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Strengthening the Competitive Advantage of Commissioning

Case study on a complex global project-based environment

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ABSTRACT:
Today's global business environment has become increasingly complex due to rapid technological innovation, changing business models and customer requirements. In a project-based environment, commissioning is the phase where a company's ability to combine its organization's competence into competitive project execution is crystallized. Yet, organizations fall short in integrating commissioning planning into the project life cycle whereas commissioning often becomes reactive by nature and end up in cost overrun. The objective of this thesis is to describe how a company's competitive advantage can be strengthened through improving its project commissioning process. An answer to this is looked for in theory related to competitiveness, organizing of firm resources in a project-based environment, project management as well as previous research on commissioning.

The empirical part of the thesis aims for understanding the internal processes contributing to competitive commissioning in case company context and give suggestions on how these can be improved. The research was conducted as a qualitative case study and data was gathered through study of secondary data and interviews and discussions with stakeholders involved in commissioning activities of the case organization.

The study identified the key factors considered critical to successful commissioning of the case product, most of them congruent with success factors found in literature. Among these the main development area was found to be in transferring of technical knowledge from project to commissioning. Using elements of action research, a framework for commissioning documentation for the case product and a proposal for responsibilities of documentation was developed. Strongly connected to theory, the framework provides a valuable base for further implementations within the case company.

It was recognized that the complexity and variance of the project scope, as well as integration with connected products, impose challenges for standardization of processes and documentation. It is however imposed that the gains of adapting a proactive approach to commissioning will win the coordination efforts related to it. Integrating technical planning of commissioning into earlier stages of a project life cycle enable early identification of criticalities, result in increased commissioning accuracy, cost reduction and better utilization of resources. Long term benefits of this is the natural inclusion of a commissioning thinking in both project life cycle and product design that might increase both budgetary and technical accuracy. Ultimately, a more efficiently executed commissioning contribute to customer satisfaction and the competitiveness of project delivery.

KEYWORDS: Competitive advantage, Project management, Project-based Environments, Commissioning Process

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Abbreviations

CM	=	Commissioning Manager
CP	=	Competitive Productivity
CPP	=	Controllable Pitch Propeller
DCV	=	Dynamic Capabilities View
FAT	=	Factory Acceptance Test
MC	=	Mechanical Completion
PE	=	Project Engineer
PM	=	Project Manager
PMO	=	Project Management Office
PBO	=	Project Based Organization
RACI	=	Responsible-Accountable-Checked-Informed
RBV	=	Resource-based View
RPM	=	Revolutions Per Minute
SE	=	Service Engineer
SM	=	Site Manager
TQ	=	Total Quality
TQM	=	Total Quality Management

1 Introduction

In a global market environment companies need to develop competitive advantage and build differential strategies in order to achieve sustainable growth. Rapid technological development, development of new business models and networks along with increased focus on cost and speed impose challenges to companies. For a company operating in a narrow area, offering knowledge intense, high-value products it is often difficult to compete with price. Neither is it possible to attain significant cost savings by introducing production improvements, production improvements or concentrating production to low cost countries. These companies need to build differential strategies and maintain a high customer centricity in order to achieve sustainable growth.

The maritime market is by nature complex. Shipbuilding consist of high-value, one-time endeavours which involve coordination of a complex network of actors and regulatory bodies. The industry is highly competitive, the demand for technological innovations in combination with tight schedules and cost limitations impose huge pressure on suppliers. While the scope of work for equipment providers has become increasingly challenging, organisational alignment towards the same goal is demanding. Managing an organisation involve not only setting up suitable organisational structure. Additionally, strengthening an organisational culture and corporate values that move towards the company strategy is important. The project organisations, and the culture within these, need to be built to secure flexibility and customer focus.

Seen from a project execution context, commissioning is the stage of a project which summarizes all efforts made in previous steps of the project. This is the phase where all parts of the project are connected and verified as a working whole. The installed equipment is inspected, tested, adjusted to guarantee its performance and operability when handed over to the customer. This is also the project phase which is most visible to the customer as part of the work is performed under supervision of the critical eyes of the customer and potential third parties. Success or failure during this phase might influence the buyer's perception of the seller, thus is there huge potential to build competitive

advantage by improving the commissioning phase of a project. Efficiently executed commissioning is a contributing factor to fulfilment of project targets and ultimately achieving customer satisfaction. Furthermore, as will be explained in the results section, issues arising during commissioning can be extremely costly. The key factors to increasing the competitiveness of commissioning are proper planning and documentation before and during the commissioning phase.

1.1 Background to the study

Commissioning is not considered a distinct profession with formal standards and regulations. The documentation and boundaries related to the job are addressed within each company (O'Connor et al., 2019). The scope of the work is often complex, demanding strong technical skills and adaptation to variating circumstances on site. Nevertheless, commissioning is traditionally considered costly and time consuming and the complexity of the process is often underestimated (Lawry and Pons, 2013). Successfully performed commissioning as a means to achieve competitive advantage has been acknowledged by few companies. To reach the full potential of the commissioning phase, there is a need for integrating the commissioning process into the life cycle of projects to constitute structured planning, execution and documentation.

The case company is an international solution provider with a long history in the marine and energy sector. The importance of developing the commissioning process has been acknowledge in the case company. The aim is to support the customers even better and provide a qualitative and efficient commissioning. Many development activities have been undertaken during the past years with the aim to strengthen the knowledge base, clarify roles and responsibility within the commissioning. This is however a continuous process and due to the dynamic environment, the case organisation struggle with keeping up with the rest of the organisation.

In the case organisation, cost budgets for commissioning are often overrun and quality issues caused by lacking information or documentation have caused high financial losses

and lost reputation in a few projects. Quality of documentation as well as clarification of roles and responsibilities regarding documentation is identified as the areas where development and alignment of a business wide directives is needed the most. Previous projects with aim to align commissioning documentation have been started but the task has proven to be challenging. For this reason, it was decided to conduct this master's thesis research on the topic in order to provide the organisation with a broader view of the value of commissioning and provide a base for improving the commissioning process and the documentation in general.

1.2 Research objectives and research question

The objective of this thesis is to describe what factors contribute to the competitiveness of commissioning and how an improvement of the commissioning phase contributes to the competitive advantage of companies operating in global project-based business environments. The analysis will be done in the context of the marine business environment, where the role of commissioning as contributor to project success is significant.

In order to achieve the research objective a qualitative case study on a company operating in the marine industry will be performed. The company's competitive landscape and current commissioning practices, and its role in the project life cycle, will be analysed. The aim is to create a framework that can be used for development of the commissioning process, strengthen its competitiveness.

The research questions of this thesis are

How to strengthen the competitiveness of commissioning on a global complex business environment?

How can the case company strengthen the competitive advantage of its project commissioning phase?

The first research question will be answered by the theoretical framework presented in the literature review section. A case study with in-depth analysis of the research findings and managerial recommendations will answer the second research question.

1.3 Limitations and restrictions

Commissioning in a project context can be studied from various dimensions. Many aspects would have been valuable to study but could not be done within the time frame of the thesis. The limitations for this thesis will be explained below.

In order to stay within the set time schedule of this thesis and to be able to collaborate with a smaller group of people, the case study is limited to one product group at one of the company's business lines. The product group was chosen by the case company because the need for improvements was greatest for that specific product. However, the key persons supervising this thesis have responsibility of the development of the commissioning process of several business lines. As they have insights into the whole marine business they contributed with a broader perspective on the issue.

As the empirical research is performed as a single case study, the findings and recommendations are also limited to this case organisation. The challenge for the researcher is the generalization of the findings based on this limited case. However, some of the findings can be present also in other organisations and companies. The recommendations might be valuable and provide ideas for development in other organisations within the case company.

The thesis is limited to improvement of the company´s internal processes while external forces in the value chain, such as suppliers and customer, will not be investigated in detail. Due to the nature of the maritime business environment both the depth of the business relationships as well as customer's expectations vary largely around the globe. Conduct-

ing a valid customer survey concerning expectations on commissioning would be extensive and complex. It is expected that improving internal processes will result in competitive advantage and increased customer satisfaction.

Many large improvement activities around the commissioning process has been performed in the case company during the last years. It was identified before this thesis started that the main issue in the case organisation is information flow in form of documentation for commissioning. This was confirmed during the initial interviews with managers in the commissioning organisation. For this reason, further interviews focused on documentation and communication flow. The suggestions for improvements are directed to the case organisations. The framework created in this thesis might however be possible to implement also in other business lines in the future.

Quantitative data on budget overruns will be presented in short in this thesis. However, the root causes of the budget overruns will not be explored in detail in this study. Instead some main projects will be discussed; projects where the lack of documentation and information transfer have been clearly identified as contributors to the overruns. It is obvious that raising the efficiency in the organisation will bring cost savings and by that also increase profit. Cost as a focus area of the competitive strategy as well as the concept of total cost of quality will be acknowledged in the theoretical part.

The projects that the case organisation deliver vary largely in scope and complexity. This aspect impedes the creation of a generic framework that could be applied on all types of projects. A classification of projects based on the level of complexity and additionally introducing a structure for recourses, documentation and preparation accordingly would be needed. This aspect will be touched on in the results section but an in-depth investigation on different project types cannot be provided within the limits of this study.

As this project will focus on commissioning the review of project management procedures in the case company will be made on a general level and focus on how commissioning is positioned in the project life cycle today. Special attention will be given to the parts that is considered part of the quality assurance and commissioning planning process.

The global Covid-19 pandemic (World Health Organization [WHO], n.d.) that broke out at start of this thesis did, in addition to delaying the writing of the thesis, result in changed data collection methods. As a result of the pandemic, the case company recommended all employees to work remotely and avoid external meetings. Due to this all interviews were made remotely. A workshop that was planned to be held with stakeholders in the case organisation was cancelled and conducted in another form later. Meeting the stakeholders in person would have given more insight into the processes. Conducting interviews in person generally build trust and create a more open atmosphere.

1.4 The expected contribution

The previous studies on industrial commissioning are scarce. The synopsis of the theoretical framework show that previous research takes different angles and many of them have aimed for improving specific areas of the process. This thesis will contribute to the literature in the area by building a theoretical framework abridging the key success factors contributing to competitive advantage in complex environments and specifically connecting it to project management. The framework contributes to the knowledge area of the maritime project management.

This study will identify the factors that are critical to successful commissioning in context of the case product and give recommendations for improvements of the commissioning process in the case organisation. By connecting this to the theoretical framework the case company receive a base for further developing their operations, both within this organisation as well as in other similar organisations.

The empirics of this study provide a framework for formulation of commissioning documentation. During this research the creation of a frame for a commissioning manual, and a RACI model for commissioning documentation, was introduced. By further developing these and implementing them in the planning process of all projects, the case organisation can improve the efficiency of their commissioning execution.

1.5 Thesis structure

The thesis starts with an introduction where the thesis subject, background and aim of the research are presented. Then follows a literature review, which constitutes a theoretical framework built in five sections. The literature review starts by describing the marine industry and its competitive landscape. The second part discuss theory on competitive advantage and how a firm's competitive strategy can be incorporated in the organisation. After that the different organisational settings that a project-based environment impose is described and discusses. Then follows a short introduction to the project management area of knowledge. Finally, the previous research on industrial commissioning process is discussed. The literature review is concluded in a brief synthesis of the theoretical which forms the framework that will be used for further analysis in the case study. After the literature review, the research methodology and research philosophy are presented. Finally, the thesis moves on to present the findings of the case study along with an in-depth analysis and discussion of the results. Additionally, managerial implications, limitations and implications for future studies will be presented.

2 Theoretical framework

This chapter will provide an analysis of the concept of competitive advantage and competitive strategy formulation in complex global business environments. The analysis will be done in the context of the marine industry with its project-based nature. The aim is to create a theoretical base that explains the competitive business environment that the case company operates in. Following chapters will build on the formulation of a competitive strategy by explaining how the competitive factors can be brought to organisations and processes, ultimately to the commissioning process which is the focus of this thesis. Commissioning as an integral part of the project life cycle will be analysed from different perspectives found in previous research within the area. In the end of this chapter the literature review will be presented as a synthesised theoretical framework.

2.1 Competitiveness in complex global environments

All businesses today face global competition in some form. The complexity for a company operating globally lies in coordinating in an environment of interconnected actors, emerging competitors and new technology. Today's business environment is a result of two contributing factors; increased globalisation and the rapid technological advancement (Hitt et al., 1998; Hill, 2013).

The strategies for coping in a turbulent business environment can be many. Suikki et al. (2006) outline that navigating in an unstable and unpredictable business environment require continuous development of new capabilities. Furthermore, during times of financial turbulence a company's success strongly depend on its abilities to find new strategies (Liu, 2003; Liu & Takala, 2011). According to De Kluyver and Pearce (2015) sustainable value creation is a key to success and depends on a company's ability to understand its competitors and customers. Hamel and Heene (1994) emphasise that survival in today's market space require radical business innovations; redefining the definition of your market and radically rendering both products and services.

Sustainable competitiveness of companies operating in complex business environments is achieved through forward-looking. This means companies need to continuously update their strategies to correspond to disruptive events affecting their operations (Liu, 2013). Different strategies for achieving competitive advantage has been proposed in numerous studies. These will be discussed further in the following chapters.

The challenge in a global market is that the changing industry segment call for evolution of company's business strategies. Hitt et al. (1998) explain that a firm's success depends largely on its ability to capture the new competitive advantages. Two main themes emerge in the literature on strategy development; one is the intercompany strategies to cope in a changing world, the other is the ability to build networks of connections to other global partners. Both equally important and a sustainable strategy uses building blocks of both, yet ever changing.

In a project-based environment complexity origin from uncertainties in the work and the behaviours of organisations and people. Projects are considered complex when they are complicated to manage; requiring integration and interaction between different parts. The concept of complexity is in its origin a description of a human perception of a situation and thus based on personal beliefs and interpretations (Project Management Institute [PMI], 2017). Wysocki (2019) explain the complexity of today's project environments originating from five main factors; increasing speed in developing new products, constant change, high cost pressure, complexity and uncertainty.

The marine industry is a unique business environment. New building of ships, as high capital, one-time endeavours, involves coordinating in a vast network of actors, complex ownership structures, regional laws and regulations. This induce high pressure on companies operating in this environment. For this reason, the characteristics of the marine industry need to be explained implicitly in next subsection.

2.1.1 The marine industry environment

The shipbuilding contracts have continuously declined since the peak year in 2008, resulting in hardened competition and structural change in the market environment. Increasing trade restrictions within the G20 countries, eg. policies that oblige shipbuilders to choose domestic producers, have made protectionism increase and thus global sales volumes decrease. This hinders the free market competition (OECD, 2018; Bazargan, 2019). SEA Europe, Shipyards' & Maritime Equipment association, is one of the organisations who push for free trade agreements and ensuring certification and approval of marine products do not hinder trade (OECD, 2018).

The marine industry has gone through a significant transition during the past decades since competition to capture the decreasing amount of newbuilding contracts has become fiercer. Europe has lost its merchant newbuilding segment to Asia whereas the European shipbuilders have become specialized in providing more complex ships. SEA Europe (2019) expects the competition on the global market to continue as challenging for the European marine cluster as South Korea and China openly declared their target to overtake Europe's position as global technology leaders and providers of complex ships. This and the growing protectionism imposed by international trade barriers further stress the importance of marine equipment manufacturers to find and strengthen their competitive advantage (SEA Europe, 2019). This has resulted in a global leadership in providers of advanced systems and technology among European equipment manufacturers. Highly educated and skilled employees as well as large annual investments in R&D help maintain this leadership position. The investments in smart and environmentally sustainable solutions is another factor which gives European marine industry a competitive advantage towards the growing tensions in the market.

Increasing regulatory pressure increase the development of smarter and cleaner technologies and creates a natural strive towards development in the business (OECD, 2018). Technology providers have a hard time to keep up with the technology required from ship owners. There is a competition to invent innovative solutions, but the challenges

are many. Integrating solutions and systems, resilience related to fear of cyber-attacks and system failures, finding and implementing new technology are a few of these (OECD, 2018; Bazargan, 2019). This technology intense environment induces a challenge in finding the key resource; skilled employees. The industry should be made compelling to employees in order to attract motivated, educated and skilled workforce (Sea Europe, 2019).

Company structures and business models in maritime business are the same as in any other business. However, the diversity of the business ads up by the many maritime clusters commonly prevailing globally. Stavroulakis et al. (2019) summarize the competitive factors identified by several scholars studying these maritime clusters. The competitive landscape on both regional and global level is influenced by clusters, rendering competitive strategy formulation (Stavroulakis et al., 2019; Porter, 1998).

Table 1. The competitive factors of maritime clusters (From Stavroulakis et al., 2019).

No.	Strategic factor
1	Presence of research centre and/or higher education institution in the region
2	Existence of a labour market
3	Shared inputs and/or local supplier synergies
4	Entrepreneurial culture
5	Corporate culture
6	Presence of an official governance structure/policy
7	Presence of financial institutions
8	Market entry and exit barriers
9	Breadth and diversity of markets
10	Existence of innovation system
11	Natural resources
12	Knowledge spillovers between firms
13	Firms' specialization
14	Firms' diversification
15	Synergies between firms' specialization and diversification
16	Trust between cluster members
17	Knowledge creation and management
18	Effective strategic management of firms
19	Factors inherent within the maritime industry
20	Competition between the cluster's members
21	Cooperation between the cluster's members

The concept of quality assurance has strong traditions in the maritime business. Quality of technology as well as documentation and human resources is assured by independent

accrediting bodies. The assessment of a company's compliance with international standards, such as ISO 9001, is made by classification societies such as Lloyd's Register (LR), Bureau Veritas (BV), American Bureau of Shipping (ABS) and Det Norske Veritas Germanischer Lloyd (DNV GL) (Institute of Chartered Shipbrokers [ICS], 2019). In addition, every ship is classed by one of these classification societies. Every class society have developed detailed specifications concerning materials and methods used in construction of ships and all equipment onboard. The classification means an approved compliance to the class regulations witnessed by one of their surveyors (ICS, 2019).

There are many international associations working with protecting and promoting interests of different actors in shipbuilding. Among these the International Maritime Organisation (IMO, 2019), an agency established by the United Nations, have a special agenda to reduce the marine environmental impact and promote security and safety in shipping. IMO itself does not govern the codes and regulations it has set but it is up to the classification societies to ensure compliance with IMO when the flag state has incorporated the IMO recommendations in it's laws (ICS Shipping Business). The IMO recommendations have been significant drivers of technological advancement in the industry.

As a conclusion, the maritime business environment can indeed be considered complex in its special construction. Both customers and regulatory bodies oppose pressure for continuous development of technology and business operations. No single competitive strategy alone can claim to be the best and sustainable one to cope in this dynamic environment. The following chapters will discuss some of the prevailing competitive strategies within the field.

2.2 Competitive advantage

International business was traditionally viewed as a simple trade of goods from a country or company specialised in producing something that another country could not. This rather simple and static view of trade however changed when theories of competitiveness were introduced. The early theories describe the basis for competitiveness as the sum

of comparative advantages that firms can achieve (Choo & Moon, 2013). The term competitive advantage refers to offering products or services that are superior compared to competitors thus offering greater value to customers. Early strategic management research tried to explain specifically why one company outperform another (Choo & Moon, 2013). As a result, the underlying strategical choices that lead to competitive advantage has been studied extensively (Hitt et al., 2001).

The research aiming to find sources of competitive advantage is vast. Many of the models for evaluating competitiveness have been developed for analysing manufacturing firms, proposing different methods for evaluating the efficiency of a firm´s operational functions (Liu, 2007). Hitt et al. (2001) describe that a company achieves competitive advantage when it incorporates a strategy which is superior to competitors and impossible to imitate or duplicate, resulting in better revenues as a result from efficiency of labour, production and recourses. Ulrich & Lake (1991: 82) describe competitive advantage as a result of a capable organisation where managers understand the balance between internal efficiency and customer value creation and set up the organisation accordingly. Tidd (2006) further emphasize the understanding of value creation, as well as ways to produce value, as keys to success. Sustainable competitive advantage is achieved when the customer recognizes the gap in received value two actors. When this occur, it is likely that the competitive advantage will remain also in the future (Tidd 2006: 28–29, 250.).

Defining a fixed model for achieving competitive advantage seems to be ambitious, researchers underline an organization's ability to adjust to prevailing circumstances. While Porter (1985) sees competitive advantage as something that is achieved by strengthening what you already have, Liu and Takala (2011) propose a model that measure operative competitiveness, helping a company to adjust its strategy in order to score better. This adjustability is emphasized by a number of researchers (Sharma & Sharma (2020), McCann et al., 2009) who state that resilience on both organizational and individual are necessities in a turbulent business environment. Michael Porter (1980) defined two main

strategies for gaining competitive advantage; cost leadership and differentiation. A business focusing on cost leadership will in practice need to integrate cost awareness and tight cost control in all functions of the company, optimizing the costs throughout the value chain. A differentiation strategy can be seen more sustainable. By differentiation a company provide their customers with something unique in terms of product, quality or service. Combining the two strategies with the activities a company need to perform to achieve market leadership leads to a third strategy; focus, or segmentation (Figure 1). Companies following a focused strategy commonly operate in an environment with limited costumers and usually has a very specific product offering not needed by a large costumer group. Companies trying to focus on both cost and differentiation will not succeed. Whatever strategy a company choose, it has to integrate the strategy in the whole value chain, fostering the same mindset in all operations of the company.

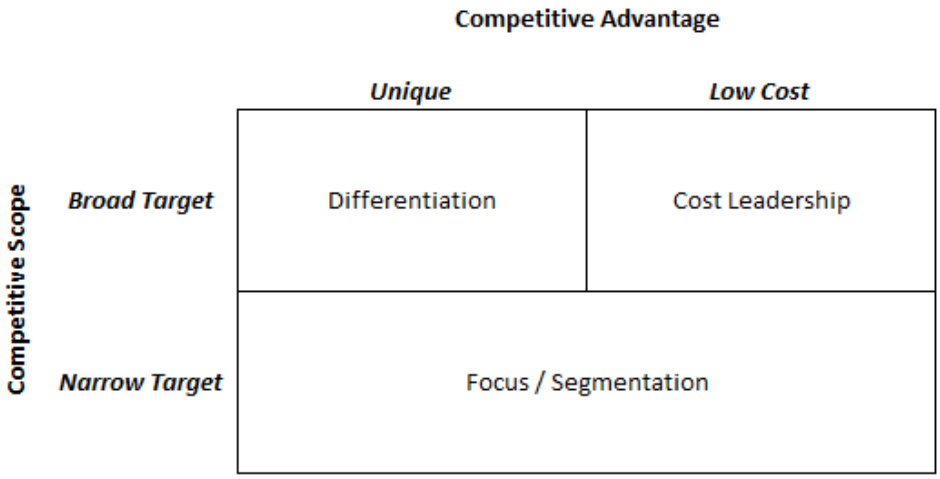


Figure 1. The generic strategies to gaining competitive advantage (Adapted from Porter, 1985).

