information and knowledge.
Today, Company X is entering too quickly into agreement with their customer. A result of a premature agreement is that adjustments and rework must be done later in the project, which complicates the purchasing process, and makes the planning of future purchasing

activities quite difficult. This results in delayed components which affect the whole project, mainly because the production must reorganize the workers to avoid delays. In many cases, the communication between certain suppliers and Company X is poor during the project. After the contract is signed, the suppliers must send a monthly progress report, but too often the PD must use a lot of resources to request the document. These are some of the challenge that are important to explore in this research to better understand how to prevent cost overruns in future projects.

1.3 Structure of the thesis

This master thesis is divided into six main chapters, with subsequent sub-chapters. The first chapter is the introduction where the background, relevance and motivation for this thesis is described. Chapter 1 presented a short description of our choice of research problem and research questions. The second chapter we present and justify the choice of methodology in the thesis. The third chapter is the theoretical framework for our thesis and is divided into three subsections, ETO, Project planning, and Purchasing in ETO. The fourth chapter is the case description where we have a short description of the case company, before we present the findings from our data collection process. These findings are separated into two main chapters: project planning and purchasing. The last part is a presentation of the challenges the case company experience. The fifth chapter is a discussion and analysis of our findings in regards to the presented theories. Chapter 6 is the last chapter where we make a conclusion and propose an answer to the research problem, before we present the limitation and encourage further research.

2.0 Methodology

In this section, we present and justify the methodology we have used in our master thesis. We have concluded that a combination of exploratory and descriptive is an appropriate type of research for our study. We have conducted a case study and presented the reasoning for a single-case design with an embedded approach used in this thesis. Last, we discuss the qualitative approach and describe how we have conducted the data collection process.

2.1 Research design

A research design is a link between the collected data and the research question. It is a logical plan for how the research is conducted and the main objective for the research design is to make sure that the evidence addresses the research question. Every empirical study has either an implicit or explicit research design (Yin 2018)

The research question defines the design of research methods. These can be divided into exploratory, descriptive or explanatory. Exploratory research has the aim to better understand different topics and problems, while explanatory research aims to understand the relationship between different variables and descriptive research focuses on a specific event, person or situation (Yin 2018).

We have used a combination of exploratory and descriptive approach in our thesis. Since both RQ 1 and RQ 2 have the purpose of better understanding one specific industry, we consider them to be exploratory. RQ 3 on the other hand, has the purpose of investigating which solutions that could improve the purchasing activities in one specific situation and is therefore considered to be descriptive.

2.2 Case study

This thesis is conducted by using a case study approach. According to Yin (2003), this is the best option when the objective is to better understand the "contextual conditions – believing that they might be highly pertinent to your phenomenon of study". Further, it is suggested that forms of questions in terms of "who", "what", "where", "how" and "why" are related to which research strategy that should be used and "how" and "why" are highlighted as typical case studies.

Due to ETO characteristics, we chose case study as a main approach to answer our research questions (Yin 2018). Limitations imposed by the corona virus led to a single case study design in a shipbuilding company located in Norway. Figure 1 below illustrates the difference between single vs multiple-sourcing and holistic vs embedded case research (Yin 2018). Further, we can either have a holistic or embedded approach. In a holistic approach, the analysis is based on conversations with only one department while an embedded approach is based on the analysis of conversations with more than one department. We chose an embedded approach by interviewing people from both the purchasing, planning and production departments. This research is placed in the left bottom corner.

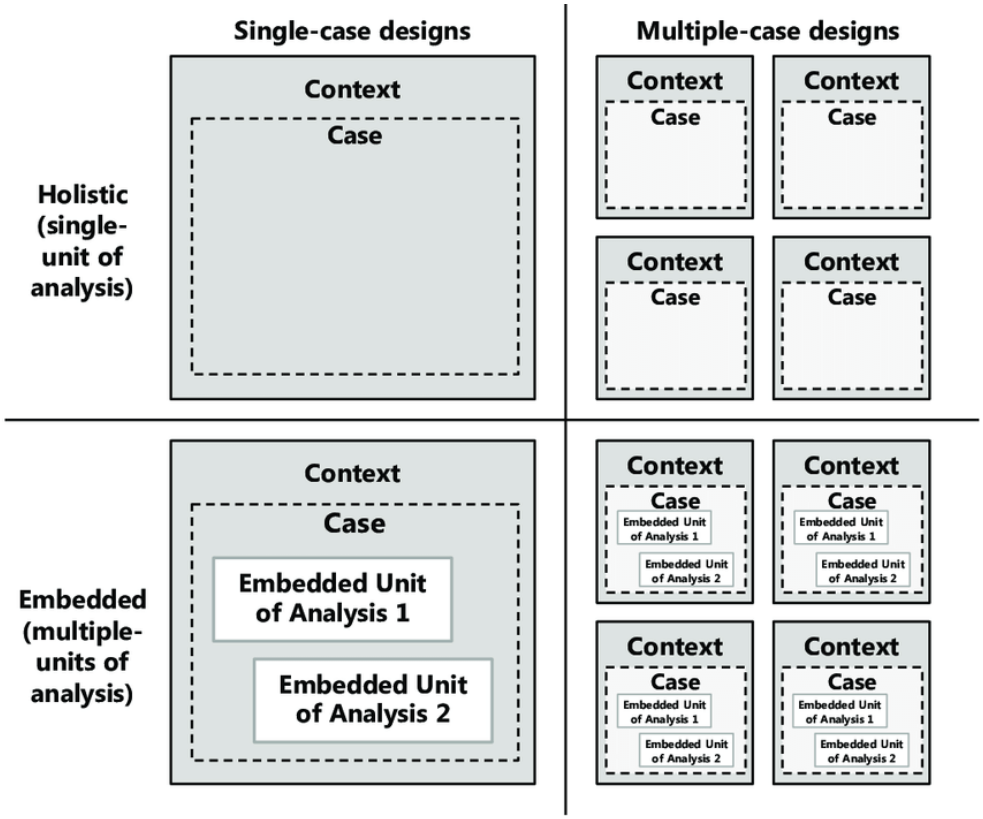

Figure 1 Types of Case Studies (Yin 2018)

2.3 Data collection

Research methodologies can be classified according to the type of data used, and the type of analysis performed on the data. Empirical data represents information collected from the real world and it is often gathered directly via surveys and interviews, as well as indirectly

via archives, other researches. To collect and analyze empirical data, we selected a case study approach where the data are qualitative in nature as it is explained in paragraphs 2.3.1 (Ellram 1996). This research is based on four different interviews from three different departments. The interviews is analyzed based on a qualitative approach, and how these interviews are analyzed is further explained in paragraphs 2.4.

2.3.1 Qualitative method

There are two different approaches for collecting the data, quantitative and qualitative. Quantitative data can be connected to numeric values, while qualitative data is in the form of other information, often text. The collection of qualitative data is also different from quantitative data. With qualitative data it is recommended to have a flexible approach and open interaction is the best option if the information is gathered through communication. Finally, qualitative data is recommended when the purpose is to analytically describe a situation or better understand relationships (Yin 2018). Since we identified a lack of research focusing on how purchasing affect cost overruns, we had to obtain insight and better understand the relationship between planning, PD and production in Company X. To better understand the preferences the workers had about the research topic, qualitative approach seemed the most suitable solution for data collection in this case.

Our research questions are typical for qualitative research with the usage of open words like “how”, “why” and “which”. Further, we are not intending to build any cause-effect models which characterizes the quantitative approach. Instead, we have a flexible approach with open interaction.

2.3.2 Sources of information

There are two types of data that can be collected, these are primary and secondary data. Primary data is new information collected directly by the researches. Collecting primary data is a time-consuming process while secondary data are collected from archives, other researches, and identified gaps in the research field, and are used to get better understanding about the research topic. Primary data have a specific purpose: to discover the research problem at hand (Ghauri, Grønhaug and Strange 2020).

Yin (2018) identifies six sources that can be used when collecting empirical data, and these are; *documentation, archival records, interviews, direct observation, participant-*

observation, and physical artifacts. To conduct a good case study, Yin (2018) recommends using as many sources as possible. Next, we describe each source of information that has been used in this thesis.

Documentation can be letters, emails, agendas, administrative documents, progress reports, formal studies, or news clipping. Documentation is not always precise but can be useful. In a case study, the use of documentation is important to corroborate and argument evidence from other sources. Documentation can also be used to verify the correct spellings, titles, and names of people that have been mentioned in an interview. Also, using documentation may help to find new questions (Yin 2018). We have communicated and gathered additional information through emails that could fill the voids we had after the interviews were done. This has helped us get a better understanding of the company and their business.

Interviews are one of the most important tools to conduct information for a case study according to Yin (2018). Interviews are guided conversations and are used by researchers to retrieve information from several people. The questions in any interview must be developed in an unbiased manner. Further, the questions must be open friendly and non-threatening. Well informed interviews can provide important insights (Yin 2018). There are three types of interviews, and the method of collecting information through interviews can be used by *structured interviews, semi-structured, and unstructured interviews. Structured interviews* involve predetermined questions of highly standardized techniques of recording. The interviewer in a structured interview follows a rigid procedure and in a prescribed form and order. *Unstructured interviews* is the opposite, and can be characterized by flexibility. This interview form does not follow any predetermined questions and standardized techniques of recording information. These types of interviews give the interviewer larger freedom to ask supplementary questions if needed. The downside with *unstructured interview*s is the lack of comparability from one interview to another interview (Kothari 2004). The interviews in this thesis were based on a combination of structured and unstructured interviews, where an interview guide was followed. The questions used during those interviews are attached in the appendix. When necessary, follow-up questions were asked, but these are not added to the appendix. Lastly, not all questions were asked due to time limits. Therefore, we prioritized to ask the most important questions first.

The main informational source of the thesis is four interviews, where two respondents work in the PD, one respondent works in the planning department, and one respondent worked in the production department. The respondents were selected based on key informant approach when respondents could give us the best and most relevant information regarding our research questions. The decision was made in collaboration with our supervisors and people at the shipyard. The first interview was done with a person form the planning department. At this interview, we mapped information about the initial stage in a project and challenges related to planning an ETO-project. The respondent agreed that the interview could be audio recorded, and was used it to transcribe the interview. The last three interviews were conducted through skype due to the corona pandemic. All respondents agreed that we could audio record the interview.

Direct observations are the last sources of information. This tool is used to get a better understanding of how thing takes place, and observe the case area. It is used to provide additional information about the topic. Direct observations can give a new understanding of and dimensions. We did not get the opportunity to follow a purchaser in his/her work or otherwise observe how they actually work during a project. Instead, during our interviews the respondents showed us how they are using different tools to plan their purchases and projects. It gave us a better understanding of how the process of building a vessel takes form and how a project develops.

2.4 Data analysis

For the data form the interviews to be useful, it needed to be analyzed and understood. The first interview was with a project planner that described how a project is developed. The project planner helped us understand the current practice in the organization, and he especially explained his role and how the PD is involved in the process. The second and third interviews were with employees working at the PD. These interviews gave us a better understanding of the procurement process and the challenges related to our topics. The last interview was with an employee working at the production department. This manager explained to us their role in a project, described some of the challenges related to delayed purchasing and the choice of suppliers as well as their effect on the production activities.

The interviews were audio-recorded, and before we began analyzing our data, we transcribed the interviews. After the transcription, we compared the interviews, identified patterns and different opinions about the challenges associated with planning the purchasing activities, and how delayed purchasing affects projects. Thereafter, we highlighted our findings and used the information to understand the situation in the company before starting the analysis, conducted in Chapter 5.

2.5 Quality of the research

The research design is meant to represent a logical set of statements, therefore, the quality of the design must be matched to certain logical tests. For good research, four tests need to be required, construct validity, internal validity, external validity, and reliability. Since we have a combination of descriptive and exploratory studies, we can exclude internal validity for this research. Internal validity concern only explanatory and casual case studies. Therefore, it will not be suitable to use internal validity for this case study, since this case study is exploratory and descriptive (Yin, 2018).

2.5.1 Construct Validity

According to Yin (2018), construct validity is about identifying correct operational measures for the concept being studied. A challenge with construct validity is if the researcher is not subjective and is trying to prove one's preconceived ideas, instead of taking an objective approach. There are three tactics used to increase construct validity when doing a case study, the first two are relevant when collecting data and the third is about reporting. The first two are *multiple sources of evidence* and *establish a chain of evidence*, these are tactics to makes sure the findings are more likely to be correct. The third tactic is to *have the draft case study report reviewed by key informants* (Yin 2018).

During the period of conducting research, we have been communicating and sharing information with our supervisor and co-supervisor. This has been important for us to make sure that they are informed about the development and progress of data collection process so that they could advice and provide us feedback. We have signed a confidentiality agreement, therefore, there are restrictions on who can review the data collection. To secure that there were no misunderstandings between us and the company during our interviews and communication, we have asked our key informants some control questions

and gave them the opportunity to read our thesis to review if the information given is correct.

2.5.2 External validity

External validity is our second test and the objective of this test is to investigate if the research is accurate and if a study's findings could be generalizable beyond the instant study. For a case study, the inability to generalize is considered to be the most common point of criticism. This can be avoided by recreating the case study and by verifying the patterns. Since we have a single case study it is suggested that we generalize our findings to theory instead of other case studies, compared to a multiple case study was you could generalize the findings more towards the case studies (Yin, 2018).

The external validity could be better since it is difficult to generalize our findings based on a single case study. On the other hand, the empirical findings discovered in this research could be generalized to literature. Both the literature presented in this research and other literature related to the topic has been carefully considered and reviewed. We have also used literature and earlier research as a guidance for the interviews to facilitate for generalizability.

2.5.3 Reliability

Here, the objective is to investigate and make sure that the findings discovered, and the conclusion made in the case study would have been the same if the case was carried out by another researcher at a later time. The goal of this step is to minimize errors and partiality in a study. The main objective is the need to document the procedures used in your case study if not, the case could never be repeated, even if it is your own work (Yin 2018). Our main objective in this thesis has been to investigate the planning of purchasing activities in ETO projects and not to mitigate bias and ensure reliability. Therefore, we have formulated semi-structured- and follow-up questions to get as much information as possible. If another researcher carried out this research at a later time, we expect that the information gathered would be somehow different. Despite this, we believe that the information gathered would have the same main findings and point in the same direction.

3.0 Theoretical framework

In this chapter, we focus on relevant literature and theory related to our research topic. The chapter is divided into three main sections: ETO, project planning and purchasing in ETO. First, we introduce the production approach ETO. The next part gives an understanding of current practice in project planning, while the last part presents common purchasing strategy and theory. The theoretical framework is focusing on purchasing in ETO projects, and tools to prevent poor planning, delays and cost overruns.

3.1 Customer order decoupling point (CODP)

The customer order decoupling point (CODP) is a stockholding point, and is used to act against the variability in demand. A forecast is used upstream from the CODP and end customer pulls downstream from CODP (Gosling and M.Naim 2009).

CODP is defined as the point in the value chain the customers are linked up to the product and is used to differentiate market interaction strategies in manufacturing. There are four types of CODP: make-to-stock (MTS), Assemble-to-order (ATO), make-to-order (MTO), and engineer-to-order (ETO) (Olhager 2010). ETO strategy is customer-driven, the customers are involved in the whole process, from design to the production (Powell, et al. 2014, Semini, Haartveit, et al. 2014)

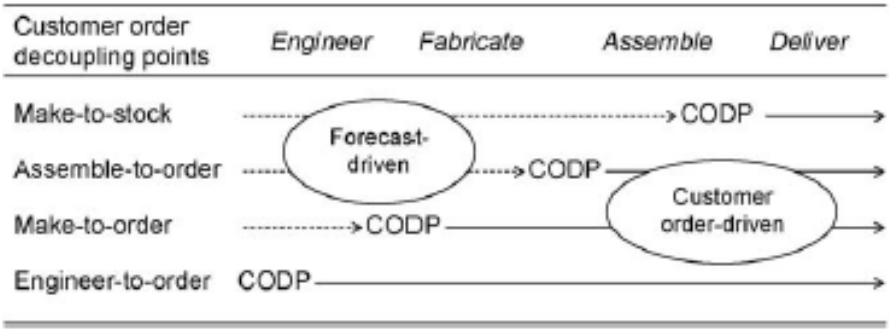

Figure 2 Different customer order decoupling points (Olhager 2010)

MTS is a production strategy that requires accurate forecasting. The CODP is located at the delivery phase, MTS produces a large number of goods to meet future customer demand. This approach is focusing on productivity and cost reduction. ATO is a

production strategy where products are assembled when a customer is ordering a product. Both MTS and ATO are forecast driven. MTO is a customer order-driven production strategy where the customer places an order before the product is fabricated. The customer can choose between existing designs (Olhager 2010).

3.2 Engineer to order (ETO) supply chain

ETO is usually associated with large and complex customized products. Product proliferation that meets customer demand is growing, so ETO has become more important as the demand for highly customized products across various industries has increased (Gosling and M.Naim 2009) (Powell, et al. 2014). ETO can be defined as follows: "*ETO supply chain is a supply chain where the decoupling point is located in the design stage*" (Gosling and M.Naim 2009, 744). Each ETO product becomes a project, which implies that each ETO company uses project management strategies to deliver each specific product (Kjersem, Jünge and Emblemsvåg 2017).

An ETO company can either use an existing design or develop an entirely new design to meet customers' demands, but new designs make the planning and control of a project more difficult because there are many uncertainties involved (Powell, et al. 2014). Further, procurement and competitive bidding is a bottleneck at the design stage because the PD cannot start their process before the design phase is completed (Gosling and Naim 2009). Last, a solution to reduce the uncertainties of procurement is to standardize parts of a project. More standardization will reduce cost and lead-time (Hicks, McGovern, and Earl 2000).

ETO differ from other manufacturing processes through higher customer involvement during the whole production process. The involvement takes place at an early stage, already at the design phase of a product. Due to limited standardization it is difficult for companies to forecast, the sales and specification from customers are unknown before the process starts (Sriram, Alfnes and Arica 2013). ETO companies distinguish from other companies with their responsibility for all parts of a project, from product development, engineering, and procurement. ETO companies are also responsible for the assembling and manufacturing of a product. As a result, the lead-time is long. The complexity in the ETO business environment has led to several strategies and approaches that have been

introduced to reduce the lead time and project time (e.g., supply chain integration, information systems, and concurrent engineering, etc. (Strandhagen, et al. 2018)

In ETO projects, there are often difficulties related to achieving on-time delivery, one of the main reasons being inaccurate coordination between engineering, purchasing and production. These difficulties are greater when coordinating multiple organizations and not that significant when coordinating a single organization. Outsourcing, and especially the outsourcing of production, increases the gap between the production and engineering, often leading to more delays. Further, missing design and poor quality of documentation are a challenge in ETO projects repeatedly delaying the procurement process. So are changes in technical requirements from the customer after the production has started (Oluyisola, Salmi and Strandhagen 2018)

A survey conducted by (Assaf and Al-Hejji 2006) shows that change in orders by the customer during construction and ineffective planning is a factor that causes delays in projects. Further, their survey discovered that 70 percent of projects experienced time overrun, and changes in the order was the most common cause of delays. On-time delivery is a great indicator to reduce costs. Further, missing designs and poor quality of documentation results in delayed procurement (Oluyisola, Salmi and Strandhagen 2018).

Elfving, Tommelein, and Ballard (2005) defines lead-time as "*the anticipated, elapsed time to complete a process*." Long lead-time has many consequences and influence different aspects of the business. One consequence is that the design department have to make decisions at an earlier point, which could result in misunderstandings and incorrect assumtions. As a result, one can experience suboptimal solutions causing further delays. Most of the lead-time for a construction firm consists of waiting on suppliers. While waiting for delivery, the stakeholders are continuously under pressure by the workload caused by the large portion of documentation. The duration of a project is often determined by the lead time on product delivery. Figure 3 illustrates a typical lifecycle of an ETO project where changes are set as the rule and not an exception. Some causes are adjustment of design, omission in contracts, and change in available materials (Elfving, Tommelein and Ballard 2005).

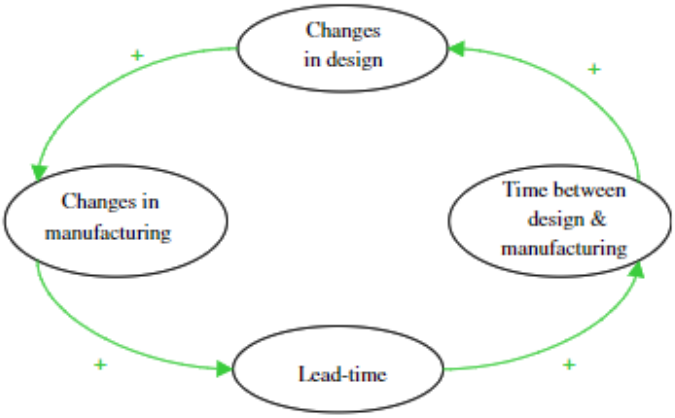

Figure 3 Cycle of ETO projects (Elfving, Tommelein, and Ballard 2005)

Elfving, Tommelein, and Ballard (2005) present three different strategies that can be applied to reduce lead-times, *overlapping, parallel execution and reduction of tasks*. With overlapping, several tasks work simultaneously. Moreover, to start downstream activities before upstream activities are completed, the upstream activities can be performed in chunks, or information can be released in sub-units to downstream activities, this results in reduced overall lead time. Parallel execution is a more extreme form of overlapping, where links between tasks are removed. It is difficult to implement this strategy because the working process needs change. However, to reduce lead times, reduction of task might be the best opportunity. It requires efficient communication between the task members. Using a combination of all these three is also possible according to Elfving, Tommelein, and Ballard (2005).

Competition from low cost countries has been challenging for Norwegian shipyards, and delivering a project within schedule is an important factor for a successful project (Pinha and Ahluwalia 2019). Ways to reduce project lead time is therefore an important step for the industry in Norway. Several methods have been used to reduce project lead time, like parallel planning and fast tracking. But the most effective method is concurrent engineering, which has several successful stories in the manufacturing industry, i.e. reduction in time to market by 30-60% (Ahmad, et al. 2016, Zidane, et al. 2015) Concurrent engineering is further presented in the next chapter

3.3 Concurrent engineering (CE)

Delays are a common phenomenon in construction industries due to various uncertainties, and advanced technologies have not solved these issues yet (Zidane, et al. 2015). Figure 4 illustrates the advantages of using CE instead of sequential approach, where each step is completed before next step begins. CE will reduce the total lead time and share concurrently the information. In sequential development the information flows one direction, while in CE it is bidirectional. Decisions are as a result based on information downstream as well as upstream (Pennell and Winner 1989).

CE is a concept that has evolved because of increased pressure on manufacturers to be more competitive and responsive to change from customers and markets. Further, improved organizational communication will have a significant impact on the effectiveness of CE (Anumba and Evbuomwan 1997). CE is defined as an *"Attempt to optimize the design of project and its construction process to achieve reduced lead times, and improved quality and cost integration of design, fabrication, construction and erection activities and by maximizing concurrency and collaboration in working practices"* (Ahmad, et al. 2016, 448). The main objective for a concurrent building process is to make a system for the project management that lays the foundation for successful completion of the project by taking advantage of possible opportunities, and at the same time avoid constraints (Ahmad, et al. 2016).

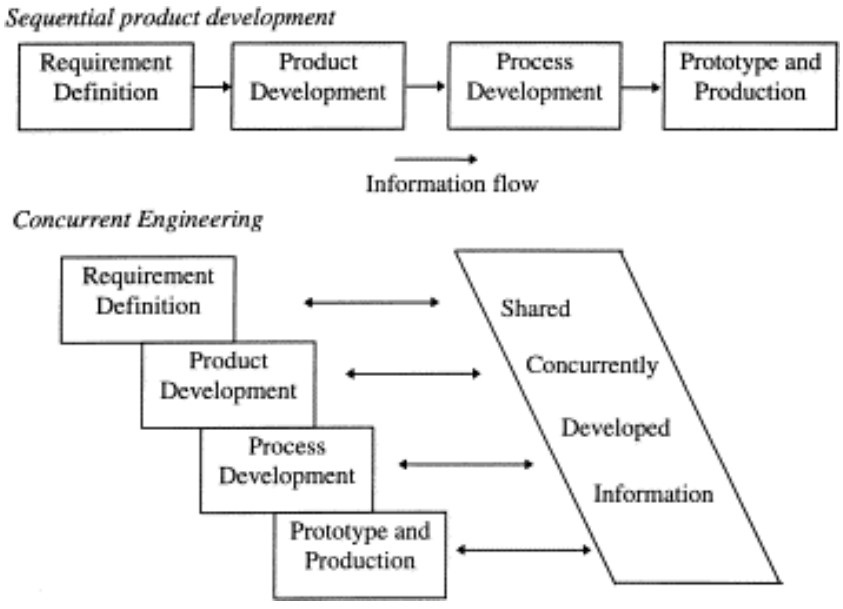

Figure 4 Concurrent engineering practices and prospects (Pennell and Winner 1989)

CE implies two main principles, integration and concurrency. Integration is important considering three aspects, the process, and content of information, between different phases of a project and between all technologies and tools used in the product development process. Concurrency, on the other hand, is more related to how the task is scheduled and the connections between different players in the product development process (Anumba and Kamara 2012). According to (Morris and Pinto 2005, 455) *the core ingredient of successful concurrent engineering is the development and effective management of organizational interfaces.* Further, it is suggested that human influence makes a significant impact to succeed with CE, therefore, the development of a collaborative culture and organizational power-sharing are especially important (Morris and Pinto 2005).