Research on competitive advantage is dominated by two main areas; the industry environment view and the organisational, or, the resource-based view. The well-known framework for industry analysis was introduced by Michael Porter in 1980. According to Porter (1980) the key to formulating a competitive strategy is analysing and understand-

ing your industry environment. A company works against, and with, the forces of an industry to gain competitive advantage (Porter, 1985). Barney (1996) introduced the resource-based view (RBV), claiming that a firm's internal resources and capabilities are the only attributes to competitive advantage. While the industrial analysis investigates the external threats, the resource-based view looks at a firm's internal strengths and weaknesses. Using the VRIO framework (pp. 145-162), is a powerful tool for evaluating a firm's recourses based on their value, rareness, imitability and organisation.

It seems the traditional theories were unable to be applied as such in the increasing complexity of global business, whereas many of the resource-based theory contributions have evolved towards the dynamic capability view (Teece et al., 1997; Mahoney, 1995). Teece et al. (1997: 518) state that "the competitive advantage of firms lies with its managerial and organizational processes, shaped by its (specific) asset position, and the paths available to it". This statement captures the adaptability required by companies also today. Recent research try to further offer new tools more suitable for global dynamic environments over time (Cho & Moon 2013; Liu 2012).

To provide a theoretical base for the analysis of the case company, one theory alone is not enough. An understanding of the external as well of the internal environment is necessary in order to create a framework for the competitive advantage of commissioning. The puzzle is twofold; firstly, an understanding of the role of commissioning as contributor to the competitive advantage of the firm need to be created. Secondly the competitiveness of commissioning phase in terms of efficiency, quality and cost need to be explained. For this reason, the prevailing theories have been chosen and will be discussed below.

2.2.1 A firm's external environment and the industry analysis

The basis for a company's competitive strengths lie within their resources and core competences. However, the company's strategy needs to match the industry environment in order to get the most out of it. Success lies within understanding the environment and

being prepared to change the competitive strategy in response to external threats. (Thompson & Strickland, 1999). The competitive landscape of an industry is very much restricted by external factors such as geographical, technological, legal, political, societal and economic factors. These factors not only influence the competitive strategy of a company but also contribute to the attractiveness of the industry (Thompson & Strickland, 1999). These attributes are also referred to as the 'general environment' in which a company operate, and which cannot be controlled (Hitt et al. 2001).

Understanding a specific market begins with understanding the economic situation with factors as market size and growth rate, scope of rivals, number of customers, supply networks, industry profitability and so forth (Thompson & Strickland, 1999). The industry environment, in which a number of factors contribute to the opportunities and threats of a company's competitive positioning, determine a company's profit potential (Hitt et al., 2001; Porter, 1980). Michael Porter (1980) introduced a model of five competitive forces (Figure 2) which describe the generic factors that influence the competition in any industry.

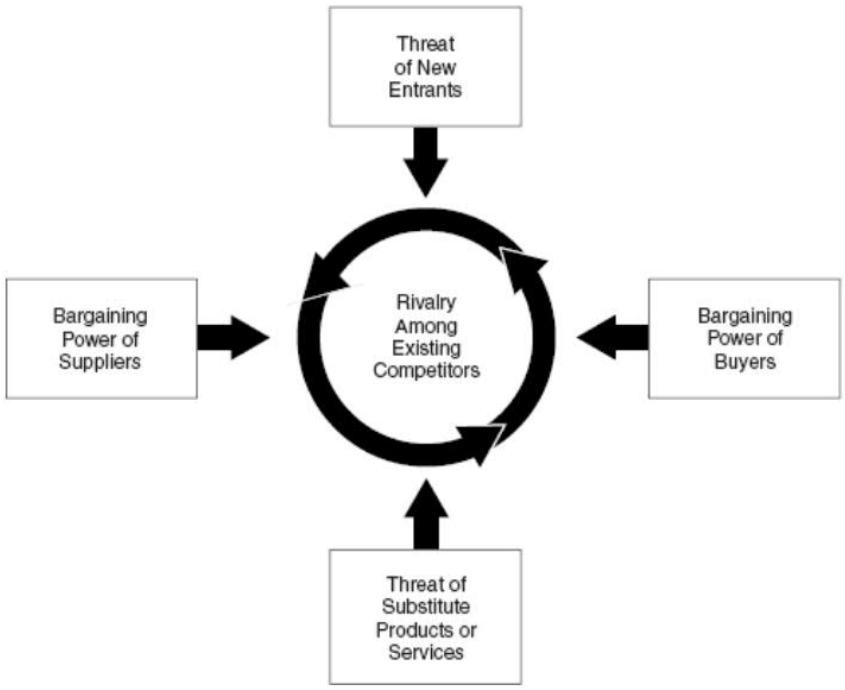


Figure 2. The Five Forces that Shape Industry Competition. According to Porter (1980).

The five force model is a powerful tool for analyzing a company's competitive environment and the company's own position in it. The strength of the forces determine the level of profitability in the industry. Strong competitive forces result in low profit while positive profits are easier to attain when the competitive forces are at a favorable level (Porter 2008). The five competitive forces will be described below.

Rivalry among competitors

Intense rivalry among competitors generally drive down profitability in an industry and is visible in form of price reduction, discount campaigns, marketing campaigns, new product development and service improvements. Even more fierce competition occurs when an industry's growth rate is low and when competing companies are rather similar in size and structure. Additionally, if the exit barriers of an industry are high existing competitors will stay in the industry competing for the profit share (Porter, 2008).

Threat of new entrants

New entrants in an industry put pressure on existing companies by competing for market shares. The threat of entrants thus influences the potential profits in an industry. The possibility of threat of new entrants depends on the entry barriers. The entry barriers are many; largely due to the economies of scale that incumbents in an industry enjoy. Incumbents often have established supply chains, technology, logistic chains that are utilized to a lower cost than newcomers would have. There are also economies of scale on the demand-side; referring to customers reluctance to change to a product from a new or smaller company. High switching costs will also influence new entrants. A number of capital requirements raise the entry barriers, such as investment in facilities, inventories and other capital resources. Furthermore, newcomers might have possession of distribution channels or material supply which may be difficult to reach for new entrants Porter 2008).

Bargaining power of suppliers

Suppliers who are in a strong position to bargain will charge higher prices and gain advantages to themselves by providing lower quality, restricted services or moving costs to their buyers. Such situations occur when there is a limited number of suppliers, there are no substitutes or when the switching costs are high. The bargaining power of suppliers is often high in industries with highly differentiated products.

Bargaining power of buyers

The buyers have similar negotiating arguments as the suppliers, pushing down prices and demanding better quality and service when there are few buyers in the market. Companies with high fixed costs will try to fill their capacity by reducing selling prices, increasing rivalry further. Industries with standardized products and low switching costs will make it easier for buyers to compete suppliers against each other. Many customers are price sensitive, for example when the purchasing price has a large influence on the buyer's total costs. In high-value, undifferentiated products quality and service can be a more important factor than price as bad quality can become far more expensive than the purchasing price in the long run.

Threat of substitutes

Substitutes are products or services that serve a similar purpose as an industry's product. Examples of substitutes are for example videoconferencing vs. traveling or plastic vs. aluminum. The attraction of a substitute grows if the price-value ratio is better than the industry's products and the switching cost is low. Potential substitutes are not always obvious; for this reason, companies should be alert to changes in trends, technological advancement and material improvements as they might impact the competitive situation negatively (Porter, 2008).

A sixth force was proposed in the mid 1990's, which is 'complementary products'. Complementary products and services are products that are provided together with another product. The positive effect of this is that customer experience added value by buying

complementary products or a bundle of products. Complements can affect the profitability and demand positively in some industries (Porter, 2008).

In some articles governmental regulations is also described as one influential force. This can be considered a valid addition as the global environment indeed offers challenges of navigating among both local and global policies and regulations. The influences of this force continuously fluctuate as a result of the general economic and political situation and in result of trade agreements between countries and economic associations. As explained in previous chapter about the marine industry, regulations concerning environmental impacts is one of the main drivers of strategic decision-making in the marine industry. However, Porter (2008) describe the governmental factor rather as a contributor to the five forces and not a force in itself for the reason that governmental regulations can't be seen as positive or negative influential factors.

Porter's five force model is one of the few theories that have has lasted over time and is today thought at business schools all over the world. The reason for its superiority is that it is timeless. The main idea, to understand your environment as a whole rather than simply focusing on your competitors, is as valid today as it was in 1980. However, the internal firm environment along with the corporate values and culture need to be in place to successfully realize the strategy. Following section will discuss this further.

2.2.2 The firm internal environment - resources, capabilities, and core competences

Many organisations strive for operative efficiency; to reach profitability by optimizing their operations. This is however not enough for achieving sustainable competitive advantage. Today's dynamic business environment forces companies to alter their operations continuously and align the operations with their competitive strategy (Porter, 2008). Although a company's competitive potential depends of the value of the recourses, the full potential can't be reached without organising the firm's resources properly (Barney, 2000).

Building the firm internal environment, utilizing resources and strengthening core competencies in line with the strategy is the next step in the process towards above average profitability (Porter, 2008).

A company's resources can be divided into physical, financial, human and organizational. Each of them contributes to the strategical landscape of the company. De Klyuver and Pearce (2015) present an evaluation of the strategical value of these resources that could be performed by four topics:

1. The value of the resource and its role in building sustainable competitive advantage
2. The uniqueness of the resource compared to competitors
3. Can the resource be copied by competitors and to what extent?
4. Does the company have capability to take use of the full potential of the recourse?

The resource-based view of a firm is a commonly used framework for analysing the strengths and weaknesses of the firm's resources based on the questions stated above with the aim to achieve sustainable competitive advantage and profitability (Barney, 2000). Fahy (2002) explains that organising the spectrum of recourses that global companies attain offers an additional dimension of complexity.

Resources can be both tangible and intangible. Many of a firm's tangible resources are common and easy to imitate or substitute by rivalling firms. Resources are unique to every company and are formed by the strategic decisions that companies take. The development of these assets forms the core competences that is the foundation of a company (Prahalad & Hamel, 1997). It is the combination of processes and core competences that result in the rareness called organisational capabilities (Ulrich & Lake, 1991).

The concepts of core competencies and capabilities are used by numerous of researchers to explain the firm internal environment and both definitions as well as applications are many. Capabilities is generally understood as elements that entitle a firm to explore and utilize its recourses, enabling management to achieve certain strategies (Barney, 1996).

Building organisational capabilities reaches far beyond simply recruiting skilled employees. Human resource practices that increase the competitiveness of people consist of appropriate training of employees, building social relationships and fostering the right attitudes and practices (Ulrich and Lake, 1990).

In a business environment with intense competition and technological innovations, price and performance the traditional analysis of sources for firm success has proved to be insufficient. The dynamic capability view, as developed by Teece et al. (1997), propose that firm success is achieved by continuously acknowledging the external opportunities and reconfiguring internal processes and routines to capture them. A firm's dynamic capabilities is referred to as the firm's ability to react to rapid changes in the environment by coordinating its network of accumulated knowledge and skills in the best way. Three main capabilities are proposed. The first being the employees' ability to rapidly create new knowledge. The second being the ability to incorporate this new knowledge into the firm processes, also incorporating customer feedback. The third being the ability to reconfigure existing company resources that has become outdated. According to Fainschmidt et al. (2018), for a company to achieve competitive advantage by utilizing its dynamic capabilities, a strategic match needs to be found between the external environment and the firm internal operations.

To summarize this section, literature point to one direction; superior performance can be achieved through organising and optimizing a firms resources in correspondence to the competitive environment and strategy of the firm. Explicit tools for doing this seems however to be lacking. Literature is combining the resource-based view with other theories to try to find the optimal explanation, whereas more recent literature emphasise the flexibility needed in today's business environment. The following chapter will examine the internal environment from a value chain perspective.

2.2.3 The firm value chain and linkage of activities

Understanding the firm's value chain is an integral step in analysing the strategic resources that a company possess and can nurture in order to achieve competitive advantage. The industry structure influences the formation of the value chains in your company and among competitors. As a reaction to this, the value chains of suppliers, buyers and sub-suppliers are interconnected and influence activities of all parties (Porter, 1985).

Figure 3 shows the value chain of a company; imposing the main activity areas that need to be considered as part of global or local coordination. A firm's value chain can be divided into primary activities and supporting activities. A company's value activities are the building blocks of a company's competitive scope.

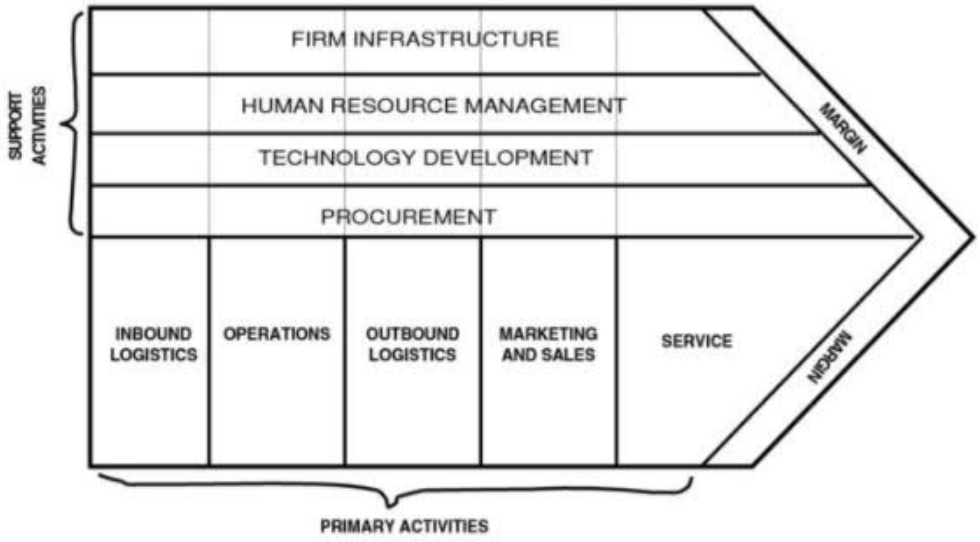


Figure 3. A firm’s value chain. (Adopted from Porter, 1985)

Comparing the cost of performing an activity against the value received is not an appropriate way to do cost analysis. The value chain gives a more distinct view of the competitive value of a firm's activities (Porter, 1985). Additionally, a firm’s supportive activities can sometimes be considered overhead costs when they in fact contribute to the firm competitiveness and efficiency of internal processes and thus drive down costs in the organisation.

Porter, 1985 explained that the linkage of the internal activities; the way activities are optimized and organised; is crucial to the efficiency of an organisation. Strengthening linkages between activities often result in reduced costs and better performance. Coordinating between vertical linkages to suppliers and other network parties might be challenging but also provide opportunities for achieving competitive advantage by innovative cooperation with external parties.

There are often linkages also to the customer's value chain. Understanding the customer's value chain and the usage of the product is important. For example, delivering a product to be installed into customer facilities require coordinating in design phase, delivery and installation phase. Creating a good relationship with the customer will improve the linkage and increase the competitive advantage of a company (Porter, 1998).

2.2.4 Human resources

The term organisational capability refers to a company that successfully adapts to changing customer and market needs by utilizing the full potential of its organisational competences (Ulrich & Lake, 1991). The strategic importance of human capital is widely recognized in management literature (De Kluyver & Pearce, 2015; Ulrich et al., 1999: p.56, p.77) However, according to Ulrich et al. (1999), the importance of nourishing and managing human resources is often underestimated. An organisations management need to acknowledge human resources as an equally important aspects as any other strategical goals.

Studies show that there is a strong connection between human resource management and customer perception of the company. Employees who are undermanned, and not provided with the support they need for doing their job, will naturally perform insufficient service to customers (Ulrich et al., 1999: 57-58.). Eldor (2019) conducted a study on how collective engagement improve value creation. The study proved the connection

between a shared and a company’s abilities to create value. This proves the value of human assets.

Hitt et al (1998) emphasise the importance of knowledge sharing as a means to strengthening a firm's core competencies. Developing knowledge management processes in a firm builds the capabilities and flexibility needed for sustaining competitiveness. Knowledge management is mentioned by resource-based theorists, where firm-specific skills that are non-imitable are considered valuable resources (Barney & Clark, 2007).

As described in previous chapters, today's business environment requires organisations to be flexible and combine their resources into dynamic capabilities in order to sustainable success. In the recourse-based view focus on analysing the role and value of human resources as well as on the efficient organizing of these. A company's HR function is traditionally seen as leading the development of a firm's human capital. (Barney & Clark, 2007). To increase organisational flexibility, the HR decisions are seen in form of restructuring, laying off activities, outsourcing etc. (McCann et. Al, 2009). More recent studies highlight that this flexibility require a high level of resiliency among employees on individual and group level. Sharma & Sharma (2020) conducted a study that proved the relationship between team resilience and competitive advantage. Organisations need to build resiliency to cope with fast changes and risks. Team resiliency is proposed to be built by fostering an open atmosphere where managers are easy to reach, all team members are free to share thoughts and ideas. This creates a common social belonging where interruptive events are handled positively and with confidence.

2.3 Organising work in a project-based environment

The main building block of a competitive organisation are three; hiring skilled employees, ensuring organisational capabilities, competences and skills needed as well as the strategic organization of a firm activities. (Thompson & Strickland, 1999). The organisational structures reflect the external and internal firm environment. The external factors as

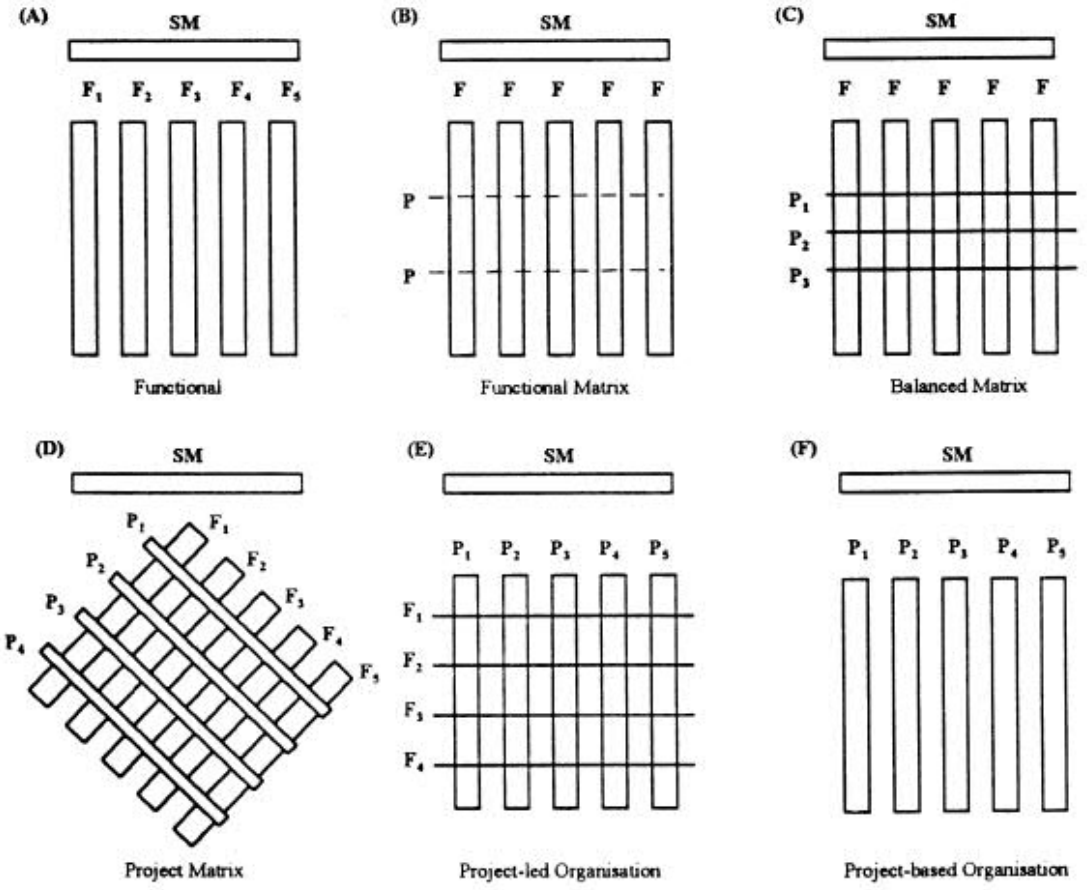
mentioned in chapter 2.2.1. in combination with the level of uncertainty in the environment, size of the company and role of technology forms the basis structure of a firm. The internal environment as mentioned in chapter 2.2.2. and 2.2.3. influence the formulation of organisational culture and values.

Variations of the traditional functional organisation are typically process-oriented organisation or decentralized organisations based on geographical location or business lines. Matrix organisations are efficient for implementing joint strategies and decision making across disciplines, while it often is seen as a rigid, bureaucratic and complex organisational form to manage. Cross-organisational collaboration and the establishment of support activities are necessary in all organisations. A mix of different organisation types is often utilized in firms; in global enterprises there can even exist different setups in different business units (Thompson & Strickland, 1999). The structural characteristics of an organisation provide clear boundaries and procedures for employees to perform tasks efficiently. However, the challenge is to balance between structure and flexibility. Today's organisations often work beyond the formal structures, with lower hierarchical boundaries and agile working methods in project teams and cross-functional teams. A project is an efficient way to utilize knowledge across organisational boundaries.

A project can be broadly defined as a one-time endeavour to design, produce and deliver a product by a group of people coming together for this specific aim (PMI, 2017). As projects are dynamic in its nature, rigid hierarchical organizations do not provide the best environment for competitive execution of projects. Today's business is increasingly project-based, whereas project-based organisational setups are becoming more common (Turner & Miterev, 2019). The delivery of high-value, complex products typically require significant engineering efforts and a high level of involvement with customers and other external parties. A flexible project-based organisational setup is most suitable to cope with uncertainties and risks related with this process (Hobday, 2000). However, the success of a project largely depends on the firm’s ability to embed the projects into the organization (Thiry & Deguire, 2007).

2.3.1 Project-based vs functional organisations

Hobday (2000) distinguishes six variants of organizational setups (Figure 4), from functional organization to project-based organization. The two main differential factors in these setups are the reporting lines and level of authority over recourses. In a functional matrix the project manager only coordinates assigned resources and both project managers and resources report to the function heads. In a balanced matrix the project responsibility is divided by project manager and department heads, while a pure project-based organization divides resources under specific project managers or projects.



Key:

* F_1 - F_5 = various functional departments of the organisation (eg Marketing, Finance, Human Resources, Engineering, Manufacturing, R&D)
* P_1 - P_5 = major projects within the organisation (eg CoPS projects)
* SM = senior management

Figure 4. Organizational setups in project-based business. A. Functional, B. Functional matrix, C. Balanced matrix. D. Project matrix. E. Project-led organization. F. Project-based organization. According to Hobday (2000)

According to Thiry and Deguire (2007), operating projects in a traditional functional organization is not optimal. A traditional organization is often static and interaction between departments is low, resulting in tensions between the flexibility demanded by projects and the control exercised by organizational heads One source of tensions is lack of dedicated resources to projects; organization heads might do work prioritizing without knowing the real status of projects. Another source of tension is conflicting reporting

practices and demands. Decision making in projects might also be slow as department heads need to be consulted for decisions, which in turn result in lack of trust and dedication to the project (Thiry & Deguire, 2007). Unclear specifications and rules of communications further deprive the success of projects, resulting in a negative customer experience (Hobday, 2000).

The connection between project efficiency and organizational setup has been emphasized by researchers. A study conducted by Hyväri (2007) clearly indicated that that the project matrix and project-based organizations resulted in most successful projects. Hyväri (2007). According to Hobday (2000), managing complex products in project-based organizations result in better customer satisfaction thanks to the project-based organization's ability to respond rapidly to changes and interruptions, as the decision making is within the project rather within a bureaucratic functional organization. Furthermore, the innovation process of complex solutions gains from the dynamic settings that constitute a project (Davies & Hobday, 2005, pp. 20-55).

The challenges with project-based organizations are commonly recognized. The main challenges are related to organizational learning, horizontal knowledge sharing and corporate strategy implementation. This since projects are considered one-offs and project teams remain in silos with little communication between teams. The coordination of resources between projects is also more challenging in pure project-based organizations. Additionally, a project-based organization can be less capable to perform routine work and develop work processes to achieve cost advantages (Thiry & Deguire, 2007; Hobday, 2000).

2.3.2 Integration between projects and organisational units

The value chain proposed by Porter (1998) analyses the activities of a firm and gives guidance on how to organize different activities. Activities are divided into groups and result in an organizational structure. This differentiation into groups, organizational departments, need coordination. This coordination is often referred to as 'integration'. The

strategic importance of successful integration of projects and organizational functions is underestimated by many firms (Thiry & Deguire, 2007; Hobday, 2000). As discussed in previous section, the organizational setup provides the base for operation. However, in order to accomplish valuable integration far more extensive mechanisms need to be in place. The organisational management should centre around value creation for all stakeholders, building on the dynamics needed for successful project execution.

In a strong project organization, the PM has equal decision power to department heads and is communicating directly with senior management of a company. He has direct control of recourses in his project. In this case customer contacts is handled fast and efficiently and team members feel empowered to serve the project as good as they can. Project team members were highly dedicated to the team and enjoyed their work. In a strong project organization, there is however the risk that top management don't see what is going on in the projects. Corporate strategies might not always be followed but tools and guides are altered to suit the project. Top management might lose control of the project as they decide which way to go. Project teams can differ very much from each other. There is no one with the role to train new employees or share lessons learned or knowledge (Hobday, 2000).

Davies and Hobday (2005) challenge the view of projects as unique and difficult to manage within structures boundaries and describe projects as opportunities for organizations to strategically develop project-led structures that foster knowledge creation and organizational learning. A governance structure for horizontal and vertical integration between PBO and matrix organization is presented by Thiery and McGuaire (Figure 5). This visualize the value of alignment of organizational strategy, project portfolio and project management.

Figure 5. The PMO as a governance structure. (Thiery & McGuaire, 2007)

According to Thiery & McGuire (2007) a Project Management Office (PMO) as a mediating function is needed to provide guidance, develop tools and methods for project management and to measure performance when needed. The foundation for establishing a PMO is an established relationship between projects and general management exist, where the two have common objectives and clearly formulated power of authority. Additionally, the importance of having a common strategy and direction is stressed; PM should influence general management and vice versa.

PMI (2017) mention integration as one of the project managers primarily objectives and a key to project success. Integration is described as two dimensional. The first dimension being the integration of organizational strategies with the project. The other dimension is the combination of knowledge, processes and team members with the aim to achieve common project goals. The role of integration in knowledge management in projects is stressed by Liinamaa and Wikström (2009), who emphasize that integration is needed at all project phases. The distinction between social and technical integration can be made,

while the varying need for coordinating activities depends on the variance in project complexity impose a need for a knowledge management process on company level.

2.3.3 HRM in project organisations

One of the main challenges with project-based operations is knowledge management. Human resource management (HRM) can play a large role in this. The main role of HRM is to secure enough recourse for the company and care for the wellbeing of employees. The special HRM practices in project environments have not been profoundly studied nor described (Turner et al., 2008). According to Hobday (2000) inter-organizational dynamics, the human factor, are often neglected in studies of project performance. The characteristics of a project-based organisation impose certain challenges for HRM practices, caused by the temporary work environment that is a project; consisting of dynamic workloads, variance in the type of projects, varying roles, collaboration with many people (Turner et al., 2008). Furthermore, leadership in projects require a high level of engagement and trust.

In project-based organisations employees strongly define themselves as part of a project rather than only members of a functional department. A project-based organisation often has integrating functions developing and steering common tasks, such as project management office, product experts or quality department. In organisations with strong project identity there is often a flat hierarchy and strategies and policies are formed by the projects. The so called "managing by project" practice of HRM is often applied, meaning the project-oriented work is affecting HRM, or HRM practices should be developed to support the project-oriented work. (Turner et al., 2008)

2.4 Project Management

A project is a temporary setting of tools and resources with the aim to deliver a product or service within a set time frame and budget. Project management is the process of planning, organizing and managing the recourses needed to fulfill a projects goal. Even

if every project is unique there are always repetitive parts of all projects, tasks, materials or resources that are used in repeated projects. It is the uniqueness of each project that demand planning and coordination of these that has resulted in the discipline called project management (PMI, 2017).

Projects can be conducted in all levels of a company and involve one or multiple persons or groups. As an increasing part of business is conducted in the form of projects, project management has extended from being focused on delivering a specific product to be conducted in numerous endeavours. The development and implementation IT solutions, transforming organisations, improving business processes, conducting research are examples of a few activities conducted as projects (PMI, 2017). The remaining part of this thesis will however focus on project management in the context of delivering industrial solution, which limits some concepts slightly.

The size and complexity of the projects determine how companies need to build their organisations and project management practices. Industrial projects are typically delivered as EPC projects (engineering, procurement, construction) or as large equipment delivered as subparts of EPC projects. Marine projects are typically large equipment deliveries, where a ship new build involve deliveries from numerous of suppliers. Project phases are generally divided into three phases, design phase, commissioning phase and operations phase (Wysocki, 2019). When delivering complex products and systems, project management can even consist of sub-projects for development, manufacturing and delivery (Hobday, 1998).

In addition to the traditional view of project management, the lifecycle of providing integrated solutions, as described by Davies and Hobday (2005, p 244.), extends the project life cycle to consist of so-called pre-bid and post-project value activities. The integrated solutions lifecycle is proposed to consist of four activity areas; strategic engagement, value proposition, systems integration. These activities range from high-level cooperation to understand the customer's needs, to developing a detailed proposal and

ultimately integrating the customer during project execution, start-up and operations. This model requires high skills in commercial, technical as well as project management aspects.

In order to reduce the uncertainties connected with the unique nature of a project, adaptation of project management methodologies is be needed. A classification of project, commonly made based on type or characteristics, is needed to find the methods needed Examples of project characteristics used for classification are risk, business value, length, complexity, scope, technical characteristics, cost. The classification in terms of type can be made using these characteristics and categorizing them into type A, B, C or D type projects (Wysocki, 2019, p.17). Ultimately, the project manager is accountable for evaluating the management methodology needed in his or her project and adapt accordingly (PMI, 2017).

Another factor that influence the project management methodology is the production mode, or level of customization, of a product. Compared to the basic production modes make-to-order, assemble-to-order and make-to-stock, engineer-to-order is the mode that has the longest lead time (Mello et al., 2015). Engineer-to-order solutions are typically customized for specific customer needs and require varying amount of engineering efforts. This in turn calls for adaptive project management methods, optimizing both the level and type of coordination between activities in order to reduce project lead times (Mello et. al, 2015; Hobday, 1998).

2.4.1 Project management systems

The dynamic network of activities that is a project require procedural guidelines. Formal project management procedures not only aid management but also makes communication between project teams coherent. A formulated and consistent framework for project management, including policies, and guidelines for all main phases also provide a base for collaboration for everyone in the organisation (Lock, 2013). In order to formalize the knowledge within the profession of project management, the Project Management

Institute (PMI, 2017) developed 'The Project Management Body of Knowledge (PMBOK Guide)' which describe the processes, tools and practices commonly used in project management. The guide is a commonly used a framework for project management worldwide.

In addition to the PMBOK (PMI, 2017), standard made by International Organization for Standardization [ISO] (2015) provide standards that contain many of the same elements. One of these is ISO standard no. 9001:2015, a widely implemented quality management system which follows the plan-do-check-act method of continual improvement is followed. This is derived from total quality management thinking, which also has many similarities with project management principles. These two standard will be discussed in brief the two coming sections.

2.4.2 PMI Standards

A project life-cycle consist of phases through which a project progress from beginning to end. The five generic phases of a project as initiation, planning, execution, monitoring and closure phase. A phase gate marks the end of a phase and a decision to continue is made based on the goals and acceptance criteria of that phase. The phases consist of activities which need to be performed in a specific order. Many activities are connected, meaning one activity has to be performed before the next one can start, or one activity influence the result of another. Furthermore, PMI (2017) explains the three factors to be considered for each activity; inputs, tools and techniques, and outputs.

PMI divide project management into ten knowledge areas. The project management knowledge areas take place in any of the process phases and can be seen to be vertical, while the process phases are horizontal. The ten knowledge areas are listed below.

1. Project Integration Management
2. Project Scope Management
3. Project Time Management

4. Project Cost Management
5. Project Quality Management
6. Project Human Resource Management
7. Project Communications Management
8. Project Risk Management
9. Project Procurement Management
10. Project Stakeholder Management

Any project starts with making fundamental project management plan and a project charter. This is part of the integration management, where the main frame for the project is drawn up. The project management plan includes a work break-down structure (WBS) of the detailed scope and time schedule. During the project life cycle, project time management and scope management includes follow up of this plan (PMI, 2017).

Assigning resources for a project is part of the initial project plan but managing recourses, assuring they work according to plan and receive the needed support needed is a continuous responsibility of the project manager. In addition to this, a project communication plan address what information is needed by all team members and establish the communication routes and frequency in the project (PMI, 2017).

A proper risk management plan made at project initiation phase will identify, evaluate and prioritize risks. A qualitative risk analysis is made based on the likelihood and impact of the main risks. The risks with the biggest scores are then analyzed quantitatively based on their impact on eg. budget and schedule. Finally, a risk mitigation plan is an important step in reducing the impact of the risks (PMI, 2017).

Despite the structured steps described in the PMI (2017), the accountability of the project manager to adopt the management methods to suit his or her project is emphasized. Project management is not an exact science, neither does it follow regulated standards. The flexibility and adaptation skills needed by a project manager is emphasized in other

project management literature (Wysocki, 2019; Lock, 2007). The project manager has the overall responsibility of integrating all stakeholders of the project, summarizing results and knowledge of the project to a whole.

2.4.3 ISO standards

ISO standards cover a wide range of processes, acting as guideline for companies on how to manage activities. The standards range from standards for specific applications, as date and format, medical devices, film and camera standards, to commonly used standards on energy management standards ISO 50001, Environmental management ISO 14000 and occupational health and safety ISO 45001 (ISO, 2020).

The ISO 9000 quality management standards is perhaps the world's most well-known group of standards. The standards aid companies in managing the quality of their products and services as well as in how they are produced, with ISO 9001 as the only quality management standards that can be certified. Basic criteria of a good 9001 quality management system are understanding customer requirements and internal stakeholders' requirements, goal setting, appropriate training of employees, controlling production processes, continuous improvement. ISO 9001:2015 includes sections about management responsibility, resource management, product realization, measurement, analysis and improvement. The product realization gives requirements for the processes related to delivering your product to the customer (ISO, 2015).

Although most of the quality management principles of ISO 9000 are applicable also to project management, ISO has developed a guidance on project management, 21500:2012. Additionally, ISO 10006 act as a guide to the quality of project management processes. The aim with the guide is to provide a systematic approach for the creation and maintenance of process for product and project quality; also incorporating this into company's management procedures (ISO, 2020).

ISO 10006 and the PMI Standards have many similarities and both can be used as guides to efficient project management. There are however some differences. Both emphasize documentation but ISO describe the documentation of all processes as a means to ensure the traceability of non-compliance. Since all processes are documented, there is minimum scope of error. Processes starting right from research and development, covering production, shipping are all well documented. Even any small change in the process has to be documented ensuring that the changes are well planned and implemented in the best possible way to ensure maximum efficiency. ISO also puts more responsibility on the staff, while PMI see the project manager as the one being accountable for managing documentation.

2.5 Elements of project success

Projects are generally considered successful when executed within specified time frame, within budget and according to specifications. In a broader perspective, efficiently executed projects create value for the business (PMI, 2017; Wysocki, 2019 pp. 7-8). The three basic performance measurements of time, cost and resources are however the most used indicator of how well a project achieved its goals. Time and cost are often fixed after the initial project plan is made while the scope can change. In complex projects the scope might change as the project proceeds, making a detailed work brake-down structure difficult to make. The budget is monitored during project execution, it is only after the project is completed that the value of the delivered scope can be evaluated and result in a possible change of budget in following projects (Wysocki, 2019).

The triple constraints are to be kept in balance; a change in one constraint affect the other constraints. Wysocki (2019) extends this concept by describing five variables of project success; cost, time, recourses, scope and quality, which are all incorporated with risks that impose a need to continuously balance the attributes. The scope triangle (Figure 6) visualize this balance and can be seen as model for aiding decision making in projects.

Picture 6. The scope triangle (According to Wysocki 2019).

The role of the project manager (PM) is to acknowledge that these resources are bound to change and continuously re-evaluate the balance between them. In complex projects this is a challenging task, both due to the external environment and to the boundaries, regulations and practices that exist within the own organisation. A clear escalation strategy within the organisation will help the project manager to solve in problems arising during the project (Wysocki, 2019).

Scholars have described the risks incorporated with a too narrow definition of project success. The different quality management frameworks, eg. ISO 9000, ISO 16000, PMBOK, have high emphasis on the measurable factors of cost and time, and on doing things right the first time. However, concepts of "zero defect" might not be realistic in complex project environments as unexpected events taking place during the project lifecycle results in iterations of schedules, contracts and even project goals. Instead aspects of internal and external customer satisfaction should be added to the palette. Internal attributes as commitment, culture and attitudes add to the overall feeling of project success and job satisfaction. Additionally, the customer's satisfaction includes a high

level of social aspects. Openness, honesty and a feeling of partnership are attributes that contribute to the customer experience (Cicmil, 2000).

Hyväri (2007) studied the factors of efficient project management from three angles; organisational design, technical applications and project manager capabilities. The study indicated that there is a strong connection between project efficiency and organisational setup, describing project matrix and project-based organisations as most influential on project efficiency. While the tools and standards related to project management are well developed and widely used, the leadership aspects should be emphasised in project organisations. The top-ranking skills expected from a project manager are motivational, communication and decision making skills. Furthermore, a project manager is expected to have high technical knowledge, knowledge about administrative processes and be sensitive to the team dynamics building a team of motivated and skilled people.

As discussed in the previous chapter, intra-organisational integration is among the main challenges of project-oriented organisations. This, along with efficient use of resources, is identified by Cicmil (2000) as important contributor to project success. Other organisational contributors are e.g. structure, internal politics, cooperation and communication. The same is confirmed by Cicmil (2000), who introduced a framework (Figure 7) which extends the traditional total quality (TQ) principles of measuring project success to including the complete organisational environment where projects operate. This framework emphasises that a broader understanding of project success needs to adopt. Organisations need to include factors as internal and external stakeholder emphasis, quality assurance and prevention, development of human recourses and leadership skills.

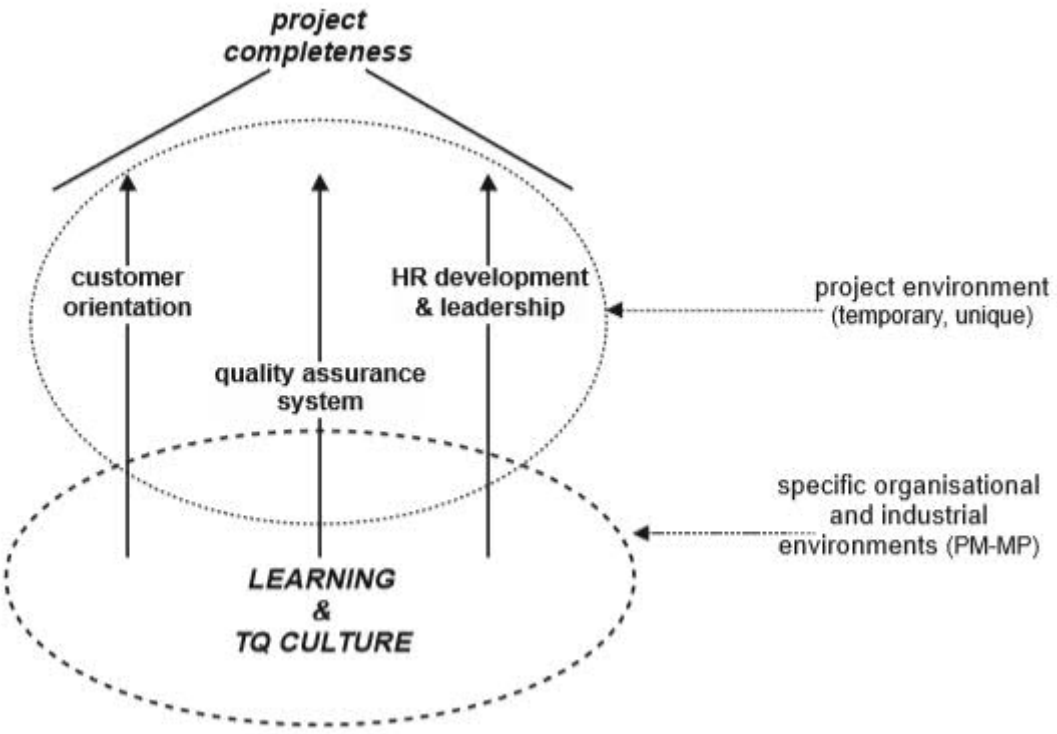


Figure 7. Project completeness framework (Cicmil, 2000).

Liinamaa (2009) takes this one step further by examining the integration mechanisms in a project-based environment, dividing the integration mechanisms in technical and social dimensions. In addition to intra-organisational integration, the network extends to customers, suppliers and sub-suppliers. In contrary to previous studies, Liinamaa emphasise the advantages of adapting a customer centric mind-set into the company project management processes. The customer involvement is mentioned also by Hobday (2000), claiming that the importance of social aspects in complex projects network often is ignored.

The role of the project manager as contributor to project success is emphasized in most literature on project management. In recent literature greater emphasis is put on the specific leadership attributes that today's complex projects demand. Managing projects is ultimately equal to managing people whereas the social aspect is not to be neglected. A survey among project team members from different project organizations conducted by Hyväri (2007) summarized the main characteristics expected from project managers.

The most important characteristics were mentioned to be the PM's ability to successfully plan, communicate and connect stakeholders. The most appreciated soft skills of a PM were decisiveness and ability to motivate and inspire team members.

In addition to managing the formal elements of projects, PMBOK (PMI, 2017) describe the project manager as an integration manager. The key to success is having a good overview of the whole project and integrating the different stakeholders appropriately (PMBOK 2017). Additionally, the project managers need to possess deep knowledge of technical and organizational aspects as well as of the business environment in which the project operate (Cimcil, 2000; Wysocki, 2019). According to Thiry and Deguire (2007), project managers seldom see themselves as "managers", neither does the vast management literature mention this group as a specific type of leaders, or as a part of the management culture.

In contradiction to organisational resources, the recourses assigned to a project are fixed for a certain time and budget. These resources are the constraints that a project manager work with to accomplish the project goals. According to the traditional approach to project management the project manager's role is to direct and control resources. This view is however outdated. Stakeholder engagement is described in PMBOK (PMI, 2017: p. 678), as an activity to be controlled by project manager. This involves identifying each stakeholder's needs, identifying roles and responsibilities and assuring stakeholder needs are met. However, the recent literature on project management discuss the dynamics between project team members and the importance of situational leadership in projects.

As described in section 2.3.2. Knowledge transfer between organisations, project teams and internal stakeholders is a key contributor to successful project execution (Cicmil, 2000; Liinamaa 2009). The PM has an important role in knowledge management in a project by integrating stakeholders from different functions. The specific tools performed in terms of managing project integration consist of building a project charter and

tasks related to manage, follow-up, handle change and close projects. Although the tools to manage project communication are widely used, studies indicate that 70% of project failures are due to poor communication (Wysocki, 2007). A successful project communication management plan should identify every stakeholder, address their needs for communication and how the needs will be met. Interconnected activities need to be acknowledged by project managers.

2.5.1 Quality and risk management

Cost of Quality (COQ) is usually related to product quality costs during the whole project life cycle and is mostly connected with portfolio management or operational activities. Quality of a product refers to it being delivered within budget, on time and fulfilling specifications and customer requirements (Wysocki, 2017). However, quality should be included in all stages of project, from planning, design, execution to delivery; and in all aspects of work. Quality management is one of the knowledge areas of project management (PMI, 2017), and follow the three process phases of planning, assurance and control. The quality planning should take into consideration not only technical specifications but also standards and regulatory demands. Additionally, quality assurance should be guided by common organizational directives.

Risks and uncertainties are natural elements of project life cycles. The traditional risk management methods focus on identifying, estimating and eliminating events and try to evaluate the possible impact of these events (Pons, 2012). However, risks can't be managed only within projects, it is the responsibility of every organisational function to handle their uncertainties. Having a cross-functional risk management perspective reveals risks within a broader scope, improve learning and development.