For construction organizations, the purchasing activities have become more significant over the last years. Considering the current market, it is more important to improve productivity and maintain high quality. To improve productivity there must be a holistic approach to reviewing factors that impact the construction industry. Further, keeping a high quality of the materials and components delivered from suppliers facilitates the high quality of the final construction product. In the construction industry, it is important to have a collaborative relationship during the purchasing process. This especially applies to large and complex projects (Janipha, Ahmad and Ismail 2015). A fragmented approach of the purchasing process will negatively affect project effectiveness, therefore, *integration, coordination, and communication* both internally and with the suppliers are highlighted as important in the construction industry (Love, Gunasekaran and Li 1998).

In this chapter we have presented relevant literature concerning CE, and since the customers are involved through the whole project, sequential product development is not appropriate for ETO projects. To share information bidirectional across departments Company X is using CE. The departments can therefore use updated information to make correct decisions, and PD can share information about changes made by the customer with the suppliers and inversely. Since different departments interact and are involved throughout a project, it is important for PD to have a clear understanding of the project. A project manager therefore need to create a proper plan. In the next paragraph we present relevant literature and theory related to project planning.

3.4 Project planning

Projects in the shipbuilding industry are characterized by complexity and many different players. These projects are often defined as turnkey projects. At a turnkey project, the supplier has all the responsibilities, including finding appropriate sub-suppliers (Ahola, et al. 2008). For many different reasons, projects are vulnerable to changes and uncertainty, this can result in both delays and cost overruns. Some of the most common factors are unexpected activities that were not identified before the project started, activities that go beyond the planned schedule, activities that must be redone, lack of the right resources and delayed deliveries (Creemers, Reyck and Leus 2015). Cost overruns can be defined as: *"The amount of which actual cost exceeds estimated cost, with cost measured in the local currency, constant prices and against a consistent baseline"* (Flyvbjerg, et al. 2018, 175)

To keep deadlines is one of the most important aspects for successful projects, but the complexity of projects and the different stakeholders involved make cost management difficult in construction projects. This results in cost and time overruns according to Pinha and Ahluwalia (2019). Weak procurement planning and frequent changes in design play a large role in project overruns (PMI and KPMG 2013). Therefore, one of the main objectives for project management is to predict these unexpected events by planning, organizing and controlling the activities so that the opportunity for successful completion increases. What is interesting about projects is that no two projects are identical and even repeated projects will have different characteristics and outcomes (Lock 2003).

The planning phase is one of the most important and critical phases of a project. In this phase, one gets an overview of the actual costs related to the construction and at the same time, this is where one experiences the most cost escalation. Normally, there is a large cost departure between the project plan and the final design stages. In construction cost management, project planning is crucial to make sure that the costs do not increase, the plan needs to be controlled and executed precisely to achieve this (Torp, et al. 2016). Effective procurement is also a major aspect of project management, over 50 percent of the total cost of a project is related to *parts, supplies, and services procured.* In high-technology projects, the procurement cost can be as high as 90 percent of the total cost. In other words, if a project manager is not managing the procurement process, he or she is only managing less than 50 percent of the total project (Morris and Pinto 2005). Long –and

medium-term production planning are tools that can be used to improve production orders with resource capacity. Further, it can also be used for material procurement. Lack of a detailed schedule can cause difficulties for a feasible production plan (Alfieri, Tolio and Urgo 2010).

Planning can be considered from two different perspectives, target-led approach, and free-planning approach. The target-led approach can be described as "*A delivery promise might already have been given to a customer in a sales proposal, or the project might have to be finished to meet a forthcoming exhibition or public event*" (Lock 2003, 163). The end date is estimated by agreement with the customer before the process starts. The planned cost of the project is important during and before the project starts. A detailed estimate can make a great foundation for the project plans, later in a project, this will function as guidance and safety for the project group. Besides, this will reduce the error in the forecast (Espinosa-Garza and Loera-Hernández 2017).

Two normal planning approaches in ETO projects are reactive and proactive planning. Reactive planning approaches do not consider uncertainties in the planning phase, so when unexpected events occur the baseline schedule must be re-designed. With a proactive planning approach, it is different, it considers the uncertainty when designing the project plan. As a result, teams avoid future disruptions, giving the project plan and baseline schedule stability (Carvalho, Oliveira and Scavarda 2016) (Vaagen, Kaut and Wallace 2017). Further, Carvalho, Oliveira and Scavarda (2016) suggest that a robust plan needs to be able to absorb future disruption in a way that does not stop the progress of the project, rather the project should maintain a normal pace due to considering uncertainties in the planning phase. Furthermore, we can distinguish between proactive, and reactive work. Proactive work means making decisions today based on anticipation of future outcomes, while reactive work making decisions based on a situation or incident (Spitzmuller and Dyne 2013)

Zidane, et al. (2015) identified different sources for delays in their article, where, "management and coordination", and "decision issues" as the most influential factor for bottlenecks and time-thieves. "Decision issues" were found to be the highest source of bottlenecks, because the client delayed the contractors decisions, while second

"management and coordination" is highest sources for bottlenecks, but was also found to be the highest source of time-thieves, and "quality issues and errors", the second source.

In large and complex projects such as a in the shipbuilding industry firms must concentrate on their core business and trust that external suppliers are able to deliver the rest. One of the main objectives for purchasing in these large projects is therefore to select and evaluate suppliers' capabilities. The most common criteria for supplier selection are price, quality and delivery reliability. In addition to cost, it has been discovered that earlier project performance and technical expertise are also important considerations when selecting suppliers. The evaluation of suppliers includes what the *supplier's capabilities are, when and how they are available,* and *how they will add value* (Ruuska, et al. 2013). It is suggested that the criteria for existing suppliers often rely on both operational and relation factors, on the other hand, the evaluation of new suppliers is more dependent on operational factors. Further, the evaluation of suppliers technical, operational and relational capabilities can be limited by difficulties with communication and knowledge sharing (Ruuska, et al. 2013).

A project has one final deadline and several milestones leading to that point. Delisle (2019) discuss the importance of time and what define time in a project. This especially applies to expected progress and lack of time and can be seen as both an advantage and a disadvantage. If there is a common understanding considering the progress plan and the milestones, it could be a good tool when planning a project. If not, it could be a source for conflict and disagreements (Delisle 2019)

Assaf and Al-Hejji (2006) present in their article different causes of delays in construction projects, and some of the most frequent causes of delays Assaf and Al-Hejji (2006) found in the article were, *late procurement of materials, delays in producing design documents, and shortage of labors.* A study done by Yeo and Ning (2006) shows that time buffer is commonly used in engineering projects to protect the project schedule and prevent these delays. This buffer is used due to high uncertainty related to the equipment and products needed in this industry. Further, there is a correlation between the procurement lead-time and time buffer, between the promised delivery date and required on-site date as illustrated in figure 5 below. A consequence of applying buffers is that it leads to excessive redundancy, and the total production time increase. Further, the study presents a survey

that shows 87% of 189 companies add buffers between the promised delivery date and required on-site. Reducing the amount of time buffer implemented in the project planning will reduce time-related costs, and earlier delivery will decrease waiting, work-in-progress, and wasting in on-site materials movement. The longer the supply chain is, the more time waste occurs because each company adds a buffer into their project. (Yeo and Ning 2006).

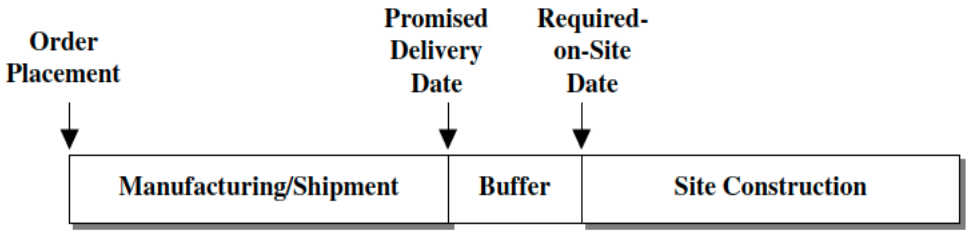

Figure 5 Insertion of time buffer (Yeo and Ning 2006).

A report made by AVEVA (2019) shows the consequences of delays in shipbuilding. If one project is delayed, it will have a negative effect on other shipbuilding projects in the yard. Further, the reputation for the shipyard might decrease which will have a negative impact on the financial profitability. In addition to the fine they have to pay, there are costs associated with extra workload. Further, the report states that up to 70 percent of the costs of a new-build vessel is related to material costs.

3.4.1 Cost overruns

Various studies have investigated the causes of project cost overruns on construction projects, and some of the findings are presented later in this chapter. According to Olawale and Sun (2010), the top five factors affecting time- and cost control are design changes, risks and uncertainties, inaccurate evaluation of project time/duration, the complexity of works, and non-performance of subcontractors. The same article presents design changes as the most important factor to control the cost and time of a project. Furthermore, the article presents a list of 90 different mitigating measures, which can be divided into three types of measures: preventive, corrective and organizational. Some of these measures can be applied to improve cost and time for projects (Olawale and Sun 2010).

A survey conducted by, Park and Papadopoulou (2012) for construction projects in Asia presents a list of 27 causes of cost overruns based on severity and frequency, and

combining these two elements, the most significant cause of cost overruns is that the contract is awarded to the lowest bidder. Park and Papadopoulou (2012) suggestions to improve cost overruns is to evaluate today's practice and apply other control mechanisms to ensure the bids provide value for money. Other factors that are causing cost overrun are: unforeseen site conditions, inaccurate estimations, inappropriate procurement route/contract and change in the foreign exchange rate (Park and Papadopoulou 2012). An article by Memon, et al. (2010) reveals that financial difficulties and cash flow by contractors were the most severe factors for cost overruns in a project performed in the construction industry. Other factors that resulted in cost overruns are inadequate contractor experience, incorrect planning and scheduling by contractors, contractor's poor site management and supervision and shortage of site workers. Further, (Stare 2011) concludes that it is important that the project final report includes an analysis that reveals causes of time and cost deviations. The data obtained can then be used to prevent similar events from re-occurring.

There are different costs related to supply chains, and these costs are measured in many different ways, *administration costs, manufacturing costs, warehouse costs, distribution costs, capital costs, and installation costs* are examples of supply chain costs. Further, the supply chain can also be measured by performance rather than costs, i.e. delivery precision, inventory turnovers, and lead time. Performance measurements are used to be able to evaluate the excellence of the supply chain (Pettersson 2011). In the table 1 below we have summarized the different reasons for cost overruns.

Title	Reasons for cost overruns	Author	Year
Cost and time control of construction projects: inhibiting factors and mitigating measures in practice.	Design changes, risks and uncertainties, inaccurate evaluation of project time/duration, the complexity of works, and non-performance of subcontractors.	Olawale and Sun	2010
Causes of cost overruns in transport infrastructure projects in Asia - Their significance and relationship with project size.	Suggest that the most significant cause of cost overruns is that the contract is awarded to the lowest bidder.	Park and Papadopoulou	2012
Factors Affecting Construction Cost in Mara Large Construction Project: Perspective of Project Management Consultant.	Highlight inadequate contractor experience, incorrect planning and scheduling by contractors, contractor's poor site management and supervision and shortage of site workers.	Memon, Rahman, Abdullah and Azis	2010
Reducing Negative Impact of Project Changes with Risk and Change Management.	States that it is important that the project final report includes an analysis that reveals causes of time and cost deviations	Stare	2011

Table 1: Different reasons for cost overruns

In this paragraph we have presented different tools to completing successful projects, and sources for cost overruns. One of the findings that were revealed was poor purchasing strategies, which leads us to the next chapter where we will present the purchasing process, and current literature written about purchasing in project related industries.

3.5 Purchasing in ETO

The purchasing in such a complicated and complex industry as ETO projects can be challenging due to a large number of different suppliers. Suppliers in this industry are often specialized firms, therefore, these specialized components can only be supplied by a few suppliers. The supplier-customer relationship in the shipbuilding industry is normally the traditional confrontation model, leaving partnership cooperation low priority. Firms that operate after the confrontation model are much more independent and do not involve their suppliers in decision-making. The suppliers are involved at a late stage in the project and the information sharing is at a minimum. Price is the highest priority when selecting a supplier and negotiations are normal. This matches the traditions in the industry, a purchasing strategy that involves strong competition among suppliers and the shipyard buying from several sources (Held 2010).

The main objective for the procurement process is to stay within budget on the planned values, normally these values are expected time, human resources and money. Traditionally, the procurement process is divided into 14 steps that describes everything from the moment the need arises until the warranty period expires. These steps are: 1) evaluating the need 2) find out if you should make or buy; 3) decide which criteria's that are important; 4) decide how the procurement should be done; 5) specify the conditions for the trade; 6) consider the different available suppliers; 7) send out request to suppliers that meet the requirements; 8) evaluation of the suppliers; 9) negotiation with suppliers; 10) order from the chosen supplier; 11) follow up on delivery; 12) control and evaluation of received product; 13) payment after agreement; 14) warranty follow-up (Brynhildsvoll 2011).