Risks will emerge throughout the project meaning the risk management process should be iterative (PMI, 2017). Perminova et al. (2008, pp.74) define the difference between risks and uncertainties; describing them as "causes and consequences". Uncertainties are inevitable in today's business environment, which brings a need for flexibility and

sensitivity towards changing circumstances rather than trying to eliminate sources of uncertainties. In ship building this is explicitly relevant, as the yard has made the contract long before the actual construction work begins. This means additional requirement or changes will surely emerge during the project lifecycle as the yards work proceeds.

2.6 Commissioning

Commissioning is the last phase of a project life cycle, where correspondence with contractual requirements and specifications is verified and the functionality of the equipment is tested and verified as a working solution. The goal is to hand over the product to the final customer ensuring its technical performance, reliability and safety. Commissioning can also be considered one of the most critical project phases, as it summarizes and verify the quality of all previous activities. However, commissioning too often ends up being a problem-solving task made on ad-hoc basis (Kirsilä et al. 2017, Lawry & Pons, 2013). Many cases end up with budget overruns, indicating that there is a high potential for savings by mitigating the issues during commissioning phase (O'Connor et al., 2016). With a professional and systematic approach, start-up of systems would be done efficiently, safely and within the set time frame and budget (Killcross, 2011; Larsen et al. 2018).

Commissioning is not one unite knowledge area due to the specific surroundings of each industry with different delivery models and varying responsibility settings between suppliers, contractors and buyers. Companies naturally want to protect their own interests and increase their competitive advantage, resulting in limited knowledge sharing regarding commissioning activities (Mock & Connor, 2019). Additionally, commissioning is not a formal profession but is performed by engineers and experts of their own field, based on the specific settings of a company and a product. Due to these reasons there is a limited amount of literature sources discussing the commissioning process on a general level. The literature sources take different perspectives, combined they can be used as general recommendations in any field that consist of delivery of complex equipment.

Different issues related to commissioning are listed in literature and previous studies. Killcross (2011) provide examples of commissioning failures in chemical and process plants originating from deficiencies in factory acceptance tests, pipe cleanliness and installation quality. Furthermore, he emphasizes that the handover from project to commissioning team, with appropriate documentation, highly influence the quality of commissioning execution. Lawry and Pons (2013) identified several general problems such as lack of resources, lack of managerial support and an underestimation of the value of commissioning. In a study on commissioning of industrial equipment, Almasi (2014) claim that most problems occur due to problems in previous stages of a project; related to design, materials, production and installation. Cagno et al. (2002) describe the risks connected with schedule pressure, organizational and technical complexity and stress the importance of risk analysis to decrease the chance of project failure.

An efficient commissioning process does not itself guarantee that the delivered product is flawless, but it identifies potential mistakes that originate from earlier project phases. Some of these can be reduced by recognizing them in an early stage. Design or material errors can be noticed during factory acceptance tests and should be properly corrected before equipment is sent out. Killcross (2011, pp. 111-112) propose that commissioning team members should participate in FATs, not only to monitor the test procedures, but also to assure the product is fit for transport and to identify possible mismatches regarding installation on site. The completeness of the delivered product is especially important when delivering a package of connected equipment, whereas as much of the pre-commissioning activities as possible should be performed before delivery (Almasi, 2014). Additionally, the quality of the final installations has great impact on the timeliness of the commissioning activities. Involvement of a commissioning engineer in the final installation stage and monitoring of the installation quality prior to actual start of commissioning significantly reduce the risk for problems and budget overruns (Almasi, 2014; Killcross, 2011).

Many studies have sought to describe strategies for mitigating the risk for commissioning failures and overruns. One extensive study on commissioning in various industrial sectors was summarized by O'Connor et al. (2016) into 16 'critical success factors'. Among these the most prominent areas are concerning awareness, budgeting, leadership, acceptance criteria and technical planning for the commissioning phase. The identification of the common shortcomings in these areas resulted in a further study on strategies to reduce risks (Mock & O'Connor, 2019b). The role of organizational involvement and early definition of roles and responsibilities of commissioning has been recognized by several researchers (Killcross, 2011; Kirsilä et al., 2007; Mock & O'Connor, 2020). Increased customer involvement has been mentioned as contributors to success rate by Dvir (2004) and Lawry and Pons (2013), and furthermore explain that the level of involvement attributes to customer's satisfaction and perception of the project performance.

One commonality found in the literature is the proclamation that the awareness of how critical the commissioning phase is to successful handover of a product need to be increased. This awareness can be improved with managerial support and adequate resourcing (O'Connor er al., 2016) and by increasing an understanding of the commissioning process among project team members (Kirsilä et al., 2007).

Integration is a concept mentioned in many recent studies on project management. In a project context, this means coordination and communication between stakeholders of an organization, proper management of interfaces and documentation that is built on from project start to commissioning (Hallila, 2019, p. 75, pp. 78-79). Kirsilä et al. (2007) divide integration into technical and social integration. Technical integration means communicating testing procedures, adjustments and acceptance criteria while social integration refers to the relationships between various stakeholders of a project, which can be a complex network of actors. Naturally, this increase coordination efforts in projects, but decrease the likelihood of project failures (Kirsilä et al., 2007).

2.6.1 Commissioning phases

Scope and milestones of commissioning vary depending on industry and product, but commissioning is commonly divided into three distinct phases, namely Pre-commissioning, Commissioning and Start-up. Additionally, equipment is tested in ‘dry-mode’ and in ‘wet-mode’ (Killcross, 2011). The marine commissioning process follow a distinct procedure (Table 2 on next page), which all equipment providers follow. Equipment installations are mainly done by the shipyards but suppliers’ step in to inspect the installations and proceed to the actual commissioning phase. The shipyard’s production management team overview the works and coordinate between the activities performed by different suppliers. Commissioning of marine installation is an intrigue processes as it requires a great deal of coordination between all stakeholders. Since harbour tests and sea trials are made according to the yards schedule, all connected systems need to be ready for testing at a defined time. After completed sea trials the ship is handed over to its final over.

Table 2. Marine commissioning process, activities per phase. (Adapted from DNV GL AS, 2015).

Phase	Activities	Output
Mechanical completion (MC)	Installation completion Pressure tests Alignment of rotating equipment Flushing of pipes Cleaning	MC checklists MC punch lists
Pre-commissioning	Completion of MC punch list Energization Check of instruments Final alignment Start of rotating equipment	Completed MC punch list Ready for commissioning certificate Signed pre-commissioning procedures
Commissioning	Equipment functional tests Equipment performance tests Testing of Emergency shut-down systems Load tests	Signed and completed commissioning procedures System ready for operation certificate
System integration tests (Harbour tests)	Functional tests of systems Final adjustments of controls, instruments and alarms Complete testing of emergency shut down system Integrated testing of PROD/DRILL plants	Harbour acceptance
Sea trials	Final acceptance of system	Sea trial acceptance

The marine class societies are involved in the commissioning process. While the execution of commissioning activities is planned by equipment providers themselves, the marine class societies have defined clear requirements on what type of tests shall be performed for certain equipment. The aim of these regulation is to assure safe operations of the equipment. Class rules also stipulate that equipment shall be tested in its final installation; a factory test is not enough. Additionally, in most cases the commissioning procedures shall be clarified to the class surveyors prior to commissioning start. Any issues during commissioning need to be solved immediately and re-testing is to be made. The class rules also state whether a surveyor need to be present during the tests or not. (DNV GL AS, 2015).

2.6.2 Preparing for commissioning

Preparations are fundamental to the success of the commissioning phase. Studies show that there is a direct link between early planning and project success in complex projects, the importance of planning is even greater (Larsen et al. 2018; Dvir, 2004). By introducing a commissioning focused planning early on in a project, the chance for project success increase. Sadly, the value of preparations is often underestimated. Killcross (2011) state, in his guide to system and equipment commissioning, that "if your preparation to the commissioning of a new asset is sloppy, without research, unprepared and unplanned, the resultant start-up will be fairly much the same.".

Appropriate planning is important for several reasons. A high focus on the planning phase result in improved cooperation between project team members and strengthened organizational support for commissioning. This in turn increase proactivity, issues that would have been solved ad-hoc during commissioning are identified and solved earlier (Larsen et al. 2018). According to Gillis & Cudney (2015) the proactivity is further increased when linkages between activities is understood. All activities in a project lead to commissioning, and all issues occurring during commissioning can be tracked back to previous project stages.

Lawry and Pons (2013) listed the main items influencing on the success of commissioning and need to be considered in the planning phase. These are

1. The nature of the project
2. Social aspects and dynamics between people of different personalities
3. Amount and complexity of commissioning phases
4. Contractual obligations and planning of the project according to these

It is however up to each manufacturer to plan, execute and control their commissioning process according to external regulations, internal procedures and contractual require-

ments. According to Lawry and Pons (2013), literature on commissioning generally present three strategies to commissioning planning (Figure X). A common misunderstanding of the commissioning phase a simple task result in companies including planning of performance measures of time and cost to their commissioning plan, or utilizing fixed templates constituting of check-lists or other generic procedures. The nature of commissioning however require flexibility, yet a structured approach for preparing for the situational surroundings is desirable.

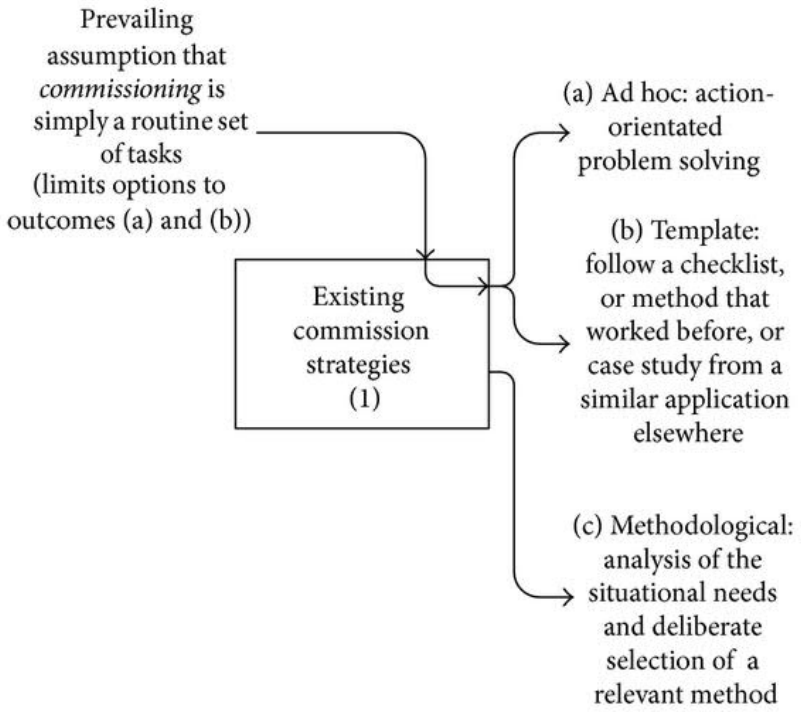


Figure 8. Three prevailing approaches to commissioning strategies (Lawry and Pons, 2013).

Preparations should start with defining scope and requirements. In addition to the basic performance boundaries of cost and time, also technical requirements for commissioning should be defined and documented. A crucial part of this is to identify interfaces to connection products early in the project. This requires an alignment among all stakeholders of the project as well as in the organization (O'Connor et al., 2016). Another important part of the commissioning planning phase is agreeing on roles and responsibilities and staffing people with correct skills. The capabilities of the commissioning team members, meaning they understand the commissioning process and what is required

from them, the product functionalities etc, influence on the project success (Larsen et al., 2018; Mock & O'Connor, 2020).

Clear commissioning leadership is identified as a key to commissioning success (Mock & O'Connor, 2020; O'Connor et al., 2016). A commissioning manager need to be appointed, with two main tasks; to ensure the product is delivered to customer and to assure project completeness. The ccommissioning manager should take the role to oversee the commissioning phase. He/she should ensure that procedures are in place, responsibilities are agreed upon, schedule and cost limitations are acceptable, customer and project team obligations are fulfilled, and mechanical installation done. A prerequisite to starting the work on site is assuring the scope is agreed upon and defined as a commissioning specification. The responsibilities of the commissioning managers end when the product is handed over for warranty. Ensuring project completeness includes ensuring product and customer acceptance are made, a final report is prepared and that possible resources as personnel, tools and materials are reassigned to other projects (Killcross, 2011).

A commissioning plan is the master plan for commissioning of the product or system. The technical planning of the commissioning phase shall lead to complete commissioning specification that describes how the system is intended to function, define commissioning milestones and the acceptance criteria for these, the order of doing things and what tests to be made. As explained earlier, engineering should take the responsibility of the product from production start to end of commissioning. This means engineering should feed the commissioning stage by providing provide needed technical documentation as input, in form of a list of documents and specifications handed over to commissioning team (Killcross, 2011). Garcia et al. (2019) emphasize the importance of documenting requirements concerning performance and function and propose that checklists shall be introduced already for the planning phase. Checklists for the design phase are made to ensure design proceeds with the commissioning requirements in mind. Ad-

ditionally, a feedback loop back to engineering, describing what modifications, adjustments and observations were made on site, ensure continuous improvement of the design.

2.6.3 Signing off commissioning

Closing of a project or project phase is clearly defined in the PMBOK guide (PMI, 2017). In order to close a project all tasks and activities that were defined as criteria for closing need to be made, such as assuring all issues are solved, the delivered documentation and products are according to specifications and updated, having received the official acceptance by the customer, costs and financial accounts are cleared, personnel are signed off the project, material resources are relocated and a final report of the project or phase are made. Furthermore, guide clearly state that a process for approval and communication in cases where the acceptance criteria of a project phase are not fulfilled should be established.

Commissioning is a project phase that should follow the same procedure as any other stage. When it comes to handing over a commissioned product to the customer, PMI (2017) define that contract activities such as final acceptance, closing claims and documenting results shall be performed. Furthermore, passing on the commissioned product to operation includes preparing a final report and signing off agreed documents. The final report should describe the work that was performed, the scope, quality objectives and acceptance criteria as well as document possible adjustments made (Killcross, 2011; PMI, 2017). The ‘aftermaths’ of a project include collecting lessons learned and distributing them in the organisation. Additionally, any type of project documentation, supportive documentation and lessons learned archives should be updated after completion of a project or project phase.

During the project closing phase, customer satisfaction is to be measured based on gathered feedback. This is when the value of a professionally executed commissioning is

proven. In addition to the critical factors mentioned in previous sections, customer involvement in the commissioning phase has shown to have a positive effect on project efficiency. Dvir (2005) confirmed this connection in a study, which also concluded that customer's perceived satisfaction was higher when being involved in pre-planning of commissioning. The same is highlighted by Doty (2007), who describe that customer satisfaction comes from successfully describing the commissioning phase to customers, convincing them that the project will be successfully executed, and their expectations fulfilled. This means a customer centric approach need to be adopted by organizations and individuals, in all project phases.

2.7 Synthesis of the literature review

The aim of this literature review was to describe the factors that influence the competitive environment of industries and on company level. Most literature look at competitive strategy from a perspective of either the external environment or the internal environment of a company. Recent organisational studies include aspects of corporate culture, integration and individual behaviours. The theoretical framework presented in this thesis constitute a broader perspective which more relevant in today's business environment. Figure 8 illustrates the framework for competitive advantage, describing the factors that influence a company's competitive strategy and the governance of project commissioning activities as a part of it.

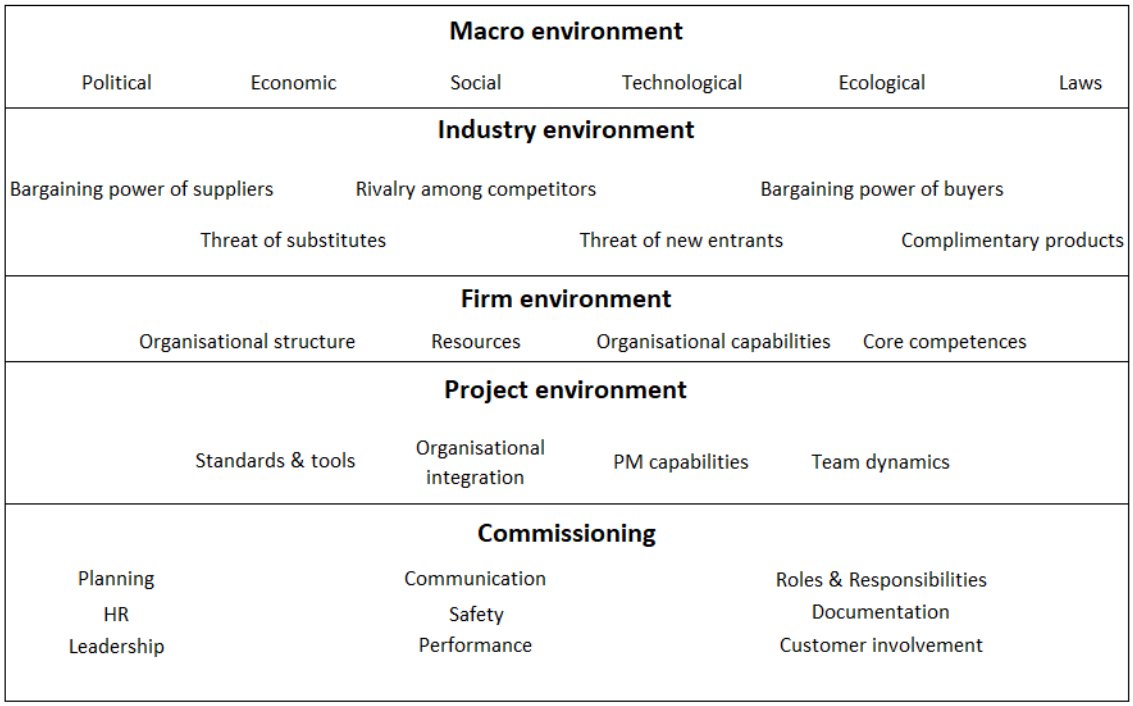


Figure 9. A competitive framework for project commissioning

This theoretical framework answers to the first research question from two perspectives, namely

1. Why commissioning contributes to the competitive advantage of a company in context of the marine business environment
2. What factors contribute to the competitive execution of the commissioning phase

When it comes to commissioning, it is considered competitive when executed efficiently and safely and when the outcome fulfils all contractual targets. The importance of preparing for this project stage is emphasised in today's increasingly complex projects where pressure on cost and efficiency is high. Commonly used standards for project management, such as PMBOK guide (PMI, 2017), describe the commissioning phase in a general matter. A specific framework with concrete tools for commissioning management in a project context is lacking. It is up to every company to define their case-specific settings for commissioning. Literature suggest that the criticality of commissioning often is underestimated and for that reason appropriate planning is neglected. Additionally,

project teams might fail to identify the risks related to installation of new systems. A literature review of the most referenced studies on commissioning identified a number of similarities in form of factors that contributes to the competitiveness of commissioning. These are presented in the table on the following page (Table 10). The studies take different perspectives, but many similarities can be drawn to commonly known project management knowledge areas, eg. organisational support, stakeholder integration, planning, communication and risk management. Additionally, the keys to success are congruent with recent studies on project management. The framework presented by this literature review provide a holistic view of the competitive advantage of project commissioning, by which the first research question is considered answered.

Title	Author (Year)	Topic/Main angle	Identified success factors
Integration as a project management concept: A study of the commissioning process in industrial deliveries.	**Kirsilä, J., Hellström, M., Wikström, K. (2007)**	Introduced a framework for technical and social integration of commissioning function into project and organisation. Identified common challenges and misinterpretations in commissioning.	Technical alignment of design and commissioning Organisational alignment
High-value, low-effort industrial plant commissioning solution strategies	**Mock, B. and O'Connor, J.T. (2019)**	Study that identified solution strategies to common commissioning and startup problems experienced during industrial construction projects.	Recognition of risks and criticalities Developing strategies for minimizing risks and criticalities
Commissioning process of water flow glazing facades	**Garcia, D., Moreno, B., Hernandez, J. A. (2019)**	Identified different approaches to commissioning process. Development of handbooks to support commissioning process and check-lists for every phase of the project as a means to formulate a commissioning specification.	Early and appropriate commissioning design Formulation of commissioning specification
Chemical and Process Plant Commissioning Handbook : A Practical Guide to Plant System and Equipment Installation and Commissioning	**Killcross, M. (2011)**	Comprehensive guide to installation and commissioning processes. Defines preparation, implementation and closure phases and the procedures and responsibilities during these.	Recognition of criticality of commissioning phase Commissioning leadership Planning as part of project life cycle Commissioning specification
Transferring projects to their final users: The effect of planning and preparations for commissioning on project success	**Dvir, D. (2004)**	Study on how customer involvement in the development process impact on project success. Emphasise the importance of planning and preparing for the commissioning phase.	Customer involvement in planning phase Proper planning and preparations
The Relation between Pre-planning, Commissioning and Enhanced Project Performance	**Larsen, J. K., Lindhard, S. M., Brunoe, T. D., Jensen, K. N. (2018)**	Investigate the relationship between pre-planning, commissioning, and project performance. Emphasise how the commissioning increase awareness of importance of pre-planning and proactivity.	Preplanning and proactivity Quality of installation Organisational support Good customer relationship Feedback loop from commissioning to organisation and project
Integrative Approach to the Plant Commissioning Process	**Lawry, K., Pons, D. J. (2013)**	Introduce a model for integrating commissioning in risk management, project management and production engineering.	Integration of commissioning throughout the project
Risk analysis in plant commissioning: the Multilevel Hazop	**Cagno, E., Caron, F., & Mancini, M. (2002)**	Introduce a model for performing multilevel Hazops with the aim to identify all potential risks in a specific commissioning process.	Early risk identification
Responsibilities and accountabilities for industrial facility commissioning and startup activities	**Mock, B. and O'Connor, J.T. (2020)**	Study of best practices of commissioning activities and responsibilities of these in industrial project commissioning projects. Resulted in a model for project delivery, activity matrix and RACI model for commissioning.	Organizational involvement Structured transition between phases and activities Responsabilities and accountabilities on activity level Recognise value of administrative tasks Frontloading commissioning activities
Simplifying The Commissioning Process	**Doty, S. (2007)**	Framework to structurize the commissioning process with aim to fulfill owner requirements. Customer satisfaction is achieved by involving the customer and increase the understanding of the commissioning phase, by setting up a structured commissioning plan.	Customer involvement in planning and execution Structured commissioning plan
Critical success factors for commissioning and start up of capital projects	**O'Connor, J. T., Choi, J. O., Winkler, M. (2016)**	Study to identify the critical success factors of plant commissioning process; summarized in 16 main areas.	Commissioning value recognition Adequate budgeting Commissioning leadership continuity Milestone acceptance criterias and deliverables Early commissioning systems engineering System focus in design Stakeholder alignment

Table 3. Summary of literature on commissioning and the identified success factors

3 Methods and case company introduction

This chapter will present the case company and the research methods. The selected research methods will be explained in detail in the second section of this chapter. As the research was conducted as a mix of several qualitative research methods and inductive analysis, also the research philosophy that justified the selection of research methods will be discussed.

3.1 Case company

The case company is an international provider of solutions for the marine and energy industry. The company is truly global with offices, production facilities and service units in more than 80 countries around the globe. The company has a significant market share in many of its niche areas and are well known for their good quality, customer centricity and service mindedness. After sales is an important business area for the company; a business area which is supported by an extensive service network including a large organization for sales and distribution of spare parts.

The product offering for the marine market ranges from engines and fuel handling systems to automation and lightning systems. The offering has gradually been broadened through mergers and acquisitions in order to offer a broad scope of integrated solutions to the customers. The marine division of the company consist of three main businesses which in turn are divided by product offering into consisting of profit and loss responsible business units. As ship building is project based, the organizational structure is mixed, consisting of a project organization and functional organization. Support functions are established within each business unit in a way that best support the strategical objectives of that specific business unit.

3.1.1 Case department

In order to limit the thesis and get more focused improvement suggestions, it was decided that the study would focus on one specific product. The product was chosen by the case company based on the suitability of the product for such a case study. It was also recognized that improvements of the commissioning process were most needed in this specific product.

The study will focus on the business line for propulsion products and one specific product group, Controllable Pitch Propellers (CPP). The case company's offering of propulsion products consists of propellers, thrusters and related control equipment for a wide range of ship types and applications. The product delivering organization of CPPs consist of around 30 employees; engineering, project engineers, production coordinators and purchasers. The engineering department consist of three main functions; hydrodynamics, mechanical and controls. In addition to these, supportive activities specifically set up for CPP consist of R&D, sales support and purchasing.

A CPP is a propeller with the possibility to pitch the blades. The benefit with a CPP is that the possibility to pitch the blades allows changing speed and maneuvering the speed without changing the engine RPM. CPPs can be installed in any type of ship but is typically in ships that are required to operate at variable speeds even when operating at constant power requirements. Such ships are tugs, trawlers, ferries, ice breakers, and small-scale warships that are equipped with gas turbines. This instead requires a gear box to be installed between the engine and the propeller shaft when running with a high-speed engine. The typical scope of supply of the case company consist of a stern tube, seals, the propeller, an oil distribution box and controls. The pitch control mechanism itself is always supplied with the propellers and installed in a so-called hub.

The propulsion products were included in the company's product portfolio when the company procured a manufacturer of propellers many years back. The CPP as such is a mature product with little development activities. Due to increased focus on efficiency,

which result in more operating mode variants, the control system is the area where most development is happening.

3.2 Research methods and data collection process

The aim of the empirical research is to study the case organisations current practices regarding commissioning process and identify the needs for improvements. The goal is to gain an understanding of the internal, inter-connected processes that is the base for developing competitiveness of the case company's commissioning process. Therefore, the research is performed as a qualitative case study. According to Yin (2012, pp. 3-5) case study is suitable in research that is descriptive and aims for analysing practices and experiences within the case organisation from multiple dimensions.

The reasoning can be either deductive or inductive. As the gathered research data in this study was qualitative and the study aimed for giving recommendations to the case company which were connected to the theoretical framework, the method of reasoning was inductive. Inductive reasoning moves from specific observations to broad generalizations (Patton, 2015; pp. 318-321). Additionally, elements of action research are undertaken to further create a development proposal constituting a concrete framework for commissioning documentation. An action research approach is commonly used when the aim of the research is to not only understand and analyze a situation, but also involving participants to develop a practical solution to a problem and achieve improvements (Costello, 2013, pp. 3-5).

Action research commonly follow a cyclical process to plan, act, observe and reflect. An important aspect of this cyclical approach is evaluating the implemented change and set actions for further developments (Costello, 2003, pp. 6-11). The framework was not implemented in practice within this study, whereas the gains and challenges couldn't be evaluated, and the study was not fully cyclical. However, one of the crucial aspects in this research process is the systematic connection of theory and practice (Costello, 2003, pp. 18-19). This was prevalent throughout this study.

Research data was collected using both primary and secondary data sources. Secondary data was collected from the case organization's documents both on business division and product unit level. These documents consisted of marine project guides, product presentations, commissioning guideline and instructions, commissioning cost reports and documents from previous studies on commissioning development. To gain deeper insights of the knowledge gathered through secondary data, primary data was collected through semi-structured interviews and focus group discussions.

The research follows following steps

1. Preliminary review of literature and secondary data provided by case company
2. Semi-structured introductory discussions with stakeholders
3. Formulation of theoretical framework and planning of main interviews
4. One-to-one theme interviews with personnel involved in commissioning process of the case product
5. Summary and analysis of interview findings
6. Review of interview findings with a focus group
7. Formulation of conceptual framework
8. Review of the framework and findings with a commissioning engineer
9. Adjustments and final conclusions

As described above interviews were conducted in two steps. Initially, semi-structured interviews (Appendix 1) were conducted with a few key persons in the case organisation as well as with commissioning department heads. This was done with the aim to learn about the organisation and the case product and gain an understanding of the current state and the challenges related to commissioning from a managerial perspective.

After this first round of interviews the value of the research and the research direction became clearer, after which the theoretical framework was formulated. It was identified

during the initial interviews that the main development need is concerning documentation and information flow from project to commissioning. Thus, the main interviews were planned with the aim to further explore this area. Theme interviews were conducted with people from different functions in the commissioning and project management organisation; most of them have worked in projects where the CPP has been a part of the scope. The interviews were planned with three main goals in mind:

1. Identify what is considered critical/important to successful commissioning of CPP systems
2. Map the current state of commissioning documentation for CPP
3. Map the expectations on commissioning documentation as basis for formulating a future framework for documentation

The main interviews were conducted as one-to-one semi-structured interviews. The interview topics (Appendix 2) were sent to the interviewees in advance together with a short description of the thesis subject and aim. The results from the interviews were summarized into statements which were clustered together into themes. A table with the themed statements was made and this was discussed in a focus group consisting of the case products technical managers, the commissioning director, manager of commissioning development and the commissioning development manager. This focus group interview was recorded and transcribed. An analysis of the discussions in form of textual descriptions of each statement was developed. A more extensive description of the conceptual reflections constitutes the empirical findings of this thesis.

3.3 Evaluation of chosen research methods

Interviews is a common data collection method in qualitative research. The interviews in this research was performed as one-to-one theme interviews. One-to-one interviews engage the interviewees to discuss freely about the questions and the topic in general, giving the possibility to gain in-depth information about the unique settings in a specific organization (Quinlan, 2011).

The main interview round was performed with a fairly small amount of people. The initial plan was to involve three persons from each discipline, a total of twelve persons. Some of the invitees could not participate due to various reasons, ultimately resulting in ten persons being interviewed in one-hour sessions. The interviewees were however all selected with the intention to find the people that have worked with this specific case product, giving the best data for the case study. Seeking in-depth data from a small group of people can be very valuable and is seen as an appropriate method to study complex subjects (Patton, 2015, pp. 311-315). The validity of the interview results was also proven by comparison to a similar study conducted in the case company one year earlier, which confirmed that the results correlate. Furthermore, the discussion of the findings with a focus group gave valuable insights into the findings on a broader level.

One of the challenges in descriptive case studies is the ability of the researcher to limit the descriptive scope yet using extensive descriptions enough to answer the research aim (Yin, 2012). This challenge was identified also in this study as the topic as such is broad. The theoretical part was used as the important backbone and guide to the proceeding of the study.

The literature review of the thesis forms a theoretical framework which is used as basis for the inductive reasoning presented in the empirical part of the paper. The aim of an inductive approach is to develop empirical generalizations in the research context. An inductive approach is a more flexible compared to deductive approach as it allows changes of the research emphasis along the research process. While deductive research aims for testing an existing hypothesis with data, an inductive approach aims for making broad generalizations from observations with the aim to create new theory (Quinlan, 2011).

In an inductive approach the researcher can be seen as a participant in the research process (Quinlan, 2011). This is true in this study; the conceptual framework presented in the end of the thesis was developed by time during various interview and interaction

with involved stakeholders. Due to the lack of a formulated model for the competitiveness of commissioning the inductive approach is well suited for this type of study.

Concerns with the validity of inductive reasoning relates to the broad generalizations made based on a small sample. The generalizations can also be colored by the biases of one single researcher, influenced by the researcher's individual interpretations. Although the conceptual framework developed in this thesis is based on broad generalizations, the validity is justified by making connections to previous research in the subject.

4 Empirical findings

This chapter presents the findings of the research. The study started by conducting semi-structured interviews with commissioning department heads and two technical experts of the case product. The interviews were semi-structured with discussion topics sent in advance to the interviewees (Appendix 1). Additionally, discussions were also conducted with the commissioning development manager and the director of commissioning and site management. This and a study of the company´s internal documents and data gave an overview of the current competitive situation of the case product and of the current procedures in project management and commissioning. This is presented in the first sections of this chapter, describing the case company's external and internal environment briefly. After this, organizational practices related to project management in the case company will be described.

The chapter continues to sections 4.3 and 4.4. whereas the company's marine commissioning procedures, and specifically for the case product, will be described and discussed. The interviewees all have vast experience within the field of commissioning and in the current organizational setup the commissioning teams support commissioning of the complete scope delivered by the case company. Thanks to this they provided a broad perspective of the commissioning process in the case company and in the marine environment in general, which contributes to the discussion in chapter 5. The interviewees were however informed that this study would focus on CPP products, which also led the discussion towards the specific circumstances and challenges connected to that product.

The initial discussions with department heads clearly indicated that the pain point in commissioning of CPPs is the documentation. Standardized commissioning documentation, including a written commissioning manual, for CPP has been under discussion for a long time but not been formalized so far. Additionally, the lack of a commissioning manual has been identified as contributing factors to commissioning budget overruns in a few disastrous projects. For these reasons, the second round of interviews was designed

with focus on documentation, with the aim to understand current practices and development needs around commissioning documentation.

As the interviews where semi-structured, the discussions gave a multifaceted view of the current situation in the organization. The study identified the areas critical to commissioning of a CPP which provides a good base for a conceptual framework and recommendations for further development at the case company, by which this chapter is concluded.

4.1 Firm environment

To understand the role of commissioning in the product delivery process, and how it contributes to the competitive advantage of the case company, an understanding of the business environment is required. This first step to this is understanding the marine business environment and the factors influencing the competitiveness of a company on a macro and micro level. This section briefly describes the external and internal company environment in which the company operate, based on references presented in the literature review, discussions with case company representatives and secondary data.

The complexity of the marine business environment was discussed in chapter 2.1.1. The competitive landscape of the marine market is influenced by structural changes imposed by increasing competition, political and economic instability as well as increasing protectionism. The main external stakeholder is the marine classification societies, which influence how companies set their internal standards related to quality, design and safety. Following sections will describe the competitive forces of the case product, based on Porters five forces theory.

4.1.1 The firm's competitive environment

The case company is a well-known supplier of a broad scope of solutions to various ship types. Interviewees explain that their customer centricity is appreciated among customers, which is said to be recognised also during commissioning phase. These factors in

combination with the global presence and extensive service network has resulted in a good reputation among customers. This subsection will explain how the case department copes in the competitive environment of the CPP product in the light of Porter's model of competitive forces.

Rivalry among competitors

There are several strong competitors on the market but nevertheless the market share of the case product is around 20-25%. The case company know their market and customers very well. There are certain markets where the activities are low or non-existing, for example in countries where local producers are favoured. Some shipyards also historically have a preference on what suppliers they use.

Several of the competitors are similar in size and structure. The CPP systems that the case company deliver are said to be similar as competitors' solutions. This results in a high rivalry among competitors with huge price pressure. During times of low growth rate, the competition in an industry is even more fierce (Porter, 2008). This drive down the price and increase the importance of differentiating by other means, as added value in form of servitization. The ability to provide a larger scope of solutions is a competitive advantage that the case company has as many shipowners of today want to reduce the number of suppliers and outsource some of their scope.

Threat of new entrants

Shipyards work with a limited time frame and budget for new builds. To reduce the risks for delays, the threshold to purchase from new suppliers is high. Supplier selections are often based on history and reputation. This makes the threat of new entrants low, entry into the marine market require high investments and it takes time to gain trust among shipyards. Rules set by class societies induce further challenges for new product introduction. Additionally, new entrants would also have to provide service of their products worldwide. There is however said to be newcomers providing CPPs; increasing the price pressure even further.

Bargaining power of suppliers

Bargaining power of suppliers is generally high in markets with differentiated products (Porter, 2008). The marine industry consists of highly differentiated products with tough quality requirements imposed by regulatory bodies. The requirements on materials and testing are sometimes difficult to fulfil, reducing the supplier base significantly. For components with a limited supplier base, the bargaining power of suppliers can be very high.

Bargaining power of buyers

The cost is high on the agenda on shipyards for new builds. Shipyards make a contract with the ship owner and then start negotiating with suppliers. As the marine market has declined the few buyers are pushing down prices, compare and compete the suppliers against each other. CPP as a product is also under great cost pressure. There are several equally strong competitors on the market which according to the interviewed product manager are similar in technology and quality. Some of the interviewees claimed that the price pressure can be seen in the product. Manufacturers are forced to choose cheaper components and cut features.

The CPP has a high purchasing cost and the price is already at its lower limit. The uniqueness of each application makes it a high-value product with high labour costs. The installations are also complex due to the high amount of automation. One competitive advantage of the case company is that it can provide a bigger scope of connected solutions. The product manager of CPP emphasised the importance of capturing this in the sales phase. Listening to the customer, proposing right configurations or better solutions adds value to the customer relationship and may have customers choosing a certain solution despite higher cost.

Threat of substitutes

The threat of substitutes is insignificant. A CPP is used in ship types that require high level of control and different operating modes, for example fishing vessels and ferries. In

general, the aim is to improve efficiency which result in more operating modes and a more complex system. CPP is an old product and is evolving slowly but since ships are getting increasingly electric it is the automation system that gets more complex.

Complementary products

Porters sixth force, complementary products, are products or services that are compatible with another product. This is where the case company have significant advantage over many competitors. With a wide product offering for ships they can provide added value to customers by selling complete solutions. Seen from a customer point of view, buying a bundled solution, including complete automation systems, from one supplier reduce risks and coordination costs. Making the commissioning process attractive in the eyes of the customer by successfully commissioning a complete system of connected solution would result in an additional competitive advantage.

4.1.2 Firm internal environment

The marine business division of the case company is divided into three main business units having formed their own functional structures in correspondence to the needs of their respective operations. Formed by the project-based nature of maritime business, the propulsion business line is built as a matrix organization consisting of support functions, sales engineering, a delivery organization managing the main production sites, and five product delivering units. As research indicate, organizations set up in matrix or project-team based forms constitute the best environment for delivering projects efficiently (Hobday, 2000; Hyväri, 2007).

Increasing servitization and customer value creation have since long been part of the case company´s strategy. In the recent years this focus has been strengthened by a line of organisational changes. One important step towards deeper customer orientation was taken when the business unit for service activities was split up and moved under the product delivering organisation. By this move, the complete life-cycle responsibility of a

product is under the same business unit. This also had a positive effect on the commissioning activities; with a straight reporting line to the product delivering organisation and common targets the collaboration between projects and commissioning was strengthened. In practice, this was noticed as less complaints about commissioning. As demonstrated in literature (Hyväri, 2007), similar organizational are proven to have a high influence on project efficiency.

Every product delivering unit have built their functions to best suit their own needs for successful project delivery. Obviously, the organization evolve in reaction to the dynamic project environment where employees continuously collaborate in order to tackle obstacles, develop innovative products and respond to changing customer needs (Hobday, 2000). While employees have a reporting line to their functional manager, the work itself is mostly project-based with high amount of cross-functional collaboration. Project teams consist of recourses from different organizational functions such as mechanical engineering, electrical and automation design, purchasing and commissioning; all reporting to the project manager in project related tasks activities. The managers of the permanent organization approve the resources needed for the project under their authority. They make sure that the planned resources are available for the project according to the project plan. They commit to the project plan by approving it from resource point of view. This organizational management form is common in project business; with varying level of project manager's authority over resources in the so called weak, balanced or strong project matrix (see figure 4, pp. 33).

The case company is certified by DNV GL for ISO 9001. The certification is global, but audits are conducted on predefined basis with separate business units. This means the case company have committed to standardise, set up and document processes so that there are guidelines to follow by anyone in the company with the aim to increase efficiency and quality. The case company have global functions for quality, HR, ICT, HSE etc corresponding to the company's vision and overall targets. While general policies are determined by the global functions, the business units manage local implementation

and arranging activities to suit their requirements. It seems these local implementations are on a varying level. General guidelines and directives were studies during this research. It was found that procedures for project management are well developed and include a description of the commissioning process in projects. A RACI has been made for commissioning managers work and a process description for site managers, but a common directive or guideline for commissioning team members is lacking.

The CPPs are said to be tailor-made in response to customers' requirements in most projects. Projects are also getting increasingly complex and it is common that new designs are developed in a customer delivery project rather than as a separate R&D project. As the director of Propeller and gear platforms stated,

"We also need to remember that what we sell at the moment, it's not these very simple installations, with stern tube bearings and a shaft, and that's it. The installations are complicated, installations for complex vessels with a lot of different operational modes and with a much higher value. So in that respect, it demands a lot more from the whole organization."

As the propeller is only one part of the complete shaft-line and therefore connected to various other product; eg. engine, gearbox and the ship's automation system, inter-organizational collaboration is a natural element of project delivery. An awareness of the interconnectedness of different components and the complexity that this brings is strongly present.

4.2 Project management procedures in case company

The company has developed a Project Management Guide which is used as a model for project management across the whole company. The guide is based on the Project Management Institute's (2017) Project Management Body of Knowledge, PMBOK Guide. The structure and content of the Project Model are based on the ABC Project Model™, developed by Project Institute Finland Ltd. A project management Forum is responsible for

the project model. Figure 10. shows the organisational context in which projects operate. The project model gives guidance taking these areas into consideration.

Figure 10. An organisational context of projects. (Case company internal documents, limited availability.

Within the model presented above, projects are categorized by their different types; customer delivery projects, product & solution development projects and operational development projects. The customer delivery projects in the marine business usually consists of equipment delivery to a ship as one of numerous suppliers; the project types are Products Delivery (PD), Integrated Systems (IS), Retrofits or Engineering, Procurement and Installation (EPI).

The basic structure of the case company's project model follows PMI's (2017) approach of initiation, planning, execution and closing (Figure 11). In addition to these project lifecycle phases there are two subsequent project-related phases outside the project, Explore and Evaluate benefits.

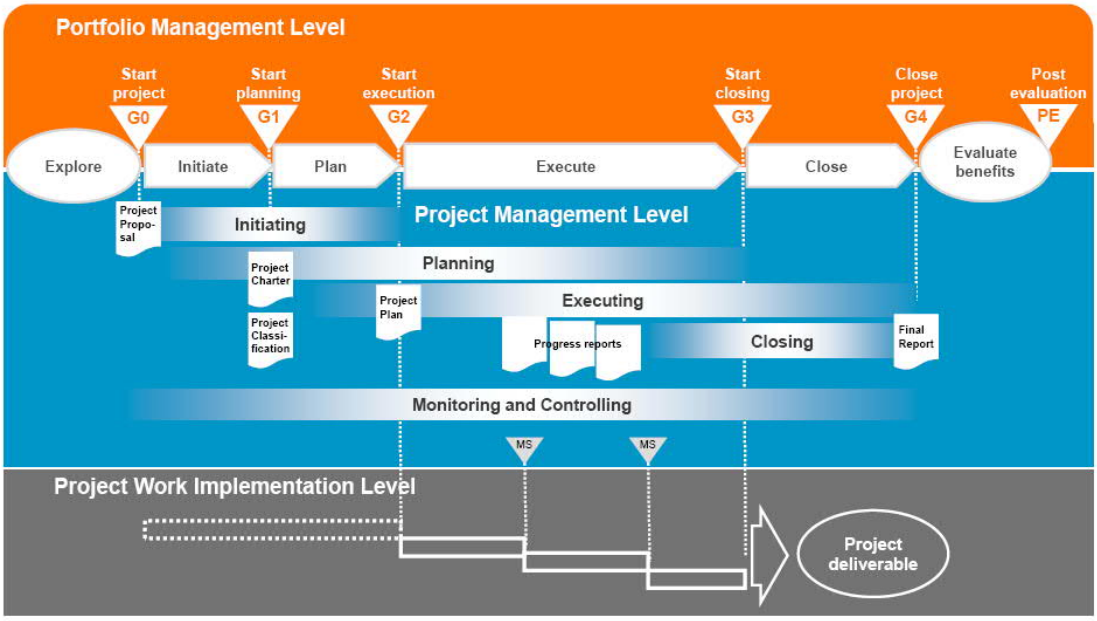


Figure 11. Project Model Framework. (From case company internal documents, limited availability).

In addition to this generic project management model, the marine business has developed a more detailed project lifecycle manual for the marine business. This manual captures the dynamic features of marine projects and provides guidance and boundaries for executing these projects. The manual describes the activities and responsibilities from project sales phase to completion of warranty. The project lifecycle manual is owned by the head of marine business quality, following marine business management team's decision to manage all marine projects according to this model.

Since marine projects can consist of a scope of several integrated products, a lead project manager is appointed and under him product project managers or product engineers. These projects require integration of team members from different product lines on technical as well as social level. This requires a project manager with high technical knowledge and management skills. Congruent to research findings, the case organisation perceives knowledge management and information flow between different organi-

sational units challenging. Project managers find the coordination between all stakeholders challenging due to the different ways of working that exist in the different product lines. Service engineers pointed out the difficulty to find documentation about the integrated products, eg. engine commissioning manual and gearbox manual are needed for checking interfaces to the CPP control system. This indicates the project delivery model for integrated solutions should be developed and improved.

4.2.1 PM tools and reporting

In customer delivery projects the project manager reports to the project owner, which is the line management or business management. Project controllers are assigned to support the project organization with planning, monitor and control. During the project the controller tracks expenditures and make reports of schedule, progress and costs. The role of project controllers is however decreasing as a new reporting tool recently was introduced. The tool, called 'PM Cockpit', is made in Power BI and is a dynamic report used by project managers, line managers and other stakeholders to follow-up project data per project, per product or per business unit. Since the length in time of a marine project from sales to start of warranty usually range from one to two years the tool efficiently gives an overview of the project's history and future for new team members stepping in. Also commissioning work is followed up and reported in PM cockpit.