As mentioned earlier, the second step of the procurement process is make or buy. A company needs to decide which products and activities should be produced in-house, and which products or activities should be bought. The strategy is decided by the company's leadership. Purchasing can be divided between functional and technical specifications, a functional specification describes which functionality the product must have. The technical specification describes the technical properties and characteristics of the product. The advantage of using functionality is that the suppliers have the opportunity to use their

expertise. Purchasing based on technical specifications might lead to over-specification without improved functionality and increased costs (Weele 2018).

Cost savings is one of the main objectives of the overall purchasing performance. According to Schütz, et al. (2018) one can divide cost savings made through purchasing in two categories: hard and soft savings. Soft savings are difficult to measure, but they might eventually have cost-saving effects. Hard savings, on the other hand, is easier to measure because the data are *"directly quantifiable through concrete measurement data"*. These savings have an impact on the bottom line and can immediately be linked with the overall purchasing performance. Hard savings are measured by comparing the final cost negotiated with a reference cost, for example, a cost paid at a previous period. They also suggest that there is a link between purchasing knowledge and the potential for saving costs through purchasing activities. (Schütz, et al. 2018)

One can divide purchasing strategies into two categories: Cost purchasing strategy and innovation purchasing strategy. With a cost purchasing strategy, firms should adapt to high centralization, high formalization, and low cross-functionality. For innovation purchasing strategy, it is the opposite (Ates, Raaij and Wynstra 2018). Normally, purchasing counts for more than half of the production cost and having a collaborative relationship instead of focusing on minimizing transaction costs could have a positive impact on the financials (Chen, Paulraj and Lado 2004). In ETO projects, one of the main challenges is different views between project teams and the PD, especially when PD lacks knowledge about the construction process to make the right decisions (Bildsten 2015). Bildsten (2015) have identified what strategic purchasing is in four steps:

1. Formal long-range planning
2. Part of the overall strategic goals and planning of the company
3. Visibility for purchasing professionals
4. Interaction between purchasing and production

Early involvement of the procurement department in the purchasing process will reduce costs, but the design from the tendering stage might change and therefore, early PO is difficult. An accurate estimation of the project will reduce the risks related to early ordering. Detailed specifications from customers will increase the procurement cost and lead-time, and reduce preferred suppliers. Designers also want to be creative and develop

new configurations, which make procurement more complex and increase costs, lead-time, and risk (McGovern, Hicks and Earl 1999).

Purchasing professional's involvement and proactive efforts in sourcing processes affect the overall outcome in projects. This is in terms of both value creation and reduced supply risk. Purchasing proactivity has been important, *"serving as a critical capability of purchasing professionals"* (Poucke, et al. 2018). Besides, Poucke, et al. (2018) got three hypotheses confirmed:

1. Purchasing responsibility positively affects value creation and supply risk reduction
2. Early purchasing involvement and purchasing responsibility positively affect purchasing proactivity
3. Purchasing proactivity positively affects value creation and supply risk reduction

Competitive bidding is a procurement practice where suppliers compete with other suppliers to win the opportunity to deliver the products the buyer has requested (Weele 2018). The common pricing method for construction projects is fixed-price contracts. Fixed price contracting is typically given through competitive bidding. Competitive bidding can simplify the supplier selection, but it can also be negative due to contract changes and lead time. In addition to the cost of the product, cost of specifying contracts, negotiation, and monitoring, are transaction cost that needs to be included. Transaction cost has often been underestimated. Adjusting the original contract is the major transaction cost in projects. A consequence of competitive bidding is that it drives design away from real needs, the probability of changes, and rework. This might result in increased costs (Elfving, Tommelein and Ballard 2005).

The efficiency of a procurement process is determined by the decisions made by the design department based upon that the specification are correct and appropriate for the components and sub-systems. Functional specifications will reduce lead-time and cost rather than using detailed technical specification which is the tendency for companies today. Customers have preferred suppliers or detailed specifications that only a few suppliers can satisfy. Another aspect that affects customer satisfaction is the ease of maintenance or operating conditions, Components with long lead-time should be considered early in the design process. Designers select components from suppliers

catalogs based on functional characteristics and the procurement department is not considered in these decisions (Hicks, McGovern and Earl 2000).

Hicks, McGovern, and Earl (2000) present in their article that many ETO companies choose the lowest price strategy, which is not the optimal solution, because then a company always needs to evaluate and inspect for new suppliers which are time-consuming and expensive. Their suggestion is to create a partnership with suppliers because the vendors will be more reliable. Last, using more modular configuration and standard items helps the procurement department to make more accurate decisions because decisions can be made later in the process. Furthermore, the level of detail specifications is one issue that determines the effectiveness of the procurement function, and using functional specification should be preferred (Hicks, McGovern and Earl 2000).

In this chapter we have preseted the purcchasing process followed by different purchasing strategies and methods used by ETO companies. Our findings reveal lack of reseach regarding how delayd purchasing affect the schedule and cots. In the next chapter we summarize the main findings and gaps from the reviwed literature.

3.6 Summary of theory

The theoretical stances presented above describe relevant research about project planning and purchasing in ETO. Most of the available literature on ETO-projects is focusing on construction industry. There are some differences between construction industry and shipbuilding industry. However, there are similarities between these two industries, and several strategies that have been applied by the construction industry have also been applied by the shipbuilding industry. Today's practice in the construction industry is to add time buffers into their plan to manage uncertainties, and to reduce the chance of delaying the project. What distinguishes purchasing in ETO projects from other production strategies is that products in ETO projects are designed for specific customer needs. Therefore, the PD has to make different decisions for each new project. Planning purchasing in ETO projects is difficult, because the PD cannot procure components before a contract is signed, and the purchasing must start immediately after the contract is signed. Delivering the project on time is set to be the most important aspect to achieve a successful project. Furthermore, our findings from the literature reveal that cost overruns are a consequence of always pushing to keep the schedule and deliver the project on time, which

can further result in inappropriate purchasing. In the shipbuilding industry price is a high priority when selecting suppliers, and the lowest bidder usually wins, a consequence of selecting the lowest bidder are not well documented, but some literature concludes it can result in cost overruns. Since one of the highest priorities is to deliver the project on time, and companies always push to keep deadlines, one consequence could be improper purchasing. Improper purchasing often results in delayed purchasing which affects both project schedule and costs. Still, how delayed purchasing affect a project is not significantly documented in the literature. Our findings shows that this happens on a regular basis in the shipbuilding industry, but the consequences of these acts are not further investigated in the literature. Therefore, this is an interesting research gap which makes the foundation for our thesis.

4.0 Case description and findings

The starting point of this research originates in a master thesis delivered at Molde University College 2019 where the results show that there is a lack of focus on planning the purchasing activities and that leads to delays and cost overruns in ETO projects. Consequently, the next step was to try to quantify the cost of delayed purchasing in a visual way that increases the awareness of the importance of proper planning of the purchasing activities.

The case company called Company X is located in Norway and collaborates with different shipyards located around the world to deliver highly customized, one-of-a-kind products to the shipbuilding industry. Like many other shipbuilders, Company X has to deal with challenges related to the downturn in the offshore industry in the world, and small profit margins. The change in product portfolio has been challenging for Company X since the new types of products require other standards, laws, and regulations for ships used by passengers. In the following, a description of the purchasing process as performed by Company X is provided. However, this process is quite similar to the ones described at other shipbuilding companies.

4.1 Description

In this part, the description and findings related to the project structure and purchasing plan, applied by the case company, are presented. We start with a short description of the structure of a project, then a presentation of the purchasing process, followed by a presentation of our findings related to this activity. Last, we present the challenges the company is facing, from a purchasing perspective.

4.1.1 Project structure

Initial stage

A project starts when Company X receives an order from a customer, the initial stage is to sign a general agreement (GA). GA is a document included in the contract and it shows drawings of the main features of the final product. This agreement is the foundation for the rest of the project and cooperation. From the GA to the final document it takes at least 3 months. The second step is building specification, after a GA is signed, Company X is starting with the building specification (hereafter called Spec). The Spec is the “bible” for

all departments involved in constructing the vessel. It contains all the items to be mounted in the vessel, and this information is used by the PD to work out a purchasing plan.

Specification phase

Based on this Spec, the engineers at the company create technical specifications. These technical specifications are sent to several specialized suppliers as descriptions about relevant equipment, materials and components to be assembled on a vessel, i.e. engine types, thrusters, cranes, etc.

When the company and the customer agree on both building and technical specifications, the company sends its requirements and demands to different suppliers based on a list of preferred suppliers. This list includes suppliers that Company X has previous work experience with, as well as the customers' preferred suppliers. The preferred suppliers vary, but often they are preferred because of earlier successful cooperation, a good reputation, and high quality on deliveries. Most customers prefer suppliers from their region or country, and often want to use the same vendor of thrusters or engines as they have used for previous projects. Company X must compromise in their choice of suppliers to please the customer, and at the same time do what is best for the project. This list is called a makers list, which shows the suppliers the company is allowed to use (by classification societies or other law regulators), or the customer wants them to use. When this is done, and they have agreed on potential suppliers, it is normal to send a request for quotation (RFQ) to three/four potential suppliers, depending on how many suppliers fulfill the basic requirements. The PD has also a list of certain suppliers they have a bad experience with, and if the company experiences several times that the supplier is not delivering on time, or other errors the supplier can be "blacklisted".

Evaluation phase

At the fifth step, Company X receives offers from different suppliers (doc 1) and evaluate these offers. They are looking at the proposed requirements and are evaluating which suppliers that are covering their needs the best. This is done both by Company X and their customer. For Company X, the price is their highest priorities, but it is also important to make sure the supplier is reliable. This step is often delayed, it is a complicated process evaluating offers and keeping both Company X and the customer pleased. This is also an important step, because often there is a mismatch between what the shipbuilder think they

are delivering and the customers' expectation. The choice of supplier is dependent on different variables, and the customer has the last word of which supplier Company X can use. If the customer does not have any preferred supplier, Company X is free to use their preferred supplier. Sometimes Company X must use a supplier that they are not comfortable using, but is the only provider of a specific equipment.

Contracting

Next is the negotiation with the selected suppliers. At this step Company X starts to negotiate with selected suppliers based on the suppliers offer, and different terms and demands are considered. The process of selecting suppliers happens through competitive bidding where each supplier offers the solution based on an RFQ. Using competitive bidding also increases the number of documentation, which gives the PD less time spending on other purchasing activities. It is difficult for Company X to negotiate long-term contracts with certain suppliers since it is the customer who ultimately decides which supplier to use. On the other hand, if the customer knows that Company X gets advantages using one specific supplier, the customer will also have something in return, and often it is about the price. If Company X is working within a new field, they often experience that the suppliers are trying to put in some extra costs, a result of them being unfamiliar with the price level. The supplier selection is often time consuming, because important details of the contract need to be clarified before a contract is signed.

In the next step, Company X is sending a purchase order (PO) to their selected supplier (doc 2). A purchasing document includes different terms as for example negotiated price and quantity. The supplier receives the PO and sends back a note when they expect to deliver the product. The delivery date is important, because it must fit Company X schedule. Receiving the note leads to the final document (doc 3) which is more specific than doc 2, and includes delivery time. There are always delays between doc 2 and doc 3, much because of the complexity and that the content in doc 3 must fit Company X schedules and milestones.

In figure 6, we have illustrated the phases of how a project is developed, based on the information Company X has given us. We have divided figure 6 into four phases, initial phase, specification phase, evaluating phase, and last contracting phase.

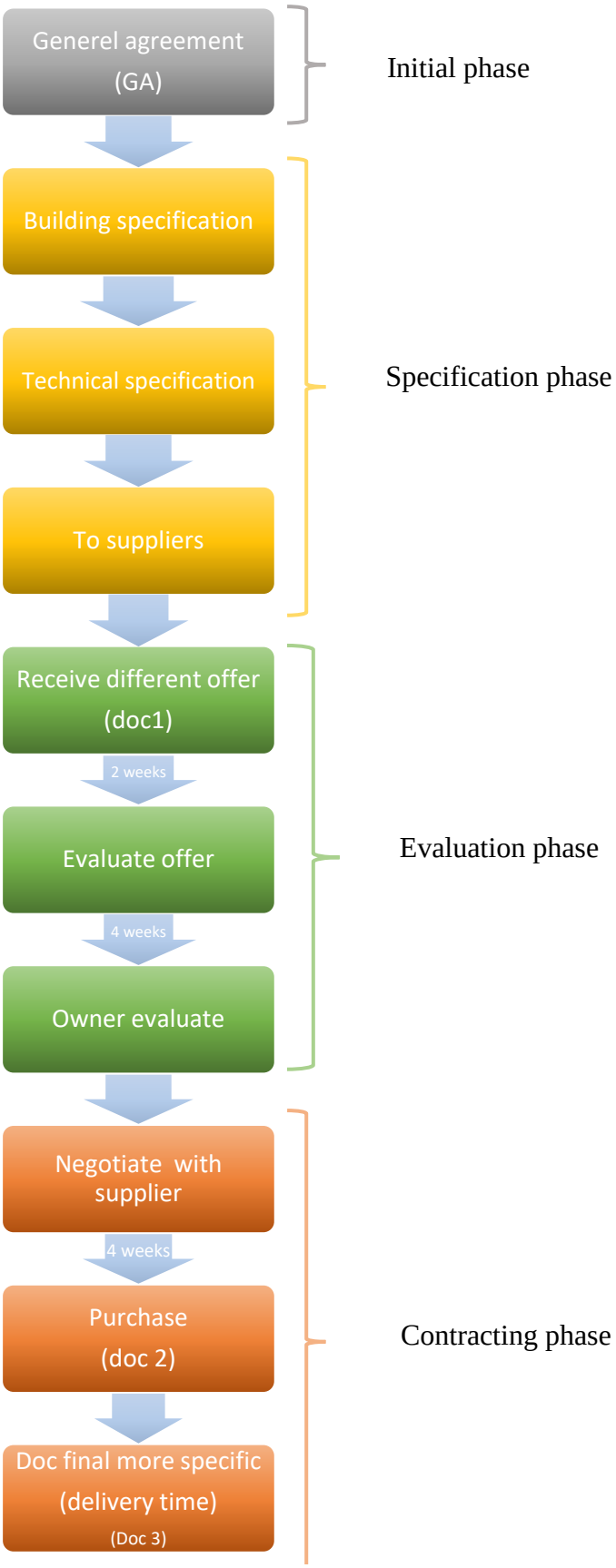

Figure 6 The development of a project

4.1.2 Purchasing process

In this chapter, we describe how the purchasing process is planned and executed in a project. We also show how the PD is operating and how they are cooperating with different departments and suppliers throughout the process.

Purchasing plan

There is a lot of preparation and work before a product is purchased. Before a GA is set, the PD is already looking for suppliers, and have regular contact with potential suppliers about their current standing. The purchasing plan is mainly made by purchasers, project planners, production, and people from the engineer department, making it a multidisciplinary process. Company X involves different departments so that all considerations are taken at an early stage, therefore, they are making the first draft in cooperation between the PD, planning, engineering and production. The first draft is then sent for consultation to get more input from the rest of the company. The main objectives at this stage is to identify critical and non-critical components.

The purchasing plan is based on a standard setup made by the company, and the plan is customized for each project, based on the Spec. The PD creates an RFQ, and sends it to suppliers Company X and the customer have agreed on in the specification phase. RFQ is made by the engineers, and partly PD. The document involves vessel description to prevent errors and mismatch. As described by a purchaser when we asked about choice of supplier: *"The optimal solution is that the customer decides which supplier the company should use, because, this will lead the customer to feel ownership of the process*".

For even better control a milestone plan is created by the project planner in cooperation with the different departments involved in the project. The milestones are based on the overall project plan and are used to measure if the project is on time. Since there are different departments participating in the development of these milestones, this helps combine the activities regardless of department. Both in the development of milestones and planning of a project, it is important to have a realistic schedule estimate on the project, neither too long nor too short. The project duration is decided based on some analytics and previous experience. The project team plans the project with time-buffers, which is a common method used in project management to make sure the equipment

comes before starting the assembly on the vessel, because critical items need to be on time to prevent further delays. If Company X is building two or more similar products, they use the same plan, only small changes need to be done, and if it is possible, they are buying the components at the same time. The main objective in a project for Company X is to match the purchasing plan with the production plan. The production needs components at a certain time for assembly. Company X is sometimes experiencing a mismatch between the expected day of delivery and the day of assembly.

Internal cooperation

One of the measures taken to achieve a multidisciplinary plan in Company X is that people from different departments sit together while working on the same project. To achieve a common understanding of the project and to facilitate cooperation across departments, Company X is setting up weekly meetings to review the process and the purchasing plan. All involved departments are attending these meetings. Company X is using a planning software where the status of the project and the activities are updated weekly, and the purchasing plan is also included in this. This plan is made in collaboration across departments. A project manager coordinates the project and the main objective for the project manager is to solve the complexity of making a proper plan where everything fits. All people and departments involved in the project can at any time check this plan to be updated on the progress in the project.

The multidisciplinary communication and cooperation regarding the purchasing is lacking between the PD and production department. Since production is the last stage in the process, they have a small influence on the choices made earlier in the process. This also applies for which products that are purchased, therefore, most of the time the production must work with the acquired components. When the PD selects suppliers, they look at the cost of the purchase separated from the production costs. The production time can vary dependent on different materials and equipment, thereby the cost, and the production is unfortunately not involved in the process of selecting suppliers. The respondents from purchasing and production both agree that there is a potential for improvement regarding the evaluation of suppliers and especially the communication across different departments at this stage. The production has lots of untapped knowledge about which components that require less production time, and which are easy to assemble. A consequence the

respondents from the production highlighted was the possibility of overseeing adaptive and time-efficient suppliers

How the PD operates affect the production. If there is a delay on a delivery, the production must reorganize and put resources at other parts of the project, this happens relatively often. Changes during a project can also be difficult for the production, but this depends on what sort of changes these are. Some products are uncomplicated to replace while other equipment is unique and must fit the hull. Every change is therefore challenging, and the production department is dependent on suppliers are delivering as agreed. The production has a lot of knowledge about the products and suppliers, but this rarely reaches the PD. As described by the production manager when we asked if they share their experience with the PD: *"We are bad at that. We do have a deviation system where we can report nonconformities, but we are not using it enough."* The reason for not using such a system according to the production manager is:

- Inadequate instruction/training in using the system
- Hectic workdays – Does not take the time it requires
- Lack of IT expertise among the employees at the plant
- Many feel it does not help, and therefore do not bother to report the discrepancies

Suppliers

After making the purchasing plan, the PD must find the most suitable suppliers. This can be a time-consuming process and there is often ongoing negotiation with suppliers through the process. Further, the process of evaluating and sending feedback between the company, and the suppliers before the actual purchase arises can be from a few weeks to several months. There are several criteria for selecting suppliers, where the company has price as the most important factor, because the shipbuilding industry is under pressure on small margins and, therefore, must focus on reducing costs. As a result, the owners have decided that Company X should focus on achieving the lowest price possible from their suppliers. In addition to price, delivery time, quality, and service are important aspects when evaluating suppliers. The different departments have different criteria, but the entirety is always important such as reducing costs, ensure high service and using reliable suppliers with experience.

An important task for the PD is to search for new suppliers. This is something that could be done continuously, especially at the spec stage. Furthermore, our findings show that the respondents have a different understanding of the need for new suppliers. One respondent says searching for new suppliers is done through trade exhibitions and that this is sufficient. Another respondent notes that the company should search for new suppliers more regularly to prevent companionship, which can result in repeated error and higher price. "*It has to do with the culture that we use the same supplier repeatedly, even though the supplier might have repeatedly problems delivering the product on time."*

This means that there are not many new suppliers involved in their project and they might miss out on other relevant suppliers. Yet, using new suppliers also comes with some risk which can lead to other challenges, i.e. the supplier does not prioritize the company, because they have not used them before, or that the purchased volume is not large enough. Selecting suppliers is also a challenge because the customer is the one that has the last word. This can sometimes force Company X into using suppliers they are not comfortable using or have a bad experience with.

After a project is done, PD and the production team evaluate all suppliers and give them a score based on well-established criteria. Most of the time PD evaluates the suppliers it has to do with large errors, small mistakes, and other regular mistakes are often ignored, while it can have a large impact on the total cost. Reporting errors is also often person dependent, which means that there is no standard reporting system. Our findings reveal that the communication between PD and production is lacking. Production has one opinion on the choice of supplier, while PD has another, and lacks a reporting system that have

Daily activities

Some of the main activities for the PD is to follow up on the purchasing plan and the suppliers. The PD collects a status report from the largest and most critical suppliers once a month. In this report, the suppliers are asked to describe how far they are in the process, if they have started to produce the product, when they expect delivery and so on. This report is sent to the project leader who needs to have a good overview of which suppliers that will deliver on time and which will not. This status report is also used by the PD to have an overview, and create ongoing plans and to be proactive if something should happen. The PD often experiences lack of documentation from the supplier about the

status on their production process. Normally, Company X experience one or two suppliers have problems delivering the product on time in each project. This puts the PD in a difficult position having to choose between a delay in the project or an extra cost to keep the project on schedule. Therefore, receiving a status report is important for the PD. This helps them to be proactive in search of new suppliers or implement other short-term solutions, as reorganize or hiring extra workers at the production to prevent delays. Furthermore, if there is a delay from a supplier or they cannot deliver as agreed, Company X must consult with other suppliers if they can deliver. Using express delivery costs tremendously according to one respondent.

As previously explained, the Norwegian shipbuilding industry has been through some challenging years with low demand for new vessels. As a result of low activity, the yards are striving for new contracts and many companies experience being too hurried signing contract with a customer. A consequence of being too hurried of signing a contract with a customer, is that it can arise a disagreement of what the customer perceives they have purchased, and what Company X believes they have sold. This can result in a conflict, and ongoing discussions through the project. If the customer wants to change something from the original plan, Company X make sure that the customer covers the extra cost, but at the same time, they must keep the customer satisfied. Furthermore, for each project, the company put costs on each activity, and classifies the potential risk for each activity. This is only used as an overall plan, and not down to each supplier or items so it is not very detailed and reliable.

In their daily activities, the purchasers focus on the critical items first, before less critical items are purchased. The purchasing plan includes different milestones in the building process, which are used to measure if the project is on time and function as a guide for the PD. Further, the purchasing plan is based on a templet, i.e. when the hull yard plan to have big equipment *(main engines, fin stabilizer)*. These are critical items that need to be at the shipyard at a specific time, therefore someone from the PD interrogates with different vendors about their status because the equipment needs to be ready and the PD well informed before a contract is signed. When a contract is signed "*a lot of emails are sent, and it is important to send RFQs to receive offers and evaluate."* The evaluation process where they evaluate the different suppliers and their offers can be a bottleneck.

In the text above, we have described how a project is developed from a project planning and purchasing perspective. Our findings reveal that there is a collection of different sources that results in cost overruns, and there is no sources alone. Since every step must be coordinated, and every step is planned down to the last detail, a single change can result in further delays. We can summarize some of the sources of cost overruns as:

1. Lack of documentation from the supplier
2. Hiring people on short term contract
3. Express delivery to prevent delays
4. Lack of involvement by the production in the purchasing

These sources are the most relevant ones in regard to the data collected during our research.

4.1.3 Challenges

Company X experiences different challenges associated with the purchase of materials, equipment, and components. We now describe the main challenges the PD experience in their daily activities related to projects. There are large variations in ETO projects, but some of the challenges are repeated in most of them. These challenges are further described in detail below:

- Communication
- Changes from customer
- Delayed purchasing
- Cost overruns

Communication

Internal communication is important for Company X, and in on our interviews we had the opportunity to learn more about how different departments communicate and share information within the firm. One respondent highlighted some challenges with the internal communication, especially related to the choice of suppliers. The production has little influence on which products and equipment that are purchased, and most of the time they have to work with the products and equipment that are chosen by the PD. A system has been developed so that it is possible for the production to share their experience about different equipment and products with the PD to prevent using suppliers who does not

deliver as agreed. Unfortunately, this information rarely reaches the PD, and the production team is not using the system sufficient in order give PD valid data.

As previously explained, the production evaluates suppliers, but not adequately. As a result, the PD is not using feedback from the production in their selection process. A consequence of not being involved in the process of selecting suppliers, Company X can oversee suppliers that deliver more innovative products or equipment. In addition, the production team experiences inadequate communication between their department and PD. The production is often questioning the choice of suppliers, products that are easy to assemble and require fewer working hours are often ignored. The production often experience beneficial suppliers are given the same priority as supplier that deliver at lower prices. Using low cost suppliers could result in equipment or products that causes higher project costs due to an increased number of hours needed in production. Today, they lack an overview of this as the production. The production is only aware of the time they spent on assembling components, and not the actual cost of these hours. Taken this into consideration, improper purchasing can result in many extra working hours of assembling the components, compared to more expensive supplier.

Communication with the suppliers during a project is important, both to have knowledge about how the project proceeds, and remain the ability to be proactive to unexpected events. It turns out that the most usual challenge with suppliers is receiving process documentation. The suppliers are often slow sending the documentation, therefore, the PD must spend an unnecessary amount of time requesting the documentation from the suppliers. Often this documentation could be essential to move forward in the project, for example, to finish a draft. Furthermore, the documentation is also important for the PD to have a clear view of what is delayed and what is on time.