4.2.2 Classification of projects

In companies where the complexity of the projects varies, a model for classification of projects is important to set up. Classification is generally made based on characteristics and type of project and the class decides the appropriate project management methodology for each project type. (Wysocki, 2019: p.17).

The case company's Project Management Guide describes how classification of project is made within the marine business. At the initiation phase projects are classified as A, B, C or D projects. Most projects are defined as class B or class C; class A projects are

consisting of scope of integrated systems in combination with complex designs or a complex customers environment. In order to manage the high risks associated with these complex projects, the project model include more communication, a detailed risk and plan, and increased follow-up and reporting.

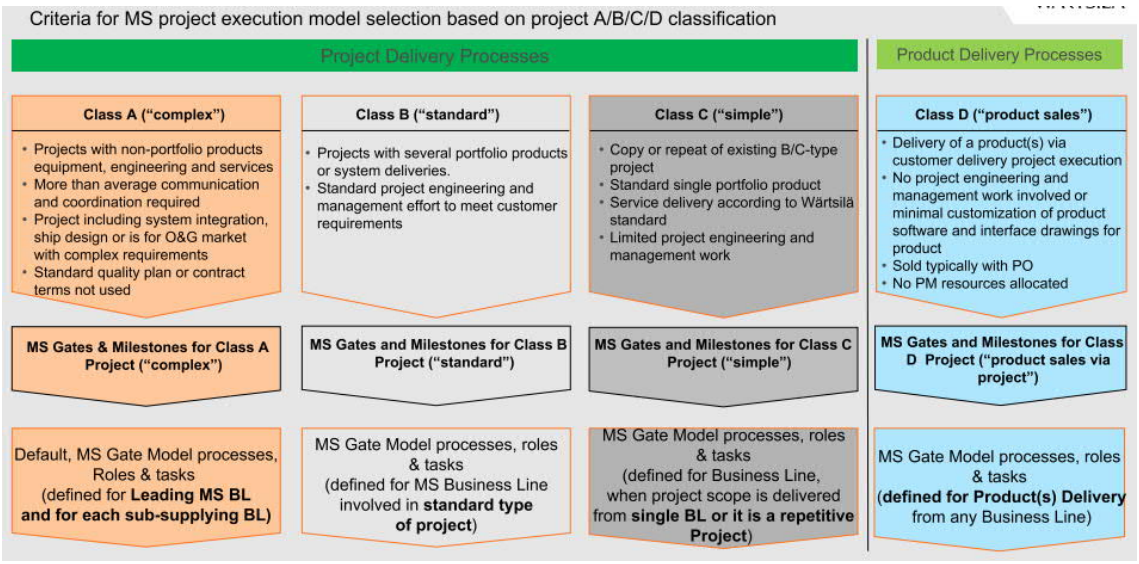


Figure 12. Criteria for project execution model selection based on project classification (Case company's Marine Project guide, limited availability).

The classification of the project defines the project deliverables in terms of preparations, planning and control. Class A projects require a stakeholder engagement plan and a project steering plan; which in turn require high project manager competence and result in higher costs for used time by project manager. In complex projects clear strategies for reporting and escalation within the organisation aid project managers as part of the risk mitigation during the project.

The project manager is ultimately accountable for evaluating the management methodology needed in his or her project and adapt accordingly (PMI, 2017). This is emphasized in the case company's project model. The project model allows change of the classification of projects, as a common decision concluded by the steering group, in case of changed circumstances in the project.

4.2.3 CPP project delivery

CPPs are usually sold as one part of the company's total scope of propulsion equipment to a ship. In those cases, the project is managed by a lead project manager and a responsible project engineers or lead engineer is appointed for each product. From each engineering discipline one contact is appointed; i.e. one mechanical engineer, one hydraulics engineer, one electrical engineer and one automation engineer. The lead project engineer for the CPP is the main contact point for the project manager and for the commissioning coordinator.

CPP product delivery include coordinating between several production sites and design teams since the main components are produced in different company locations. The product itself is not new but configurations are never standard due to increasing demand for more controls and better efficiency. This, in combination with the fact that the complete system is not assembled and tested as a whole until it is installed in the ship, means close collaboration of all stakeholders during design and production phase is critical to the successful completion of the last stage of a project.

4.3 Commissioning procedures in the case company

Commissioning follows the case company's project gate model. While the work is project based all employees are organised according to function in a matrix organisation. The organisational structure is complex; team members report to several different organisations and work together across functions. Figure 14 shows a simplified picture of the reporting lines of the project team members in a typical CPP project delivery.

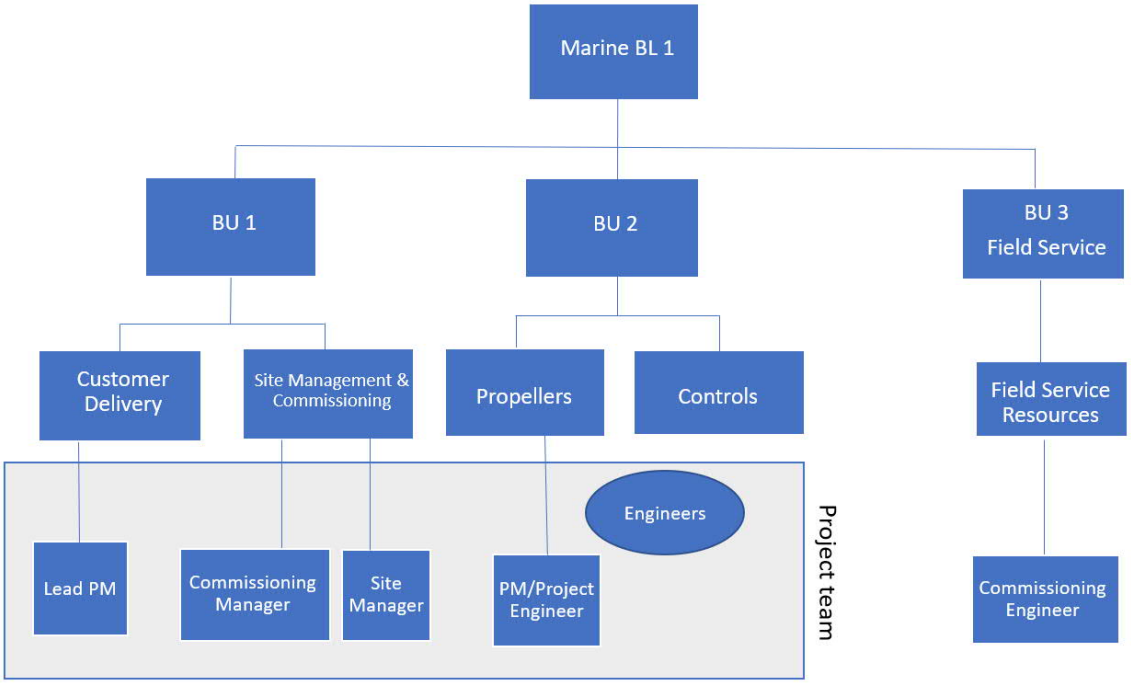


Figure 14. Simplified chart of project team members and their organisational reporting lines.

Commissioning managers and site managers' report to the same organisation as project management, but to different line managers. Site personnel, consisting of the service engineers who perform commissioning work on site, belong to the business unit for Field Service. The Service organisation is responsible for securing the availability of resources based on regular forecasts provided by the product delivering organisations. Commissioning engineers are not considered project team members but are called in as site resources close to commissioning start.

The commissioning organisation is truly global with employees around the globe. Service engineers have traditionally had the company's main offices or main production locations as their home base and travelled to shipyards when needed. This is however gradually changing, and more service engineers are hired locally. The case company is currently focusing on strengthening the local presence close to main customer sites, eg Korea and China. The outbreak of Covid-19 (WHO, n.d.) has increased the importance of development towards this direction as a result of travel restrictions and the increased health risk. Local presence also saves travel costs and increase flexibility significantly.

4.3.1 Planning for commissioning

The commissioning planning and execution phase is described in the case company's gate model (Figure 14). When a contract is signed a commissioning, manager is appointed to the project and is included in the project charter. The commissioning manager participate in project or product kick-off and after this makes a preliminary plan and preliminary site recourse booking. Closer to the commissioning phase a kick-off with customer (MS8) is arranged whereas more detailed plans are made. The exact schedule of yards often changes, whereas resources bookings and travel arrangements can be fixed only a couple of weeks in advance.

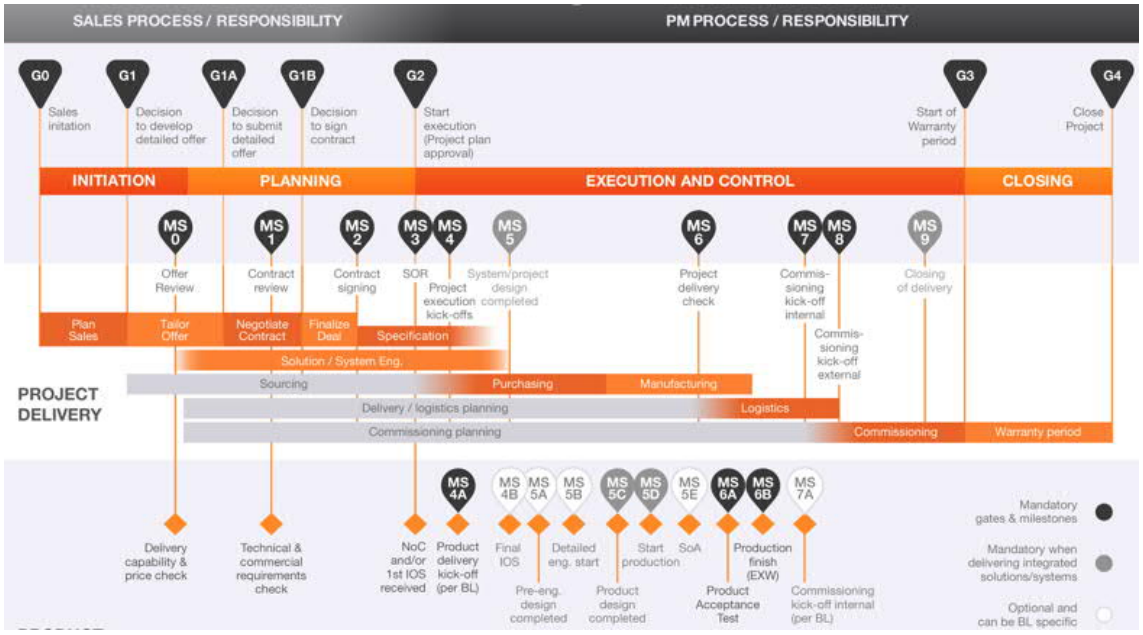


Figure 14. The marine project gate model. (Case company's internal data, limited availability)

The project manager should arrange an internal commissioning kick-off (MS7A) meeting minimum two months before the commissioning starts. This meeting is however optional according to the gate model. Participants in this meeting are generally the project manager, project engineers, commissioning manager and site manager. In this kick-off meeting project technical specification is reviewed, contractual terms presented, and possible special requirements highlighted. Commissioning resources, documentation, organization and reporting routines are also agreed upon. After this meeting, or two

weeks before the commissioning start at the latest, an internal work order for the site resource is made. The service engineers are generally not involved in the project before this.

The commissioning team on site is responsible for assuring the work is done safely, requiring knowledge about various safety aspects on shipyards. The work shall be performed in accordance with commissioning responsibility matrix and other documentation such as commissioning manual, acceptance protocol and IPI. Site management reports non-conformities to Project Manager.

Site manager or service engineer arrange a meeting on site with the counterpart and review planned and performed actions before start of commissioning activities. A commissioning responsibility matrix is both in sales contract, the IPI and in commissioning manuals. This defines the responsibility split between yard and the case company in terms of preparations and installations.

4.3.2 Commissioning completion

Closing of site activities is always made in a mutual agreement with the customer and site personnel. When the sea trials are completed successfully a Completion of Commissioning certificate and commissioning checklists & acceptance protocols are filled in and signed before closing of site activities. Responsible Site Manager shall ensure correct signatures and hand the document over to Commissioning coordinator and to the customer. Red mark drawings or documents are handed over by site personnel to the commissioning coordinator who in turn hands it over to project manager. The project manager sends the as-built documents to customer. A commissioning review meeting or project review meeting is usually kept within 6 weeks from closing of activities.

Commissioning progress is reported from site on a regular basis as agreed in the internal kick-off meeting, normally on a weekly basis. The site personnel then send a report to responsible commissioning manager and to the customer if that was agreed in the kick-

off meeting. If a site manager is involved, he/she ease the service engineers' administrative burden and collects, stores and distributes reports to relevant stakeholders.

4.3.3 Commissioning management

The Marine division of the case company has a team of dedicated commissioning managers for their marine projects. Commissioning managers enters the project at milestone MS6 whereas an internal kick-off is arranged to review the project and the required commissioning activities. A commissioning manager is responsible for leading the commissioning activities of all products delivered to the assigned project; such as creating work orders, ordering resources, solving nonconformities before handover as well as coordination of issues that arise during the commissioning phase.

Commissioning can be seen as a "project within the project", led by the commissioning manager. Based on active communication with the yard, the commissioning manager knows the current situation and can plan resources accordingly. Trust and good communication are proved to result in better planning. Another important task is to make sure all conditions and input is set for the commissioning engineers to start the work on site. The commissioning manager is the link between project and site, reporting progress, identifying and reporting issues to the project team.

4.3.4 Site Management

Site management as a function was established a few years back from a need for stronger local coordination. Site managers are organised according to location of main customers, close to shipyards with high activities, in order to build a close and long-term relationship with yards. Site manager is a local "manager" of the site, acting as a coordinating link between project and customer, assuring pre-installations and preparations are made with regards to safety before commissioning engineers arrive to the shipyard. The site manager is supporting the customer on site to improve the quality of commissioning and

the handover phase; which is valuable especially in complex projects. A good relationship with the local service team and back office guarantees a smooth commissioning phase. In projects where a site manager is appointed, the administrative tasks of service engineers is reduced significantly.

4.3.5 Commissioning Engineers

The team of commissioning engineers, or service engineers, consist of around twenty specialists and superintendents. They report to their line managers in matters related to HR, training and tools but it is the commissioning managers that schedule their daily work. The commissioning engineers report progress and spent hours directly to the project team. Commissioning Engineer possess high technical knowledge; their main role is to act as centre of excellence and perform commissioning activities. The role of the line manager is to focus on getting commissioning engineers trained with enough knowledge, keep them updated about new systems etc. This is said to be a challenging task since new products are often sold without both proper documentation and training.

4.3.6 Commissioning development

A few years back the case organisation set up a department for development of commissioning activities consisting of a handful of development managers. In the past commissioning development function was heavily involved in delivery projects, for example helping with scheduling, budgeting and commissioning coordination in projects consist of several integrated solutions. Today it is more of an advisory role, supporting with expertise knowledge and development of processes, tools and documents. Commissioning development is closely connected to and act according to the real needs of the organisations.

4.3.7 Commissioning cost management

The estimation of commissioning cost is currently made in the sales phase with a price calculator which is based on a detailed activity matrix of commissioning. The configurator is based on historical data of products, resources and traveling costs for the specific application in order to provide an accurate estimate of the number of commissioning days needed in each project. However, there are factors that are difficult to capture in a tool, such as project complexity, circumstances related to specific locations or customers. The case company is aware of these factors; thus, the budget might be adjusted when a project is handed over to operations and the PM evaluates the sold scope.

A review of the marine divisions commissioning cost budget overruns was made and is presented below (Table 4). The marine division started using Power BI for reporting in middle of 2019, before that reports were compiled manually using data from different tools. Due to this the figures for years 2017 and 2018 from Propulsion business line couldn't be retrieved. Additionally, current reporting practices does not give transparency of the commissioning hours spent per product and phase.

	Engines, scrubbers & propellers			
	2017	2018	2019	Q1-Q2/2020
Projects with budget overrun	47%	40%	25,7%	17,6%
Sales budget vs. Actual (average)	-26,65%	-26,93%	+4,2%	+12,3%
	Propulsion			
	2017	2018	2019	Q1-Q2/2020
Projects with budget overrun			39%	40%
Sales budget vs. Actual (average)			-24%	-1,25%

Table 4. Commissioning cost overruns in the marine division 2017-2020.

The figures of the whole marine power division show a positive trend; project manage to succeed the budgeted commissioning hours. However, around one fourth of the projects end with budget overruns, indicating that many of the initial budget estimations are incorrect. This points to the variation in project complexity, making it difficult to do accurate estimations in the sales phase. The positive trend shows a clearly increased cost awareness.

The figures of commissioning costs in the propulsion business units are said to be better than in the past. However, around 40% of projects end in budget overruns and a budget deficit of -24% was reported in 2019. The situation seems to be on the right path since the only -1,25% was reported for the first two quarters of 2020.

The positive trend seen in the figures in the marine division shows that there indeed is an increased cost awareness both at seller and buyer. Interviewees explained that project managers are more often claiming costs which are outside the agreed scope, and customers more often understand and accept this. The downside with increased cost focus is the pressure on site personnel to perform the job within budget. This was perceived as a stress factor by some of the interviewed commissioning employees. Site managers claim that the focus on cost is too high and that budgets too low. It is a constant struggle to try to squeeze the costs on site without compromising on quality.

4.4 CPP commissioning process

The propellers are machined and assembled at the case company's main production facility for propulsion products. The propeller is installed to the hub, containing the pitch control mechanism, and tested before delivery. Other components, such as gearbox and oil distribution box, are produced at other locations and not assembled together until they are installed at the ship. The propeller is delivered with the hub installed and is lifted into the ship from the rear end. After that the shaft and seals are installed and the

piston yoke is bolted to the blades. The Installation Planning Instructions (IPI) is a contractual document delivered to customer and contain instruction on how to perform the installation of a product.

The mechanical installation is said to be straightforward but associated with high safety risks due to the size of the components. The installation involves hoisting of heavy components with special hydraulic lifting tools, requiring skilled personnel. The installation is done by customer and a service engineer supervise certain parts of the installation. Before installations start, a job safety analysis is performed after which the case company representative has the authority to stop work if site safety criteria are not fulfilled.

The first step before starting the actual commissioning work is to check that the customer has performed the installations correctly, that proper alignments between shaft and gearbox is made and hydraulic piping is cleaned. Most customers fill in a check list to communicate that they have completed the installations and the commissioning can start. It is however said to be common that the site engineer arrives to the shipyard and notice that the agreed preparations have not been made. This cause corrections and additional waiting time for the site engineer.

The goal of commissioning is to combine the propeller with the gearbox and start the engine. The challenge during the pre-commissioning phase lies in coordinating the work of propellers and gearbox and the difficult task of ensuring proper clutch alignment. The major part of the CPP commissioning work consist of getting the controls to work; requiring the controls team to be more involved in giving input about variables, settings and functionalities. Picture 15 shows the work performed at each phase of the commissioning of a CPP system. As the complete system can be turned only when the ship is in water, the most important tests are made during harbour acceptance tests and sea trial tests.

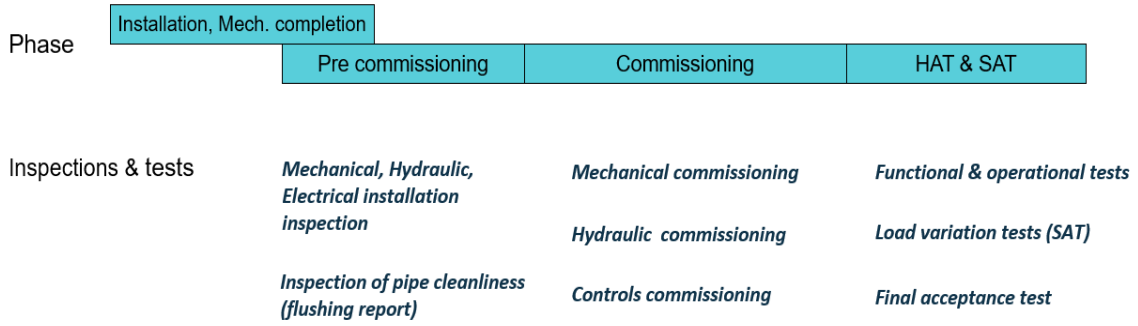


Figure 15. CPP commissioning phases and inspections.

As explained, the installation of CPPs is straightforward and is generally made according to instructions in the IPI with minor or no back-office support. The complexity lies in the control system and the variance in different operation modes. Definition of operating modes is mentioned as one of the most challenging aspects of a CPP system as it is the most vital data for design and for testing of the system on site. The operation modes are based on the specific customer's requirements, which are communicated in an early phase of the project in a hydrodynamic questionnaire. This hydrodynamic questionnaire is the cornerstone of the customized design of CPP controls and thus important to have formally written. There seem to be unclarity in how to list and communicate the operating modes from design to commissioning. Service engineers mentioned that operational modes are not always mentioned in any document, or only described on a general level. Furthermore, they propose that this should be in a commissioning manual because the modes are supposed to be programmed and tested before sea trials.

One of the reasons for the unclarity regarding the operating modes is described by the manager of commissioning management; the differing expectations of shipyard and final ship owner. The case company has a contract with the shipyard, which provides the hydrodynamic questionnaire based on the expectations by the final owner communicated in an early phase of the project. When preparing for sea trials, the owner is present and might dictate how they will operate the vessel, resulting in conflicting expectations between yard and ship owner. Ultimately you might end up with a huge amount of operational modes, but not necessarily all calculated for.

4.4.1 Documentation for commissioning

The case company's marine installations generally define three document types used for installing and commissioning of their equipment. These are Installation and Planning Instruction (IPI), Commissioning Manual and Commissioning Protocols. The Installation and Planning Instruction (IPI) is a contractual document to be provided to customer prior to delivery of the equipment to the shipyard as a communication of installation specific functionalities, requirements and recommendations concerning the operating environment as well as installation and start-up instructions of the supplied products. It also includes a responsibility matrix which clarify buyer/supplier responsibilities of the installation work. The project engineers are responsible for the compilation of the IPI, which in practice is made in a tool that extracts both standard and project specific documents, adapting the final version to the project specific needs.

A commissioning manual is a document describing the steps in the commissioning phase, the acceptance criteria and project specific adjustments. An important part of this document is the final acceptance form to be signed by customer at handover of the commissioned product. Commissioning manuals are made per product as generic templates which then can be modified according to the scope in a specific project. A previous study made in the case organisation showed that the practices regarding commissioning manuals vary largely within the marine organisation. The commissioning manuals for different products vary in quality, details, usage and naming. Neither is it clear who should write and maintain the templates for the manuals.