A consequence of receiving the process documentation late, is that Company X has an unclear understanding of the development of the project, or if the items will be at the yard at the right time. In a worst-case scenario, this can result in reactive purchasing, and Company X must order items on express delivery, which cost the company a lot more than planned. Therefore, Company X has trouble staying within budget, and they often experience cost overruns, because they push to deliver the product on time. In addition to express delivery, other solution Company X is using to prevent time overruns is engaging

employees on short term contracts or reorganizing the workers to speed up parts of the process. These actions make it difficult to remain within the estimated budget. Some reasons can be disagreement on what is purchased from the supplier or inaccurate work at the beginning of a project.

When asked why this was happening a respondent explained that it already started at the initial stage in the GA: "*Since it is so important to get something sold, we are a little too eager to enter into agreements. It is important that we do a thorough job and have a good starting point before we sign anything. Rubbish costs us a lot! At the same time, there is often an ongoing disagreement with the customer on what they have bought. We are trying to keep the customer happy and at the same time get them to pay the bill*."

Changes from customer

Another factor that has an impact and can result in delayed purchasing is changes from the customer during a project. This is something that happens regularly, but the cost is often covered by the customer. Regardless, every change during a project affects the project some way. It can delay the project, or force Company X to find another supplier due to changes that are not possible with the current supplier. Another consequence could be hiring people on short term contracts to finish something else on the vessel to keep the project up to speed. Company X tries to avoid any changes that are not strictly necessary, or not demanded from the governments, but happens on a regular basis anyway because Company X does not have the power to reject changes from the customer since this is also part of their competitive advantage as mentioned earlier in this thesis. To deal with changes from customer during a project can be difficult, and it depends on what sort of change are demanded. Some components are easy to replace, while other components are uniquely tailored to the vessel based on demands from the customer makes them difficult to replace.

Since production is the last stage in the process, they have a small influence on the choices made earlier in the process. If there is a delay in a product or equipment, the production department must reorganize and put resources at other parts of a project which happens relatively often. A challenge of reorganizing the workers is that certain parts of the workers are not qualified for other types of work, this is because the work needed on the vessel could be very specific.

Delayed Purchasing

Delayed purchasing happens at unforeseen times during a project and is often a result of unexpected events. These events are typically very expensive and happen once or twice on average in every project. The challenge is that this can happen anytime in the project from GA to delivery of the product, and the respondents describe them as impossible to predict or plan for. Still, the respondents give us the impression that there is some potential for improvements. As explained earlier, changes from customer and delayed documentation can lead to delayed purchasing, which in turn results in higher costs for the respective item as well as unexpected costs for the new materials or equipment. There are costs related to express delivery, using suppliers who know that the shipyard is in a hurry, and other soft costs. To prevent delays, Company X has implemented tools for better information sharing between different departments to reduce the risk of delayed purchasing. Despite this, delayed purchasing still occurs. Our findings show that lacking tools for evaluating suppliers based on criteria like communication with production, information exchange with suppliers, and suppliers that don't send process documentation are a bottlenecks. Furthermore, some of our respondents propose that a document where all suppliers are evaluated can be used to reduce the risk of using inappropriate suppliers.

Cost overruns

One of the reasons why cost overruns are happening is because of delayed purchasing. Instead of accepting the delay, Company X is putting in extra resources to keep the project on time and, therefore, transforming delayed purchasing into cost overruns. At this point, the company does not have any tool or mechanism to analyse these types of cost overruns and have no idea how much delayed purchasing costs. In addition, reporting errors is often person dependent, which means that there is no standard reporting system. Such a system could be used to divide parts, materials or suppliers that stand out negatively, and help Company X to improve projects in the future. One respondent had a clear opinion on what effect such a tool or mechanism could have, and one of them states: "*There is a great potential for improvement. It would help us see if there are any parts, materials or suppliers that stand out negatively. It could have been very exciting*."

The shipbuilding industry is very complex, and therefore very demanding for the suppliers. It is not uncommon that the suppliers have challenges with making the right adjustments and configurations to fit the equipment to the vessel. This can put Company X in a difficult

position. A tool Company X is using to prevent delays is time-buffers. This allows them to have some delays from the suppliers and still deliver the project on time. Sometimes, this buffer is not large enough, and they must order from another supplier, and the respondents revealed that ordering late from suppliers costs them a lot. Since the company is dependent on having the parts at a certain time in the project, they often must pay extra for express delivery. This is done to ensure that the project does not get delayed, as this is their highest priority. Therefore, Company X prioritizes to stay within the planned schedule, but exceeds their financial plan regularly.

4.1.4 Summary

In this chapter we have presented the development of a project, and how the procurement plan is formed. The case is described from a planning and purchasing perspective. The respondents have presented their views and provided insight in previous, and current projects. Based on their perspective and experience, we have presented how Company X is completing a project, from planning it, developing a purchasing plan and most recently the challenges associated with the process of building ships. We now present our discussion and analysis of the findings while considering the presented literature.

5.0 Discussion and analysis

The number of different suppliers involved and the complex components which can only be supplied by a limited number of suppliers make the shipbuilding process challenging. The divided responsibility for all parts of a project complicates the operations and makes coordination an important task to deliver the vessel on time. Changes in the estimated plan during the project complicates decisions making, and a lot of reactive work is done to deal with delays. Furthermore, companies cannot forecast their purchases because the sales and specifications from customers are unknown before initiated the GA (Sriram, Alfnes and Arica 2013). In this thesis, the purpose is to investigate how one can prevent cost overruns by addressing improper purchasing and planning in ETO projects.

5.1 Initial phase

The project officially starts when the GA is signed, and this is also where the challenges begin. Shipbuilding requires a detailed plan, and it is important to have a well-functioning plan to ensure a successful completion of a project. Even though the process has been standardized, every project is different and needs new configurations. Company X experience a lot of waiting in this stage, and the PD cannot start their process before a detailed plan of the components has been developed. Often, the PD must wait until they receive enough information. As a result, the initial phase is a time-consuming process, and waiting for the documentation often results in delays. A delay this early in the project affects the entire project by increase the total lead time, because it is difficult maintaining the schedule if the project is behind from the beginning of the project. Making up for lost time can result in impulsive decision and are something Company X try to avoid. Therefore, to prevent delays in the initial stage, Company X operates the phases and activities of their projects concurrently, meaning different task works simultaneously and information is shared bidirectional to reduce lead time. To fulfill the two main principles of CE, integration, and concurrency (Anumba and Kamara 2012), Company X works with multidisciplinary teams, and representatives from different departments are involved to develop the optimal plan with the ambition to reduce lead time. A proper plan is required to accomplish effective use of CE. As previously stated, it is time-consuming to develop a proper plan, because it often requires detailed information from different departments and their opinion on critical tasks for the progress of the project.

The planning phase is one of the most important and critical phases of a project. In this phase, one gets an overview of the actual costs related to the construction and at the same time, this is where one experiences the most cost escalation (Torp, et al. 2016). Development of the plan is difficult, and our findings reveal that there are always delays associated with making the plan because all parts and activities of a project must match. Considering the importance of the planning phase, Company X should prioritize this phase and make sure they are as well prepared as possible. Unfortunately, today, the planning phase and their overview of the costs related to the project are negatively influenced by their eagerness to secure sales. Company X is rushing into agreement with their customers and has therefore not sufficient time to plan and to calculate the costs before signing the contract. In this phase of the project, it is necessary to have input and information from the different departments to make the right decisions, but too often the decisions are made based on assumptions and previous experience. Furthermore, the shipbuilding industry is categorized by high complexity and specificity (Strandhagen, et al. 2018), and a small change could have a huge impact on the project. Therefore, it is important to consider uncertainty when planning in such a complex environment.

5.2 Concurrent Engineering

Since shipbuilding projects are concurrent, internal communication is important for Company X to better deal with the concurrency. Hence, Company X has invested in a planning tool to improve internal communication within each project. Besides, this tool helps Company X to prevent mismatches between different departments and make sure that the milestones are available for everyone involved in the project, an important success factor in most projects (Delisle 2019). Using this tool to communicate increase the dependencies between the different departments significant, because the PD, production, project planner, and engineers all need up to date data to make decisions. Despite good information share tools, we have identified challenges with the internal communication between production and PD. The production experiences a small influence on the choices made earlier in the process. Our opinion is that the downstream communication from the PD to production is sufficient, but that the upstream communication from production to PD is deficient. This defies with one of the core ingredients of successful concurrent engineering *effective management of organizational interfaces* (Morris and Pinto 2005). This requires attention and we will come back to the coordination between these two departments later in the discussion.

One advantage of using CE is that it will reduce the lead time, and increase the flexibility to handle changes from the customer (Pennell and Winner 1989). But as described above, it requires a proper plan and Company X is often behind schedule before the execution of the project even starts. Therefore, it is important to reduce lead times to stay within the planned time frame. Different tools can be implemented to reduce lead-time. Company X has implemented overlapping in their working practice. Overlapping means that several tasks are worked on simultaneously. Company X is working with several tasks, and several projects simultaneously to reduce lead time and utilize the workforce. Furthermore, to be able to be even more efficient and utilize the workforce, Company X is using parallel execution, where Company X has divided the vessel into "building blocks". By using this strategy, Company X can handle delays in one "block" and continue working in other "blocks" by reorganizing the workers. Using this strategy helps Company X to proceeds with the project when delays occur. The last strategy is reduction of tasks and this might be the best opportunity to reduce the total lead times, but it requires efficient communication between different task members (Elfving, Tommelein and Ballard 2005). The communication and coordination between the departments are sufficient in order to use overlapping and parallel execution, but using the last strategy involves that coupling between tasks removes. To take advantage of this strategy the communication between the PD and production needs to be improved. With an improvement, it can be possible to reduce working hours on installation and thereby reduce the total lead-time of the project. The production has a clear opinion on what equipment, materials, etc. that are easiest to work with. This information rarely reaches the PD, as our findings have revealed, due to a lack of an integrated system where information about suppliers flows between departments. Why this is happening will be carefully discussed later. However, it is possible to use all of these three strategies at the same time and significantly reduce the lead time, but using them increases the requirements for internal and external coordination and communication.

The communication with the customer and supplier is also an important aspect to consider when gathering information on how the project proceeds. This information is essential to remain the ability to be proactive when unexpected events occur. Related to customers, as we already have addresses, our findings reveal that the planning phase is adversely affected by a premature agreement between the customer and Company X. This is because

it is important for Company X to secure sales and, therefore, prioritizes short-term over long-term gain. The outcome of the premature agreement and limited details at the beginning of the project is that the plan needs to be corrected throughout the project. This is challenging and an unfavorable start of the project for Company X.

CE plays an important part in being competitive and responsive to changes from the customer and to reduce lead time. Since project teams work on several tasks simultaneously, the delay in one department will affect the other departments. From the PD perspective, a delay in receiving documents will result in delays in purchasing which later will affect the production (Anumba and Evbuomwan 1997)

5.3 Planning

In ETO projects there are mainly two planning approaches, reactive and proactive planning (Carvalho, Oliveira and Scavarda 2016). As presented earlier, Company X has challenges in planning proactively. Today, their approach is closest to a reactive planning approach, where Company X only reacts to changes when they occur. We believe that the desire to reduce lead time in the planning phase prevents Company X to involve uncertainties and risk in their plans, and only handle uncertainties in projects by including time buffers. A change to a proactive planning strategy will help Company X to handle the uncertainties better, and be able to foresee some events which could help them to reduce costs. However, using a proactive planning strategy involves a less tight time horizon at the beginning of the project because it involves postponement in the design stage. In practice, this means that they need to postpone the design phase to be more flexible to changes from the customer or other unexpected events that may occur. A postponement of the design will increase the total lead time and may result in delayed purchasing. Therefore, the proactive approach presented by Vaagen, Kaut, and Wallace (2017) could be difficult to implement for Company X in the way they are developing their projects today. Regardless, the reactive approach has shown to not be efficient enough and they should at least consider a hybrid solution between a reactive and proactive approach.

In addition, as a result of the premature agreement and limited details at the beginning of the project, Company X experience a lot of adjustments and rework. Therefore, using a proactive planning strategy where decisions are based on anticipation of future outcomes, instead of waiting for a situation or incident as today's practice is (Spitzmuller and Dyne

2013). Company X is calculating some risks on certain activities, but based on the respondents, these risks not detailed described, and are often covered by adding time buffers. Company X experience too often that they must change their baseline schedule, the plan is not as robust and cannot absorb the disruptions that occur without delaying or causing cost overruns in the project (Carvalho, Oliveira and Scavarda 2016).

Further, there is another consequence of the premature agreement with the customer. They do not have a good enough overview of the costs and obtaining a better understanding of the actual costs at the beginning of the construction-related work is important. In construction cost management, project planning is crucial to make sure that the costs do not increase, the plan needs to be controlled and executed precisely to achieve this (Torp, et al. 2016). An important part of planning a project is to identify potential unexpected activities and costs. Improved project plans could, therefore, help Company X to better manage changes from the customer and the uncertainty. A better estimation of the costs in the initial stage of the project will reduce the gap between the planned cost and actual cost (Creemers, Reyck and Leus 2015) (Espinosa-Garza and Loera-Hernández 2017).

For Company X, their highest priority is to keep the deadline, which is set to be the most important part of a project (Pinha and Ahluwalia 2019). As stated before, the projects are often delayed at the beginning of the project. Using time buffers increase the total production time, and reducing the number of time buffers will reduce time-related costs (Yeo and Ning 2006). To deal with the uncertainty, Company X always plan a project with time buffers. This is done to secure that that they receive the equipment before they need it to prevent the processes from being delayed and to protect the plan. Company X still experience delays in receiving components, which affect the production team. However, using time buffers results in excessive redundancy of projects, and other measures may have a better effect on reducing costs and protect the projects. As a result, Company X is now dependent on time buffers to proceed with the project. Therefore, other tools should be evaluated to reduce the dependency and amount of time buffers in projects, to reduce the total lead time. Assaf and Al-Hejji (2006), presented some usual causes for delays, late procurement of materials, delays in producing design documents, and shortage of labors, these are potential for improvements in Company X and can reduce uncertainty and reduce the number of time buffers.

To better manage changes to the project plan, Company X is setting up weekly meetings. Representatives from each department are attending these meetings to review the process and purchasing plan according to the milestones developed. Further, these meetings are important to agree upon tasks that must be prioritized, and they can see which components are delayed. In addition, people and departments involved in the project can at any time check the plan in the software, and be updated on the progress in the project. Still, Company X has internal weaknesses regarding coordination and communication. Today, outfitting is the only department located at the shipyard, and are the department experience the most lack of involvement in parts of the process. One important aspect to be able to respond quickly to changes in the project is the suppliers. In addition to internal coordination and communication, the external conditions are also highly important in this industry and one of the most influential is the suppliers.

5.4 Suppliers

The suppliers are very important for a shipbuilding company, and for Company X to have a successful project they are dependent on their suppliers. Most of the suppliers are selected based on competitive bidding. One of the advantages of this strategy is that Company X is more independent, and it also simplifies their supplier selection. But there are also some disadvantages making the supplier less reliable, costs of monitoring, and negotiating the contract (Elfving, Tommelein and Ballard 2005).

Furthermore, using the traditional confrontation model result in a lack of coordination with the suppliers. Firms that operate after the confrontation model are much more independent and do not involve their suppliers in decision-making (Held, 2010). Since the suppliers are so little involved in the project besides delivering what is required, they feel minimal ownership of the project. This can result in them doing nothing more than absolutely necessary and can be one of the reasons why they often are delayed with sending documentation. One example is the lack of a progress report that is requested from the suppliers by Company X every month. With the relationship that occurs when using the confrontation model, it is difficult for Company X to encourage the suppliers to make an effort to improve, as they do not see the value this add for Company X. As a result Company X must spend an unnecessary amount of time requesting the progress report. As Zidane, et al. (2015) revealed “management and coordination” were found to be the highest source of time-thief. Using the traditional confrontation model, result in a lack of

coordination with the suppliers. The outcome of applying this strategy to several suppliers results in time-thief, which delays the projects. Furthermore, the lack of documentation is also a cause for "decision issues" between Company X and the suppliers, which can result in disagreements about delivering time. Considering the big influence suppliers have on the progress of the project, the selection of suppliers becomes more important.

This documentation could be essential to move forward the project, and the progress report gives PD an understanding of when the components will arrive at the yard. If this documentation is received as planned, it allows the project manager to act proactive and prevent delays if the supplier is not able to deliver the components as agreed. Today, there are no consequences for the suppliers if they do not deliver this documentation on time, but major negative consequences for Company X. This is not feasible, and Company X should demand more from their suppliers. This may be through a contractual agreement which gives the supplier greater responsibility for delivering the documentation on time. This could prevent some delays for Company X and be more proactive. Thereby help them stay within budget because of a better overview of their components.

5.4.1 Supplier selection

The supplier selection starts immediately after the sale is secured. The selection and evaluation of suppliers are one of the main objectives for the PD. Today, Company X has the price as the most important factor, and today suppliers are often only selected based on this criteria, due to pressure from the management and the owners. This is based on the lowest price-strategy (Hicks, McGovern, & Earl, 2000). Other important criteria as, delivery time, quality, service, and previous experience are therefore given less attention. Furthermore, due to the lack of an overview of previous experience, it is difficult to compare the suppliers based on other criteria than price. Earlier in the discussion, we have mentioned that the coordination between the PD and production need to be improved. This is especially important for supplier selection. Today, the influence the production has on the process of supplier selection is very limited. A system where they can evaluate suppliers exist, but our findings reveal that the production team is not using the system in a sufficient order to give the PD necessary data to improve supplier selection. This is in line with findings from the literature that shows that the evaluation of suppliers' technical, operational and relational capabilities can be limited by difficulties with communication and knowledge sharing (Ruuska, et al. 2013). An interdisciplinary assessment that includes

other criteria in addition to price when selecting the supplier should be considered, our findings show deviations in supplier evaluation. The production manager presented four reasons for not using the evaluation system:

- Inadequate instruction/training in using the system
- Hectic workdays – Does not take the time it requires
- Lack of IT expertise among the employees at the plant
- Many feel it does not help, and therefore do not bother to report the discrepancies

As we can see, there is potential for improvement to give PD the necessary data to improve supplier selection. In addition to lack of training using the system and hectic days at the plant, the production has the impression that their opinion on suppliers does not influence the PD and therefore do not bother to report. This illustrates the effect of an insufficient system. When the production team experiences their feedback does not help, Company X needs better tools involving the production team. A culture where the suppliers are evaluated needs to be implemented in the production as part of their working routine. Furthermore, our findings also reveal that the PD does not use the evaluation system adequately. The system is too person dependent and varies too much from project to project. Besides, most of the time it has to do with large errors. Small mistakes and other regular mistakes are often ignored because the impression is that it has little influence on the total costs. This is something they need to change to avoid inappropriate purchasing (Park and Papadopoulou 2012). The PD needs a system that gives them a better foundation for supplier selection. The PD is lacking an overview of data that shows the total cost for each component, making it difficult to improve and make the right choice. A tool where the production gives the PD input on installation time and working hours could give them better data for supplier selection in the future. Company X sits on a lot of experience and knowledge about the industry and possible suppliers but is missing this advantage by not systemizing their suppliers. Such a system or tool could affect the lead-time and reduce the cost overruns that Company X is experiencing, by reducing work hours in production and at the same time secure high service and reliability for the PD. After selecting the right supplier, the next step is to reach an agreement on the terms of the deal. To have a better baseline in future projects, Company X should include the suppliers in the final report (Stare 2011).

5.4.2 Negotiation

Company X has different approaches related to the different suppliers based on what they are delivering, but it is often, as mentioned, based on the traditional confrontation model. This strategy has price as the highest priority and often set suppliers up against each other to achieve the lowest price possible (Held 2010). As described earlier, Company X is still experiencing cost overruns in their projects, even though, they are selecting the supplier with the lowest price. Therefore, this strategy may not be as beneficial as planned. The idea of purchase the components from the supplier delivering lowest price seems like the prominent tool for cost savings. But, when Chen, Paulraj, and Lado (2004), presents that half of the production cost is related to purchasing, and Held (2010) presents that 60-80 percent value-added in shipbuilding projects are procured from external suppliers. Using the lowest price strategy may reduce costs related to purchasing, but other hidden costs may increase because Company X always has to evaluate and inspect for new suppliers. Hicks, McGovern, and Earl (2000) suggest a partnership with the suppliers because then the suppliers will be more reliable. This strategy will be difficult to implement for Company X because it is the customer which ultimately determines the choice of supplier and that different suppliers suit different projects.

Negotiation is an important task for the PD. The PD has the experience and knowledge to negotiate and enter into an agreement with suppliers, while other departments have more knowledge about equipment and materials that need to be purchased, a result is a lot of documentation circling between the functions involved, both internal and external. This exceeds the duration of the negotiation phase. Negotiate with the suppliers is, therefore, a time-consuming process, where most of the process involves waiting on documents from suppliers. The fact that Company X is using competitive bidding has shown to increase the number of documentations, which leads the PD to have less time to spend on other purchasing activities. A consequence of using competitive bidding is the value-adding time, according to Elfving, Tommelein, and Ballard (2005) over 80 percent of the time used was just waiting, while 16 percent was actually time spent in competitive bidding. Furthermore, based on this, it is difficult to reduce lead time in competitive bidding, since most of the time is used waiting for suppliers. But since a lot of time is used waiting, it is difficult to proceeds with the projects. Often Company X experiences delays in the negotiation process. According to Elfving, Tommelein, and Ballard (2005) negotiating

contracts includes several factors that have a negative impact on the total costs of a project,. In addition to the price of purchasing the equipment, there are hidden costs such as, monitoring, negotiation, and adjusting the contracts. These are rarely considered in ETO projects. A result can be that the total cost of components exceeds the purchasing price. Today, Company X lacks an overview showing the total cost of each supplier. Even with successful supplier selection and negotiations, there are still some external challenges, and this can often be related to the customer

5.4.3 Changes

In ETO changes in technical requirements from the customer after the production has started are a normal challenge (Oluyisola, Salmi and Strandhagen 2018). If changes occur it is important for the PD, as early as possible, to identify how this change will affect the plan, and what consequences are associated with the change. Based on our findings, if a change occurs and the supplier is not able to deliver, PD is not acceptably prepared. There are several reasons why the PD is not acceptably prepared for these changes. The first reason is their eagerness to enter into an agreement with the customer. The planning phase is one of the most important and critical phases of a project and in this phase, one gets an overview of the actual costs related to the construction (Torp, et al. 2016). When they are too eager to enter into an agreement there is no available time to go through different scenarios. At the same time, with a short period before the agreement, misunderstandings can quickly arise between Company X and the customer regarding specificity and what they agreed on. The fact that Company X is practicing a reactive approach rather than reactive neither helps them to absorb changes (Carvalho, Oliveira, and Scavarda 2016). The combination of rushing into an agreement and practicing a reactive planning approach makes Company X vulnerable to changes. Today, changes could force them to search for new suppliers, and then it is not suitable or time for a normal purchasing process. This leads to an improper purchase, and the cost of the new components exceeds the previous one. We believe that better preparation before entering into agreement and implementing a proactive planning approach will help improve Company X's ability to handle changes.

On the other hand, changes will always be a factor in these ETO projects. Competitive bidding requires that the building owners decide on detailed issues and specifications early in the project which makes their future input unpredictable and increases the probability for changes later in the process (Elfving, Tommelein and Ballard 2005). This is

challenging for all the parts involved in the project and affects both the customer, Company X, and the suppliers. Considering this, it is even more important that Company X facilitates good communication and coordination between the different parties so that one can better respond to these changes.

5.5 Purchasing

The customer and Company X determine different specifications the components should have, bot functional and technical. To reduce costs, early involvement by the PD in the project is necessary (McGovern, Hicks and Earl 1999). The customer and Company X determine different specifications the components should have, both functional and technical. Even though, our findings show Company X often experience a mismatch between what the customer perceives they have procured, and what Company X believes they have sold. The combination of technical and functional varies but depends on how detailed information in the Spec is, and what information Company X considers is necessary to get the components they request. Being too hurried at the beginning of the project, especially with the Spec details can result in disagreements and increase the duration of a project because adjustments and rework have to be done to proceeds with the project. Finding the balance between technical and functional specifications is difficult.

Technical is more detailed and gives the supplier-specific requirements that need to be fulfilled, while functional are less detailed and the suppliers are more dependent on how the supplier solves it. According to Weele (2018), using technical specifications can lead to increased costs and over-specified products without improving functionality. Therefore, it can clearly be argued that Company X should only consider functional in their description of the components. Further, the article presents that functional specification gives the supplier the advantages of using their expertise to give the equipment improved functions. However, using technical specifications results in increased costs and lead-time, during our interviews the respondents have specified that costs and lead-time are two of the most important criteria's when selecting a supplier. Having technical specifications makes it is easier to know exactly what has been purchased. This gives Company X the advantages of developing a more detailed and predictable plan, and changes in the baseline-schedule can be prevented. To reduce the adjustments and rework is important, this will also reduce the workload, and help them to stay within budget. Company X often experiences a mismatch between what they perceive they have purchased, and what

suppliers believe they have sold. This discrepancy can force Company X to make changes in their project plan to assemble the equipment. This can be a consequence of only using functional specifications which are not detailed enough. Therefore, Company X needs to make the right balance between technical and functional specifications. For Company X, a solution of only using functional specification cannot be an optimal solution due to all the uncertainties and specific requirements that need to be considered. Most of the products and equipment need to fit the specific vessel, if not, problems arise with rework and adjustment on the hull. As discussed above, the complexity of the components makes it difficult to only use functional specifications, and completely ignore technical specifications (Hicks, McGovern and Earl 2000). Furthermore, using competitive bidding in cases where there is a lot of details can force the design away from real needs (Elfving, Tommelein and Ballard 2005). This can be a consequence of having a lot of technical specifications and results in delays.