A commissioning protocol is a checklist used by the service engineer on site. The purpose of the document is to guide the service engineer in what to do in every stage of the commissioning. The document should describe the pre-conditions, adjustments and checks that eventually lead to final acceptance of the product. A review of the secondary data again showed variations in the commissioning protocols for different product groups.

A review of the current documentation for CPP revealed that a commissioning manual specifically for CPP is lacking. Instead, a chapter about commissioning is sometimes included in IPIs. This was said to be added by the project engineers if a customer asks for a commissioning manual. This commissioning chapter is generic, containing checklists for installation and commissioning and an acceptance form to be signed by customer at commissioning completion. There is a commissioning protocol for CPPs that was made in 2014. The service engineers that was interviewed for this study all claimed that the current commissioning protocol template need to be updated to correspond to the latest design configurations. Furthermore, the current protocol was found to be too generic and in its standard form contain faulty information or scope that is not included in that specific installation. In its current form it is a mere checklist without guiding documents, acceptance criteria or project specific parameters. Most alarming is that service engineers find the protocols too inaccurate to be used; some simply sign it off at end of commissioning while some spend time modifying it on site.

4.5 Previous studies on commissioning (secondary data)

As part of the companywide vision, the vision for commissioning of their solutions is to become positively differentiated among customers. This means performing commissioning safely, efficiently and within the agreed time frame. In 2018 an ambitious initiative to develop the commissioning process was started, resulting in a strategy formulation for the years 2018 to 2020. The strategy included many development initiatives including clarification of roles, standardizing work processes and instructions, recourse and competence development, improve reporting and incorporation of digital tools. As a result, several development projects and studies were performed during the past years. In this chapter I will describe some of the studies which were part of the large amount of secondary data used for analysing the current situation in the case company.

One year prior to this study an operational excellence wave with focus on commissioning documentation was performed. The aim of the project was to improve the commission-

ing documentation for selected products, formulate a RACI model and a common framework for commissioning documentation. As basis for the development vast interviews with commissioning managers, site managers, project engineers, field service engineers and Technical services management were conducted. The interview results were similar to the results of this thesis. In many cases commissioning is started without proper documentation to guide the work, and the quality of documentation is not what it should be. There is a need for defining ownership of the content and the accountability for creating documentation in the projects. Additionally, a process for template maintenance was pinpointed as one of the main deficiencies.

Additionally, a thorough comparison of commissioning documentation for different products was performed by a master's thesis worker who later was employed and continued the study. The aim was to define the current state and the potential future state of commissioning documentation in the marine business division. The study showed that different product groups have developed their documentation in their own way, resulting in significant differences in commissioning manuals and protocols. The proposed future model consisted of three different setups. The setup requiring the largest efforts proposed a harmonized commissioning documentation and terminology, integrating the full scope of products into one commissioning manual and possibly develop a digital tool for documentation on site. The author also proposed connecting the commissioning manuals already in the sales tool which is used to compile the project scope. The first alternative was to do a quick fix, doing only minor updates to all commissioning manuals and protocols and fill in gaps where such are found.

The two development projects described above were both paused as the persons leading them left the company. Due to several recent reorganisations in the company it was not possible to fill these positions and continue the development. The need for improving the quality of commissioning documentation is however said to be identified in several forums but concrete actions has been difficult to agree on.

A few cases where the quality of documentation was clearly identified as root cause to financial losses have recently been identified in the case department. In one of the cases the rotating direction of the propeller was not indicated in technical documentation, causing the motor and propeller to have different rotating directions. The system was started despite the different rotating directions because it could not be clearly determined from the documentation that they had different rotating directions. This mistake had a significant direct cost impact, caused customer dissatisfaction and delay in the complete ship delivery. The solution to this issue would be to have proper and complete documentation, integrating all connected solutions.

Another case that resulted in huge losses was mentioned several times during the writing of this thesis. This project was a special case which consisted of delivery of six new thrusters. A thorough investigation of the root causes of the project failure was conducted due to the major financial losses. Interviews with the persons involved in the commissioning phase of this project showed that accurate documentation was not available at start of commissioning. IPI and OMM were not available when commissioning started. No commissioning manual was made; a document that could have provided the commissioning personnel with the needed instructions and parameters for commissioning. This case was one of the justifications for conducting this thesis.

4.6 Discussion and proposed development areas

Department heads explained that the commissioning organisation work fully aligned with company's strategy to be customer centric. Customers often find that products are easy to install, and their flexibility and support received during commissioning is appreciated. The challenge however lies in balancing between providing innovative and efficient technological solutions and fulfilling shipyards expectations on efficient and safe installation. Products are getting increasingly complex and many components require dependencies during commissioning, making commissioning more time consuming. Several of the interviewees mention that a standardization and simplification of the products would make the commissioning phase more competitive. Internal processes also

affect the efficiency. The organisation is however well aware of the flexibility needed from them, both as organisation and as individuals. As one of the department heads stated:

> "There is never a commissioning job that is the same as the previous. The order of doing things, the items that may have been failing in transport and installation or wrong designs that need our immediate attention. You name it."

Congruent to previous studies, the integration of connected products is challenging. When the project consists of a large scope, integration between different parties throughout the project would be needed. Engine, gearbox and propellers are all connected into a functioning whole on the ship. Despite this, these are treated as separate products and the design and delivery of these take place with little integration between products and business lines. The project manager, who is accountable for integrating different stakeholders in his/her project, has a difficult task to coordinate these efforts when organisational practices for this are lacking. Commissioning is the phase where the dependencies between different products are most evident. Service engineers explained how they struggle with finding information about for example engine loads, gearbox when the function of these are described in separate IPIs and commissioning manuals. As a commissioning manual for CPP is lacking, there is no place to document and communicate these dependencies to commissioning engineers. The importance of designing for complete system integration was identified as one commissioning success factor in the study by O'Connor et. al (2016). In the case context, this result in additional, unbudgeted work hours when service engineers search for information about integrated systems.

As literature describes, project management is a well-developed area and countless modern tools for project management are available today. This was seen also in this case study; processes and procedures are built to suit the complex environment. Governance of the global procedures follow the corporate strategy, formed by the customer centric values that seem to be strong within the organisation. Commissioning, as a part of the

project delivering organisation, also benefit from the development of PM processes. The tools for reporting are especially important as the figures on commissioning are integrated in the PM cockpit, making it easier for project managers to follow up commissioning progress and budget. Development of a separate business wide directive for commissioning would be beneficial to develop.

As interviews and study of secondary data indicate, there are variations in the documentation practices in different business units and product lines. Improvements are made but still the business line for propulsion products is lacking a consistent setup for commissioning documentation. As mentioned by several interviewees, it has been tried to put procedures on paper before but has not succeeded due to complexity, different expectations and new organisations. Concerning the case product, Controllable Pitch Propellers, a commissioning protocol is existing but is outdated. Some of the interviewees claim that technical documentation is not delivered in time and no clear specifications with acceptance criteria are made for the commissioning work. This means service engineers are sent to shipyards to perform commissioning without needed input and acceptance criteria.

As explained, the main interview round was conducted with personnel experienced from CPP project commissioning. The interview data was analysed and grouped into a few core concepts. A synthesis of the concepts resulted in an identification of six key themes, or success factors; areas that can be considered critical to efficient and successful commissioning of CPP systems (Table 5, next page).

Table 5. Identified commissioning success factor/development area.

Theme	Identified success factor
Pre-conditions	Clarify Seller/Yard responsibilities
	Assure that all preparations are done before arriving to yard
Back office support	Contact details to technical experts should be clear on site
	Fast and firm support needed from technical experts in firefighting situations
Documentation	IPI should be finalized at start of commissioning
	Project specific documents to be ready and available at handover from project to commissioning
Acceptance	Commissioning Protocols
	Clarify acceptance criteria for commissioning
	HAT/SAT to be described clearly
Reporting	Clear reporting rules for site personnel at start of commissioning
Technical input for commissioning	Needed input gathered at start of site works
	Interfaces to other products (engine and gearbox)
	Description of operating modes
	FAT reports and punch lists

These topics, along with a presentation of the current state, was presented in a workshop with technical department heads, the director of commissioning and the manager of commissioning development. This resulted in a constructive discussion which both supported and rejected some of the conclusions made by the author. This discussion gave valuable input to the creation of the framework for commissioning documentation which is presented in the coming section of this thesis. Another discussion with an experienced service engineer was conducted to validate the conclusions drawn after the workshop. A more detailed list including description of current state and proposed developments can be seen in table 6 (Appendix 3).

The discussions pinpointed two areas that can be seen as already taken care of as a part of the regular operations; pre-conditions and back-office support. The completeness of pre-conditions is are already addressed in form of checklists for customers to be filled in prior to commissioning start. In projects were a site manager is involved, it is possible to evaluate the progress of the installations before sending service engineers to the site. Back-office support was not seen as an issue generally. Back-office personnel are involved during commissioning and in some cases spend several hours assisting site personnel from remote. It was however discussed whether it is most time efficient to create detailed documentation or instruct the site personnel during the commissioning phase. Additionally, it was noted that site personnel on locations further away from the country of the production unit lacked contacts to the engineering team and were more prone to take own decisions on site. This is one of the common challenges in global organisations but might also be due to cultural aspects.

Reporting is an improvement area mentioned by a few interviewees, currently reporting practices vary from site to site. Reporting practices are often clarified with the customer by the service personnel when arriving to site. Instead, a standard way of reporting progress as a part of the general commissioning directives could be developed. According to the interviewed project manager an agreed baseline for reporting would ease the customer relationship and reduce risk for varying working methods in projects.

As shown in table 5, in addition to installation instructions (IPI), guiding documents with project specific technical settings and acceptance criteria need to be available at start of commissioning. The definition of acceptance criteria for each commissioning milestone are identified by several past studies as among the crucial elements of commissioning preparations (O'Connor et. al, 2016; Killcross, 2011), and acceptance on both product and system level should be a part of the commissioning planning process (Killcross, 2011, pp. 100-101, 104). Additionally, the definition of HAT and SAT procedures, and ac-

ceptance for these, were mentioned as importance to the competitiveness of commissioning. These procedures however vary depending on respective class society, which might contribute to the unclear definitions of these phases in current documentation.

As already described in earlier paragraphs and in section 4.4.1, documentation is the area where there is most room for improvement. The main technical input listed in table 5 is made as a part of project documentation but a structured way to pass on this information to commissioning engineers is missing. In many cases, site personnel are sent to site regardless of the completeness of commissioning documentation. Interviewed commissioning engineers explained how they need to search for documents from several different document management systems and request information about the systems intended functionality from the engineering departments. Although the case company's gate model clearly states that the preparations in commissioning planning phase shall include formulation of technical procedures, checklists and instructions; a guideline on how to do this is not described. The internal kick-off meeting, milestone MS7 in the gate model, includes checklists for whether involved stakeholders have been prepared for commissioning and that needed documentation has made available. Commissioning managers, who most likely take care of commissioning of several products, might not have the possibility or knowledge to take up technical matters on a detailed level in this meeting. In the workshop with department heads it could not be fully clarified how to proceed with improvements concerning the documentation; and who is accountable for the content of commissioning documentation. It however provided valuable input which could be used for formulating a proposed model for commissioning documentation which is presented in following section.

4.6.1 Framework for commissioning documentation

The data collected in this case study, in combination with literature and PMBOK guide (PMI, 2017) was used to formulate a framework for commissioning documentation. This framework is presented in Appendix 3, Table 7. The approach is supported in the case organisations project management guide, which is developed following PMBOK. The

company's project manual guide already defines the project manager to ensure appropriate planning of the commissioning phase. According to the company's gate model, the aim of the internal commissioning kick-of meeting MS7 is to

1. Identify needed skill, documentation and tools to be arranged for planned scope of work (e.g. installation, supervision, commissioning).
2. Agree on the responsibilities to prepare documentations needed for commissioning. The target is to have them ready latest at the external commissioning kick off meeting with Yard/ Customer.

Project manager is responsible for collecting all stakeholders' requirements, integrating them into a whole (PMI, 2017). Following the PMBOK guide, commissioning is part of Project Quality Management, simultaneously considered a separate project stage. Derived from PMBOKs framework of Plan, Execute and Control of activities; a complete commissioning specification should constitute following steps per phase:

A. Preconditions
B. Adjustments and tests
C. Acceptance

Figure 16 visualize the reasoning that led to the formulation of the documentation framework. This generic commissioning planning process should result in a complete commissioning specification, guiding the competitive execution of commissioning phase.

Figure 16. Generic commissioning planning process.

In addition to the planning of resources and schedule, the planning phase shall lead to formulating a project specific commissioning specification. This specification (commissioning manual) should provide guiding documents and drawings with acceptance criteria. It is important to highlight and describe case specific circumstances and criticalities. As part of the acceptance, case specific adjustments and corrections need to be documented and reported back to the project. Customer sign off is the last stage of commissioning. However, it would be good to sign off each phase before proceeding to next phase.

A review of a few kick-off meeting memos shows that there is check-lists for these points but the detailed needs per product are not clearly defined. As there is need for improvement in how information is transferred from project to commissioning, a framework for this is proposed in List 1, Appendix 3. Some of these points are derived from an 'Internal briefing check-list'; an in-official check-list service engineers have prepared for themselves to check that they are ready for the job in hand. This study however propose that a proactivity is increased by bringing this checklist to commissioning managers responsibility. Additionally, a checklist for handover from commissioning manager to service engineer was developed during this study (List 2, Appendix 3).

4.6.2 Responsibilities of commissioning documentation

It was identified that clear responsibilities of commissioning documentation are missing. Based on interviews, analysis of secondary data and the workshop with managers and experts from the case organisation a general framework for the responsibilities for commissioning documentation was proposed. The main responsibility split is presented below (Table 8).

Table 8. Responsibilities for commissioning documentation

Commissioning Manager	Project Engineer	Engineering disciplines	Service Engineer
• Clarify stakeholder needs • Ensure responsibilities are clear • Follow up, communicate, report documentation status • Ensure documentation is available to SE before commissioning start • Approve start of commissioning based on documentation provided	• Create IPI, commissioning manual and protocols • Ensure content and scope is project specific • Gather input from each engineering discipline, where needed • Follow up that guiding documents are made and available • Collect and communicate feedback on documentation	• Each discipline review own scope of commissioning manual & protocols • Add project specific aspects, acceptance criteria and parameters • Ensure guiding documents are done before commissioning start	• Fill in and file protocols • Report • Feedback

This responsibility division describes the high-level process for producing project specific commissioning documentation. During the process if this study, a preliminary proposal for a detailed RACI model for commissioning documentation was created (Appendix 3, Figure 17). As the organisation went through a major organisational change while this

research was conducted, the RACI need to be revisited and discussed in detail in order to assure they reflect the latest organisation chart. It however provides a base for further and more detailed discussions within business line propulsion on the governance of documentation. The aim of the RACI is to guide projects towards proactively formulating a complete commissioning specification as well as provide a structure for the feedback loop from commissioning back to projects and product owners.

4.6.3 Opportunities and barriers for implementation of the framework

The objective of this section is to highlight some of the opportunities and challenges related to the implementation of the proposed improvements within the case organization and in a broader context in the case company.

As found in the theoretical review, the first limitation would the understanding of commissioning as an integrated part of a products and a projects lifecycle. The starting point is managerial support, which is emphasized by previous researchers (O'Connor, et al. 2016), and specifically the embeddedness of commissioning planning into project management processes (Larsen et al., 2018, p.2). To achieve a broader implementation of the framework, an understanding of how the framework contributes both to the competitive advantage and the efficiency of project execution need to be achieved. During discussions with managers from the product delivering organization it could not be finally clarified who should govern the commissioning documentation. The interpretation of the current situation is that management support for commissioning planning within the product delivering organization need to be strengthened. Currently, the view of product delivering organization seem to be that their responsibility of documentation end with the installation instruction.

As described in the secondary data analysis, attempts to create a business wide process for commissioning documentation have been made in the past. While this indicates there could be strong support for implementing this framework, creating standardized

documentation with a one-size fits all approach might be too ambitious in an environment of tailor-made, complex products. Using the proposed framework and focus on one product might be achievable.

The connection to other products can't be neglected when developing standard documentation. For CPP systems this is most relevant and might be one of the reasons why previous attempts to create a commissioning manual has failed. A coordination with other product lines and finding a common model for the integrated solution would be needed. Again, this might become a barrier for swift implementation.

The current documentation for CPP commissioning, protocols and commissioning chapter of IPI, contain the main elements needed. As a part of this study it was proposed that a cross-functional group consisting of a service engineer, commissioning manager, technical writer, project engineer and experts from each engineering discipline would be assigned to together implement the proposed changes based on the provided framework. In the past, Technical service department used to be the owner of the documents and made some of them based on their own view in cooperation with the platforms and field service engineers. Involving technical service would be a good way to receive best technical knowledge.

As already explained, documentation for commissioning should contain technical input and acceptance criteria. It was however found during this research that the expectations vary largely between different functions. The challenge is to find a balance between the details and making a document that is both easy to read and easy to maintain. Simultaneously, it should preferably be a document that could be presented to the customer without revealing sensitive information.

The variance in complexity and scope impose challenges to creating a standardized documentation. It's assumed that commissioning of non-portfolio products would require more efforts during planning and creation of project specific documentation while it in

more standard projects would be possible to conduct commissioning with minimum preparations and costs. A categorization of the commissioning phase based on complexity of the product could be a way to tackle this. A classification of the commissioning efforts of each CPP system in A, B, C and D could be made according to the level of technical complexity based on eg. scope of new technology, control system complexity, amount of operation modes. External factors as complexity of integrated solutions, new suppliers, unexperienced shipyard, new customer could also be considered. The classification would result in a model for governance of the commissioning planning phase specifying the level of efforts that should be put on preparing project specific commissioning document as commissioning manuals and protocols. An A-type project would also include more preparing meetings, including at least one integration meeting concerning connected products. An internal meeting connecting designers and service engineers would also increase the proactivity by identifying potential risks in an early phase.

The studied literature on commissioning all emphasize the importance of planning as contributor to successful project commissioning. Clear indications of the connection between planning and performance in terms of both quality and cost was found by Larsen et al. (2018). Additionally, technical planning of commissioning early enough in the project life cycle is mentioned by many researchers. As indicated by Kirsilä et al. (2007) In the case context, the proposal to include service engineers and site managers earlier in the project lifecycle will have a slight cost impact that come from increased number of meetings. It is however implied that in complex projects consisting of several integrated solution, these are relatively small efforts that will pay off. Identification of risk, criticalities and potential planning mistakes early in the project may eliminate potential disastrous issues during commissioning. Among the social aspects it can be mentioned that one result can be increased employee satisfaction as site personnel feel included in planning process. Additionally, connecting site personnel and engineers might result in faster resolution of issues occurring during the work on site.

The creation of templates for a commissioning manual and updating the commissioning protocols is an extensive task that require involving several persons. It is however a one-time task; the maintenance of the templates and the efforts needed to keep them up to date with latest designs need to be evaluated by the accountable persons. In delivery projects, the adjustments of commissioning manuals and protocols to project specific settings will require some efforts from project engineers. It is however difficult to estimate the amount of work this requires since the documentation was not developed to its final version within this thesis. The efforts depend on the level of details of the final developed documents. The gains with a commissioning specification are however many. Congruent with previous research, it is believed that the accuracy of the commissioning work will increase. With a first-time right approach, having requirements documented upfront, commissioning phase will result less problem solving. The benefit of this is reduced need for back office support.

With an improved commissioning accuracy, it is also believed that cost overruns will decrease. Exact figures are difficult to estimate since cost overruns often occur as response to various reasons, one being the dynamic environment that is a shipyard. By time, an increased awareness of commissioning within the organization in combination with increased feedback from commissioning to engineering will further improve the accuracy of both budgeting and technical planning for commissioning.

As found by Kirsilä et al. (2007) a basis for achieving customer satisfaction is connecting stakeholders in a project on both practical and social dimension to ultimately deliver a project successfully. This study propose that the development of a complete commissioning specification will achieve this and improve customer satisfaction. Presenting professional documentation to customers, as a baseline for a structured approach to both preparations and execution, would contribute to the competitive advantage of the case company.

5 Conclusion

This study identified the factors that contribute to the competitive advantage of commissioning of project-based deliveries. The research was performed as a case study on an international company delivering solutions to the marine industry. The focus was on how this complex environment influence organisational structures and project management practices. The importance of the commissioning phase as a contributor to the competitive advantage of a company operating in this environment was described. The empirical result of the study is a theoretical framework for competitive commissioning and a proposed framework for commissioning documentation to the case company. In following sections, the authors managerial recommendations for the case company along with limitations and implications for future research will be presented.

The main finding of this thesis is that project commissioning phase clearly contributes to a company's competitive advantage, yet, organisations underestimate this and fail to build processes that support the successful execution of commissioning. Inducing an awareness of the commissioning phase as an integral part in the project life cycle, is the first step to correct this. In the context of the case company, commissioning management and planning procedures are improved but there is still a gap in the transfer of technical requirements from engineering to commissioning.

The specific features of the marine business environment were described in this study. This business environment is thought to remain complex due to increasing political and environmental forces, increasing price pressure and changing technology. The theoretical part of this thesis discussed the specific competitive strategies that companies commonly adopt in order to survive in this, such as differentiation, servitization and selling complementary or integrated solutions. As concluded by some researchers, companies adopting a customer centric mind set will have better chances to capture the market shares that more rigid companies might miss.

Literature describe how companies can choose to organize internal operations in response to the external environment. The core is naturally to recognize the accumulated skills and knowledge that exist within a company and organise resources in a way that best utilize these. Recent studies emphasise that companies need to not only strengthen their core competencies, but also build dynamic capabilities and continuously adapt to the changing environment. Studies show that the uncertainties and risks connected to delivery of high-technology, high-value products are best addressed in a flexible organisational setup. This also require a lot from employees, who need a large extent of resilience. Within the case organisation, the corporate values are clearly seen in the operations. The agility needed in order to fulfil customers expectation seem to be in place on organisational and individual level. Additionally, business wide guidelines and directives provide the backbone for the practical work. However, employees seem to miss a distinct guideline for commissioning.

In a project context, this case study showed that the integration of connected solutions is a challenge. This need to be addressed from two perspectives. Firstly, organisational design and governance of product and project portfolios need to be set up in order to bring value to customers. Secondly, the organisation needs to support project management with agreed processes, tools and enough resources in order to fully be able to connect all strings. The need for integration in form of stakeholder involvement is emphasised the marine project environment, as the PM role include coordination between internal parties, customers, yards and external regulators (marine class societies).