If components are delivered a few weeks later than planned there are internal disagreements on how these delays should be characterized. Company X lacks an overview of the actual cost of delays, and who is responsible for the delay, and therefore the cost is not covered. For the PD it is important to have gone through different scenarios and made a proactive plan that considers uncertainty in the project plan.

5.6 Contracting specialized workforce

The shipbuilding industry is challenged to lower their profit margins and a high priority is to secure sales in this business, several projects can be handled at one yard at the same time, and delay at one vessel can result in delays in other vessels at the shipyard. A report made by AVEVA (2019), presented the consequences of delays in projects, that delayed delivery of a vessel can adversely affect the shipyard reputation. Today, the main goal for Company X to deliver the vessel on time. To do so, Company X is using more workers or make more resources available and shifts the delays in the project into costs. This results in cost overruns. Our respondents at Company X reveal the reorganization of workers as challenging, and in many circumstances workers are hired on short time contracts for a specific project and task. This strategy gives the Company X the flexibility to change in market demand, and reduce the number that is a full-time employee. However, this strategy requires training before they can start working with specific tasks. As a result of

the internal reorganization, the workers are often set to do other tasks than they were hired to do. This results in insufficient use of the workforce.

5.7 Analysis

The purpose of this research has been to contribute to ETO and purchasing literature by investigating how Company X can prevent cost overruns in future projects by improving their purchasing activities. We developed this RP:

RP: How can ETO projects avoid cost overruns by improving their purchasing activities?

We have conducted a single case study on a Norwegian shipbuilding company, Company X, and developed three RQs who have made the foundation for the discussion. We have investigated the major reasons for cost overruns in ETO projects, the main reasons for delayed purchasing in ETO projects, and what solutions can be applied to improve the purchasing activities.

To answer RQ1, we have discovered that there are several reasons for cost overruns in ETO projects. One of them is that shipyards are rushing into a premature agreement with their customer. The desire to enter into an agreement leads to an inadequate basis for planning of the project, and an unclear overview of the costs. Furthermore, there are often delays at the beginning that propagates further in the project. To be able to deliver the vessel on time, more workers are hired on short-term contracts. In addition, there is a high demand for flexibility in this industry and that leads to continuous adjustments by the customer, which generates changes in the original design for Company X. These changes throughout the project result in delayed purchasing and a need for reorganization of the workers in production to maintain the schedule. This results in inefficient use of the workers and thereby changes delays into cost overruns. Further, delays in receiving documentation from suppliers can result in delayed purchasing, and thereby cost overruns. Besides, we have discovered that Company X does not take advantage of the experience and knowledge within the firm, resulting in suboptimal choices, especially upstream communication.

To answer RQ2, we first must mention the high complexity and specificity that categorizes the ETO environment and makes the purchasing much more complex. This places greater demands on accuracy in the planning phase and their suppliers. Our findings reveal that changes from the customer and delays from the supplier are two of the main reasons for delayed purchasing. The delays from the supplier are forcing the PD to act reactive instead of proactive as we find as the optimal approach. Due to the complexity and specificity in this industry, it is even more important to have good coordination both internally and externally. It is important to have good information sharing across the departments, to the customer, and with the supplier. Even if this is time-consuming, the lack of this coordination leads to delayed purchasing.

To answer RQ3, we have discovered that there is a potential for improvement regarding the suppliers and how this is handled. We have discovered that Company X lacks an overview of supplier-related costs and that their low-cost supplier strategy may not be the optimal solution. Based on our findings, Company X cannot look at the purchasing price isolated but must include costs as production, outfitting, service, etc. Besides, the system they are using for supplier evaluation is not sufficient and they must implement a different routine to make sure that the PD has more data for supplier selection in future projects. Both the challenges presented above can be reduced by better coordination between the PD and production. Better coordination and cooperation between the PD and production could also help them reduce the lead-time by making a reduction of tasks. Entering into a premature agreement with the customer is also making a negative impact on the PD. This leads to adjustments and rework later in the process and complicates the purchasing activities, making the planning more difficult as components could be delayed. Lastly, we would suggest that Company X changes their approach from reactive to proactive to be able to better absorb changes. This approach will improve their responsiveness to changes and help them stay on schedule.

6.0 Concluding chapter

In this research, we have discovered that several parts of the purchasing activities must be improved for Company X to reduce their cost overruns. First, a change in routines for the evaluation of suppliers is needed to give the PD a better foundation for supplier selection in future projects. This can be resolved by better cooperation and communication between the PD and production to better utilize internal knowledge. We also suggest that Company X should spend more time on conversation and negotiation with the customer before entering into an agreement. Improvement of the supplier selection and a better overview of the costs and scope of the project before entering into agreement would positively affect the purchasing activities throughout the project. Further, we suggest that increased communication and stricter requirements are necessary for their relationship with their suppliers. Progress reports and other needed documentation which the suppliers are now sending with delays should be included in the contract agreement to prevent delays of this documentation in future projects. We also encourage that Company X is reconsidering their lowest-cost supplier strategy as this might not be the optimal solution as these suppliers might lead to a higher total cost. Last, increased specificity between the customer and Company X before the tendering process can prevent adjustments and rework in future projects.

In this research, we contribute with additional support to the ETO and purchasing literature. This study has investigated how delayed purchasing influence the total cost of a shipbuilding project. Our research shows how improved evaluation of suppliers will give the purchasing department a better foundation for supplier selection which can reduce costs in future projects. The results of the case study analysis also show the importance of cooperation between the PD and production to better utilize the knowledge within the firm. Lack of communication and coordination are the main reasons for improper purchasing and delayed purchasing, which potentially results in cost overruns. Current literature suggests that one could benefit from using functional specifications rather than technical specifications to reduce lead times. According to our findings, this suggestion is not valid for the shipbuilding industry, due to the high complexity and specificity. Further, early involvement by the purchasing department is highlighted as a critical factor in the literature to reduce costs. However, this research has discovered that early involvement does not help if they are too eager to secure sales and hurrying into an agreement with the

customer. The urge to secure sales leads to an unclear overview of the costs and often improper purchasing which propagates in the rest of the project and results in a lot of adjustments and rework. Lastly, we discovered using the lowest-price strategy in the supplier selection process might not be the optimal solution and that this strategy can lead to higher costs in total.

7.0 Limitations and Further research

7.1 Limitations

In this research, we have conducted four interviews and this small number of participants can be a limitation to our conclusion. We have respondents from three departments, two purchasers, the project planner, and the production manager, as it was important for us to get insight into the project from different perspectives. Since we only have two respondents from the PD, which have separate opinions and are working on different projects, these findings could be difficult to generalize. The optimal solution would be to have more respondents from the PD and respondents that work under the same circumstances on the same project. Our two next respondents are managers and their opinion may not be sufficient to generalize as other members of their department may have other input. Unfortunately, the limited time available and the challenges that occurred related to COVID-19 made it difficult for us to get more respondents from these departments.

This is a single case study, and therefore, limits the external validity and generalizability of the research. We considered to involve more companies in the process and perform a multiple case study, but one company withdrew during the process and the limited time made it challenging to consult a new one.

Lastly, it is important that our findings are interpreted cautiously as the main data and the foundation for this research is conducted from interviews. It could have been an advantage for us to exploit other sources to emphasize our findings.

7.2 Further research

Several topics are suggested for further investigation. This research has revealed that a system with an overview of delayed components does not exist, therefore, it would be interesting looking into different components that have been delayed. A good investigation could help identify and show the costs of delayed purchasing.

Furthermore, based on the findings in this research, it would be interesting to analyze how improved supplier selection and evaluation will affect cost overruns. Today, they select a supplier based on the price of the components and the available data are limited. If they had a tool that gave them more data about the number of working hours of assembling different components, service, delivery accuracy, and more. It would be interesting to investigate the effect on the total costs of a project.

Last, since the shipbuilding industry operates concurrently, it would be interesting to investigate how information is shared externally, between the shipbuilder and the customer after a contract is signed. This is because we have discovered that there often could be a disagreement between what has been procured and what has been sold. One opportunity could be to follow different components and look at how these components are changed and how these changes affect the project.

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9.0 Appendices

Interview guide 1 Project planning

Can you describe the procurement plan in a project, and how the plan is developed?

- What is included in the procurement plan?
- Can you describe why you have chosen this procurement plan?
- Who are involved in making the plan?

What are the main challenges in planning a project?

What are the main reasons for delays during a project?

How often do you organize planning meetings with all disciplines?

How often is purchasing department participating in the planning meetings?

Does your project plan contains conditions for sound purchasing activities?

Do you register and analyze reasons for delays of procurement activities?

Do you have an RCA (root cause analysis) for delays due to changes in design and engineering activities that affect the purchasing schedule?

If there is a delay in purchasing activities, what are the consequences?

- If there is a delay: Which factors are most important to priorities (Price, quality, delivery times, service, guarantees)?
- What are the initiatives to prevent delays in purchasing activities?

Do you consider uncertainties in the planning phase of a project?

How do you react to if you have to makes changes from the original plan?

Anything else you want to add related to planning that effect the overall performance of a project?

Interview guide 2

Interview with purchasing department

Introduction

Can you describe the procurement plan in a project, and how the plan is developed?

- What is included in the procurement plan?
- Can you describe why you have chosen this procurement plan?

At which stage in the project is the purchasing department involved?

- Who makes the decisions on which stage the purchasing department is involved?
- Who are involved in making the procurement plan?

Which factors are most important to achieve a successful purchase? (Price, quality, delivery times, service, guarantees)?

- What are the main goals for the purchasing department? (Price, quality, delivery times, service, guarantees, flexibility)?

Process

Is there a common understanding in the purchasing department on which stage in the process the project are?

  - If not: Which solutions have been applied to solve this problems?

How do you communicate with other departments in this process?

- Do you feel confident that you have enough information to make the right decision?
- Is there any problems that occurs with the communication during this process?
  - If: Which solutions have been applied to solve this problems?

If there is a delay in purchasing activities, what are the consequences?

- If there is a delay: Which factors are most important to priorities (Price, quality, delivery times, service, guarantees)?
- What are the initiatives to prevent delays in purchasing activities?
- If delays occurs, how do you act?

How do you respond to changes made by design and detail engineering?

- If changes are made by design and detail engineering, how does this affect your plan for future purchasing?

Do you often experience that you have to deal with critical issues instead of following the prepared plan?

- If: How do you handle this situation?

How often do you experience cost-overruns on a project compared to the plan?

- If yes, what are the main reasons for these cost-overruns

How often do you experience time-overruns on a project compared to the plan?

- If yes, what are the main reasons for these time-overruns

Do you have any tools that you are using to analyse why this is happening or to prevent it from happening?

Do you have any mechanism to prevent unexpected events and reduced uncertainties? (Controlling systems, how the organization is organized?)

- Do you consider uncertainties in the planning phase of a project

Suppliers

Can you describe the criteria's for selecting suppliers?

- What are the most important criteria's?

How often do you evaluate and search for new suppliers?

Which factors are most important in the purchasing processes when you negotiate with suppliers? (Price, quality, delivery times, service, guarantees)?

Who are involved in supplier selection?

Can you describe the relationship with your most valuable suppliers?

- Close relationship/contracting etc…

Can you describe the challenges you have with your suppliers?

- How do you react if the suppliers are delayed?

How do you react to changes made by design and detail engineering?

- If changes are made by design and detail engineering, how does this affect your plan of purchasing?

Materials/Equipments/Components

Can you describe the process of following the procurement process (from the customer order to the receiving of goods)?

If a delay occur, who has to cover the cost overrun?

- How much on average (percent) do delays cost compared to the original price?
- Are you secured against cost/time overruns in contracts with your suppliers?

What happens when the purchasing order is sent to the supplier later than planned? Do suppliers ask for an increased price when the delivery time is shorter than the "normal" lead-time? If yes, can you appreciate the increased percentage on the final price?

Are suppliers increasing prices for change orders (when an item goes through several changes before the delivery)?

Interview guide 3 Production leader

1. Can you describe how you get involved in a project, and are you involved in developing the project plan?
2. Can you describe how you share information and cooperate with the purchasing department?

3. What influence do you have on components that are purchased? (expereince, quality, service etc.)
4. Cheap vs expensive purchases - Do you have any preferences on the significance of the price level? (based on different criteria, quality, guaranties, service, etc.
5. If there is a delay in the delivery of a component, how do you respond? (hiring, more training, reorganization, etc.)
6. Do you have any tools to share your experience with the purchasing department?
7. Are the prodcution involved in evaluating the components you get from the suppliers (quality, service, etc.)
8. Which criteria are most important for the production? (reliable, price, knowledge of the supplier/components, etc)