This study identified several factors critical to commissioning success. Many of these factors are congruent with the PM knowledge areas, and of some of the areas specifically addressed in recent studies. Among these are planning, social and technical integration, management support and stakeholder involvement. This means the managerial aspect of commissioning phase is mainly to be addressed within the boundaries of a project. The managerial responsibilities and practices of commissioning team members were

found to be well defined in the case company and many recent improvements in this aspect can be seen.

One conclusion of this study is however that technical planning of commissioning is not included to enough extent, there is a gap between engineering and commissioning. If the planning does not include formulation a complete commissioning specification, the commissioning phase is executed on an ad-hoc basis and often result in cost overruns. One critical role of commissioning is of course to detect possible mistakes that were made earlier in the projects, such might always occur. Nevertheless, many of these could be detected earlier by appropriately planning the commissioning phase.

One finding in this case study was that improvements regarding commissioning documentation is needed in the case company. It was identified that a commissioning manual for the case product is missing and commissioning protocols are outdated. On project level, site personnel are not provided with the needed input in a structured manner. This is probably due to a combination of time, awareness and knowledge. Including a commissioning thinking throughout the project lifecycle, where all project phases eventually lead to commissioning would be the ideal state. With regards to the documentation, an agreement of accountability for technical content of commissioning documentation need to be made. Secondly, the responsibilities for documentation within the boundaries of a project need to be made.

Researchers have proposed different approaches to preparing documentation for commissioning. Some literature proposes that checklists for every stage of a product design process shall be applied, eventually leading to a complete commissioning specification. Some researchers proposed that commissioning handbooks should be divided into an external commissioning handbook and one internal commissioning handbook. Nevertheless, there is not one model that fits all products, it is up to each company to define

the case-specific needs for governance and documentation. The variations in setups dependent on the product was clearly identified in this case study. However, creating a model per product is a prerequisite for commissioning success.

Commissioning is performed under the critical eye of customers; successfully completed commissioning contribute to customer satisfaction and to customer's perception of project performance. This case study found that commissioning engineers and site managers find organisational support important to the customer relationship. Creating a baseline for commissioning, with standard procedures and documents that could be presented in meetings on site, would provide site personnel with a confidence that surely would be noticed by customers. Additionally, a clear presentation of what will be done during the commissioning phase would look professional to customers.

The case study showed that despite the deficiencies in documentation and information flow from project to site, the result is mostly good. Customers are satisfied and issues are solved thanks to high technical skills and flexibility of the organization. This proves that a customer centric mindset is adopted in the organizational culture. People are dedicated to do what is required, and sometimes more, to satisfy customers. By gradually implementing the framework proposed in this thesis, it will also be possible to keep budgets, have motivated employees and exceed customers' expectations.

As concluded in this case study, commissioning success is a combination of good customer contact, processes, products and people. Commissioning is competitive when executed within the set time and budget and fulfils the technical scope. Further competitive advantage comes from exceeding customers' expectations, influencing customers' perception of the whole product delivery and ultimately a company's reputation. Setting the standards for commissioning, with a baseline for procedures, reporting and documents is a start.

5.1 Managerial implications

This case study showed that many improvements have been made in recent years towards better planning, better reporting and overall strengthened management of the commissioning phase. This has resulted in an increased focus on further increasing efficiency of commissioning. However, an inclusion of commissioning into the technical planning of projects is needed. Emphasis need to be put on knowledge sharing and organizational learning practices in order to increase knowledge of commissioning in projects and engineering. This thesis research was an important first step towards this; as it brought together representatives from technical departments and commissioning. It is proposed that the discussions continue in cross-functional constellations.

Analysis reveals company faces some difficulties in delivering integrated solutions end-to-end. Commissioning process is the phase where the challenges are generally most easily noticeable. Some cases where failing integration resulted also in losses were identified during this study. This indicates that the portfolio management should be strengthened. The value of this is not realized until a project is in its operational phase. Project management need to have capabilities to manage a broad scope connected products; in order to achieve this collaboration between product lines need to be deepened. It is therefore recommended that a governance model for integration of operations is formulated, linking activities, products and people on an operational level.

It is recommended that the company evaluates the need for resources for development within the area of commissioning. There seem to be a demand within the organisation for this advisory expertise function. The task to further develop and implement the documentation framework, connecting and streamlining with other products, is a demanding task. Greater benefits might be achieved when the task is being led by a party that has insight into several business units. As identified during this research, the need for improving commissioning documentation is not new. It is suggested that this work is continued and a model for governance of commissioning documentation is developed.

One recommendation for the case company is regarding meetings in commissioning planning phase. Today the milestone MS 7A, internal commissioning kick-off meeting, is optional. Additionally, an integration meeting between connected products is optional. The recommendation by the author is to make these mandatory in projects where the scope consist of connected products. It should be considered whether site managers and service engineers could be involved in these meetings. As this study has shown, involving commissioning engineers at an earlier stage might aid early detection of risks and challenges. Including design engineers into this meeting would also increases the awareness of commissioning among other team members.

It is recommended that a model for classification of project commissioning per project is made. A classification would aid the identification of risks and criticalities related to commissioning early in a project. It would also make it possible to have enough budgeting, appropriate resources, meetings and stakeholder involvement. By increasing the governance in A-class projects, the formulation of commissioning documentation would be assured.

The balance between preparations and assistance on site need to be found for each product. This might be more important in future due to the increasing complexity of automation. Remote commissioning could not be included in this thesis but there are both studies and experience showing that remote commissioning of automation systems improve commissioning efficiency. It could for example be considered to have the automation engineer spend one day participating in commissioning activities remotely.

It is obvious that increased preparations and coordination comes with a cost. The increased coordination efforts might seem irrelevant in projects where the scope consist of a standard product with few commissioning days. It is however proposed that the cost for coordination is evaluated against the gains. Increased coordination and higher focus

on documentation quality will result in efficiently executed commissioning. Early identification of issues related to design, installation or interconnected products is less costly to correct compared to failures that are identified on site (Figure 18).

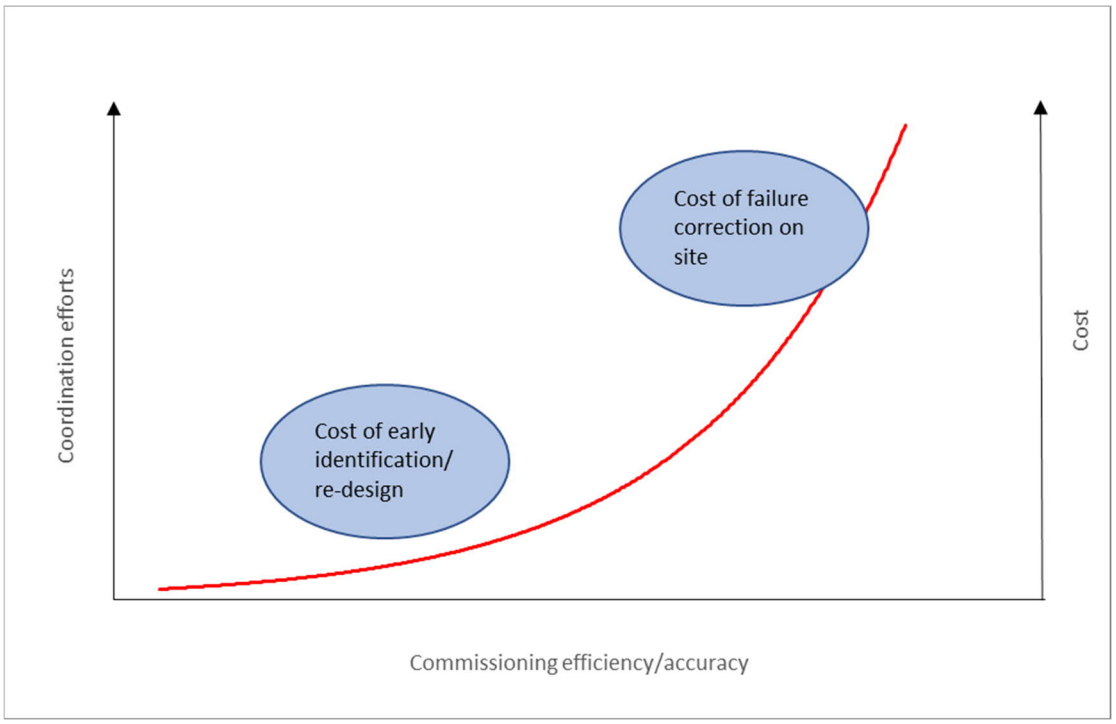


Figure 18. The value of coordination and preparations for competitive execution of commissioning.

The costs of preparing project specific commissioning documentation are difficult to estimate. They might also vary largely depending on the complexity of the project. This study indicate that the gains will be visible in increased execution accuracy as things are done first time right. It is believed that commissioning hours will be reduced as one-time costs and long term as an improved budget accuracy. Additionally, identification and documentation of criticalities related to the connection of integrated solutions will reduce project risks dramatically. Ultimately, setting the standards for commissioning contribute to customer satisfaction and potentially to the reputation of the company.

5.2 Limitations and implications for future research

This section will present some of the limitations noted in this study as well as give recommendations for future studies to the case company. This study identified a few development areas with suggestions for improvements that could make the commissioning phase more competitive. Some of the proposed improvements could however be studied in more detail.

First, it must be mentioned that this thesis research was made while the case company was midst a major organisational change. It was at times difficult to reach stakeholders and get requested information. This was probably due to a combination of high workload and unclear or changing roles. This thesis describes the organisation and its practices based on the information at hand now, as interpreted by an outsider.

Among the limitations it can be mentioned that the dynamic environment in which the company operate makes the development of a standardized operating model for commissioning difficult. Projects and customers vary and technology change rapidly; something that works today does not necessarily work after three years. Therefore, it is natural that the company should avoid too rigid structures and build on their dynamic capabilities also in the future.

A large share of the CPP commissioning work consist of testing and adjusting the control system. Aspects concerning control system commissioning were not specifically addressed in this study. A closer study of commissioning of control systems could be conducted e.g. in order to investigate opportunities for remote commissioning. Remote commissioning is getting increasingly common today and the outbreak of Covid-19 pandemic (WHO, n.d.) has already resulted in a few remote commissioning trials in the case company. The experiences and perceived value of this would be interesting to study.

Although commissioning documentation in this study refers to traditional documents made with MS Office tools, it is recommended that future studies would investigate the

possibility to transfer to cloud-based solutions for commissioning. A digital solution for collecting, sharing and signing off commissioning documents could be more efficient than the maintenance of separate files. Additionally, a digitalization would probably decrease administrative work. As witnessed during the interviews, this would be the long-awaited solution to site personnel's detective job.

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Appendices

Appendix 1. Topics for interviews with department heads

Initial discussions with department heads, discussion topics

Describe your team in brief

Resources and scheduling

What works well concerning:

- Organizational collaboration
- Work processes
- Roles & responsibilities
- Documentation

What could be improved concerning:

- Organizational collaboration
- Work processes
- Roles & responsibilities
- Documentation

Appendix 2. Theme interview questions

- What are you lacking in the current documentation on commissioning?
- How could commissioning documentation improve the customer interface?
- What are your expectations on a commissioning manual?
- What should be included specifically in a commissioning manual for CPP?
- What are the most critical issues considering commissioning of CPP (acc. to your experience)?

Appendix 3. Empirical findings from the case study

Table 6. Identified success factors and development areas.

Theme	Identified success factor	Current state	Proposed development
Pre-conditions	Clarify Seller/Yard responsibilities	A responsibility matrix included in IP clarifies this. Sometimes not updated to be project specific.	To be reviewed at internal briefing.
	Assure that all preparations are done before arriving to yard	This is managed today with check-lists for site readiness are used with some yards. Still common that site personnel arrive at yard noticing that preparations are poorly executed.	
Back office support	Contact details to technical experts should be clear on site	Questions are channelled through commissioning manager or service coordinator. This communication is sometimes slow, making Ses go directly to the source. Contact details to	Include a communication matrix in commissioning manual
	Fast and firm support needed from technical experts in firefighting situations	The cooperation between site personnel and technical departments is on a good level, not seen as an issue.	
	Site support should be minimized in normal situations	Controls team is more involved in commissioning of new solutions or when site personnel is unexperienced.	Mandatory for engineering is eg. evaluate alignment of shaftline and feedback of jack loads. In other cases they don't hear from site unless there is need for clarification or problems.
Documentation	IPI should be finalized at start of commissioning	This is a contractual document and is generally delivered on time. However, at delivery of new solutions the esperience is that IPI is delivered late, not up to date.	
	Project specific documents to be ready and available at handover from project to commissioning	Documentation scattered in different locations, sometimes collected by service engineer	To be a part of the technical commissioning specification. Deadline defined in project plan

Acceptance	Commissioning Protocols	Project engineer is responsible only for IPI. Protocols are standard, not updated with project specific design values.	An update round is needed. To be considered whether different versions are needed and if protocols can be project specific.
	Clarify acceptance criteria for commissioning	Current commissioning protocol contain check-lists on what to be done but no acceptance criteria.	Engineering not aware of what information is needed. Feedback from SE needed. List of input and drawings should be mentioned in a commissioning manual.
	HAT/SAT to be described clearly	Current commissioning protocol contain check-lists on what to be done but no acceptance criteria.	Define and make the procedures more detailed.
Reporting	Clear reporting rules for site personnel at start of commissioning	No clear reporting guidelines for site personnel. Vary from project to project.	PM is in the lead to agree and communicate customer's expectations on reporting. Internal work hour reporting done to line manager.
Technical input for commissioning	Needed input gathered at start of site works	Needed input documents are not compiled at handover to commissioning. The documents are scattered in different departments, separate documents and different management systems.	To be a part of the technical commissioning specification.
	Interfaces to other products (engine and gearbox)	Information found in different IPIs or other separate documents. Not compiled at handover to commissioning engineer.	To be a part of the technical commissioning specification.
	Description of operating modes	The operational modes are not mentioned in IPI of CPP today. The controls IPI contain some information, there mentioned which different sailing modes there are. Just mention the different loads and what modes there are. These are defined together with PE.	Should be communicated by PE to service engineers. Measurements and expected values are internal information that shouldn't be available to customer. To be a part of the technical commissioning specification.
	FAT reports and punch lists	Scattered in document management system. No clear way to compile.	To be a part of the technical commissioning specification.

Table 7. Framework for commissioning documentation for CPP

Commissioning specification CPP			
		Standard	Project specific
General	Project information		x
	Project administration, contacts (PM, commissioning, yard)		x
			x
	Schedule (input from yard)	x	
	List of other input needed from yard	x	
	Budgeted commissioning days		
	- Highlighted that any support outside this scope will have a cost	x	
	Communication matrix		x
	Responsibility matrix		x
	Scope		
Installation conditions	Installation specific settings, conditions, criticalities		x
	Alignment		x
	Connections to external system		x
	Reference drawings		x
Installation completion	Installation check-list (filled in by customer)	x	
	- Document not performed activities, issues or criticalities.		x
	Pre-conditions:	x	
	What are the mandatory (minimum) preparations before going to site	x	
	- preparations by customer	x	
	- internal preparations		
	Approval to proceed	x	

Pre-commissioning	<u>Mechanical</u>		
	Guiding documents	x	
	What to check	x	
	Acceptance criteria		x
	<u>Hydraulical</u>		
	Guiding documents		
	What to check		
	Acceptance criteria		
	<u>Electrical</u>		
	Guiding documents		
	What to check		
	Acceptance criteria		
	<u>Software</u>		
	Guiding documents		
	What to check		
	Acceptance criteria		
	Approval to proceed		
Commissioning	Pre-conditions and approval to start commissioning	x	
	Guiding documents	x	x
	What to check	x	
	Acceptance criteria/settings/values		x
	How to adjust	x	
	Record of adjustments and measurements made		x
	Approval to proceed	x	
HAT	Guiding documents/drawings		

	What to check Acceptance criteria/values Record of adjustments and measurements made Acceptance -sign off		
SAT	Guiding documents What to check Acceptance criteria/values Record of adjustments and measurements made Acceptance -sign off		
Final acceptance	Signature by customer Remarks and open points Final commissioning report	x x	 x
Guiding documents needed on site (not in IPI)	Sensors and switches list I/O and setting list CPP Pitch measurement form for the OD Box Mode descriptions Software descriptions Combinator curves with proper explanation (sometimes in IPI) Coupling between shaft and measurements for these Is alignment done Flushing report		

List 1. Handover from project to commissioning manager

Handover from project to commissioning

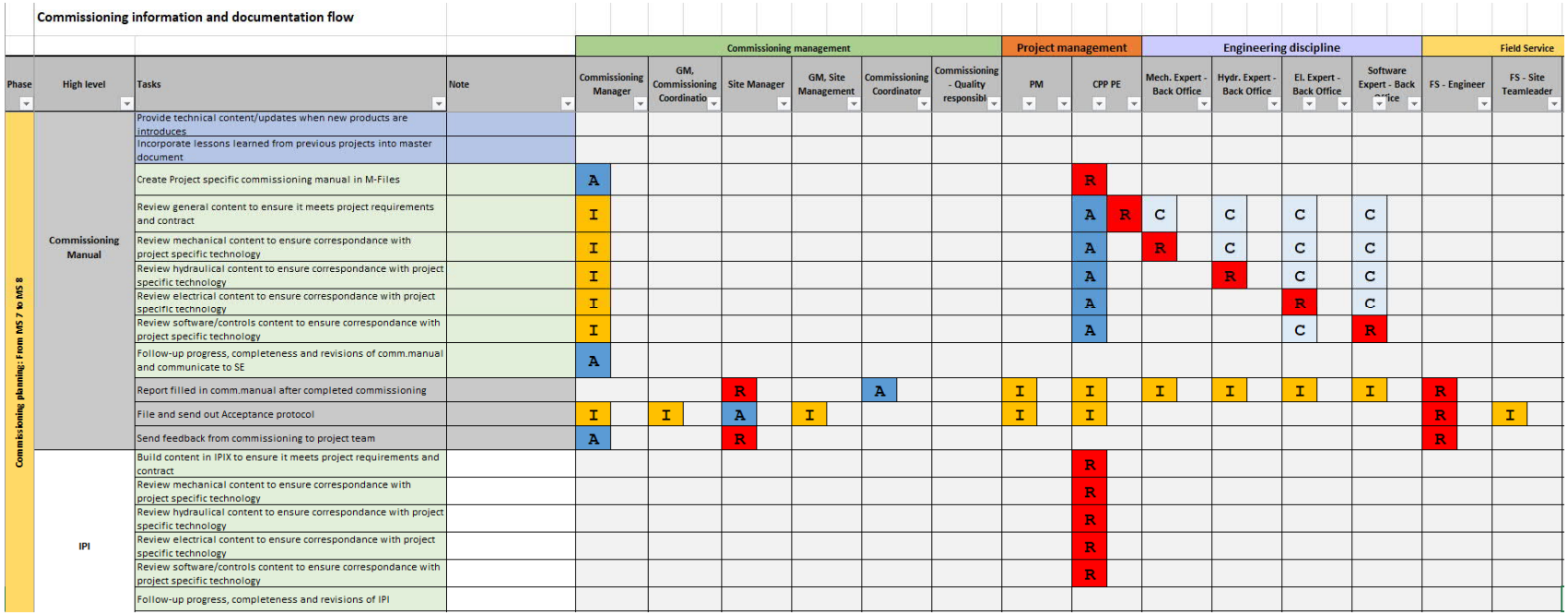
- Scope of supply clarified
- Contact persons clarified
- Responsibilities clarified
- Are there special equipment?
- Document related
  - Is IPI and OMM made
  - Are all drawings available
- Design related
  - Eg. Are oil quantities known?
  - Ship operational profile clarified
    - Diesel and Gas operation
    - PTO/PTI/boost
    - Combinators' curve and pre-setting
    - Propeller power curve
    - Ship speed/bollard pull
- Reporting practices (any project or customer specific requirements?)

List 2. Handover from commissioning manager to service engineer (or/and site manager)

Pre-requisite: Project specific commissioning manual and protocols have been made

- Scope clarification, highlight new/additional equipment
- Contractual man-days and number of trips
- Back-office support -name of main contacts
- Design aspects
    - Drawing of special project purchasing equipment as Shaft brake, Torque meter, Air guard system.
    - all loose parts for mounting propeller blades is delivered during arrival inspection.
    - A statement that shaft alignment has been approved by Wartsila
    - GA (General arrangement)
    - Stern tube assembly
    - All piping flow chart, lubrication, hydraulic, air - (HPP/servo/hub lubrication, shaft brake)
    - Mode of operation
    - What type of Control system (Lipetronic/Protouch. Gear-box lay-out. PTO, PTI, Two speed, Boost, Diesel electric
- Drawings, documents etc
- FAT reports
- Highlight risks
- Reporting guideline
- Procedure for ordering of additional parts (yard non-conformity)
- Checklist for office day before going to site

Figure 17. Screenshot of preliminary RACI for commissioning documentation for CPP product delivery



Commissioning information and documentation flow

				Commissioning management						Project management		Engineering discipline				Field Service	
Phase	High level	Tasks	Note	Commissioning Manager	GM, Commissioning Coordinatio	Site Manager	GM, Site Management	Commissioning Coordinator	Commissioning - Quality responsibl	PM	CPP PE	Mech. Expert - Back Office	Hydr. Expert - Back Office	El. Expert - Back Office	Software Expert - Back Office	FS - Engineer	FS - Site Teamleader
Commissioning planning: From MS 7 to MS 8	Commissioning Manual	Provide technical content/updates when new products are introduces															
		Incorporate lessons learned from previous projects into master document															
		Create Project specific commissioning manual in M-Files		A							R						
		Review general content to ensure it meets project requirements and contract		I							A R	C	C	C	C		
		Review mechanical content to ensure correspondance with project specific technology		I							A	R	C	C	C		
		Review hydraulical content to ensure correspondance with project specific technology		I							A		R	C	C		
		Review electrical content to ensure correspondance with project specific technology		I							A			R	C		
		Review software/controls content to ensure correspondance with project specific technology		I							A			C	R		
		Follow-up progress, completeness and revisions of comm.manual and communicate to SE		A													
		Report filled in comm.manual after completed commissioning				R		A		I	I	I	I	I	I	R	
		File and send out Acceptance protocol		I	I	A	I			I	I					R	I
		Send feedback from commissioning to project team		A		R										R	
	IPI	Build content in IPIX to ensure it meets project requirements and contract									R						
		Review mechanical content to ensure correspondance with project specific technology									R						
		Review hydraulical content to ensure correspondance with project specific technology									R						
		Review electrical content to ensure correspondance with project specific technology									R						
		Review software/controls content to ensure correspondance with project specific technology									R						
		Follow-up progress, completeness and revisions of IPI															