Kristina Kjersem

Contributing to Resolving a Project Planning Paradox in ETO: From plan to planning

Molde University College
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To my mother

List of publications

The choice of dissertation type was discussed early on this PhD project, and the conclusion was that a monography-based type of dissertation would be most suitable. Nevertheless, as part of the academic work, I authored and co-authored fourteen conference articles as presented in the table below. One of these articles was further developed into a journal article. The articles presented here are part of the work as a PhD student, but they are not directly included in this dissertation.

Year	Title and authors
2019	**Changing markets: implications for the planning process in ETO companies** (Kristina Kjersem and Marte Giskeødegård) **APMS conference**
	Det kan være et veldig godt verktøy, hvis det fungerer (Marte Giskeødegård og Kristina Kjersem). Presented at **Fjordkonferansen**
	Lean project planning and control: empirical investigation of ETO projects (Gabriele Jünge, Erlend Alfnes, Kristina Kjersem, Bjørn Andersen) – **International Journal of Managing Projects in Business**
2017	**Project Execution Strategy and Planning Challenges** (Kristina Kjersem, Gabriele Jünge) **APMS conference**
2016	**Improving planning processes for ETO projects: a case study** (Kristina Kjersem, Gabriele Jünge) **APMS conference**
	Categorizing Engineer-To-Order Companies through their Project Execution Strategies (Kristina Kjersem, Gabriele Jünge) **APMS conference**
	Addressing waste in design and engineering through lean project planning and control: A case study on ETO industry (Gabriele Jünge, Kristina Kjersem, Erlend Alfnes) **EurOMA conference**
	The maturity of planning and control in ETO projects (Gabriele Jünge, Kristina Kjersem, Erlend Alfnes, Bjørn Andersen) **PMA conference**
2015	**Implementing Lean in Engineer-To-Order Industry: A case study** (Kristina Kjersem, Lise Halse, Peter Kiekebos, Jan Emblemsvåg) **APMS conference**
	From First to Last Planner: Applying a Capability Model to measure the Maturity of the Planning Process in ETO (Gabriele Jünge, Kristina Kjersem, Mikhail Shlopak, Erlend Alfnes, Lise Halse) **APMS conference**
	Managing uncertainty in purchasing in engineer-to-order manufacturing (Lise Halse, Kristina Kjersem, Gabriele Jünge, Mikhail Shlopak) **EurOMA conference**
2014	**Literature review on planning design and engineering activities in shipbuilding** (Kristina Kjersem and Jan Emblemsvåg) **IGLC conference**
	Implementation of Lean Project Planning – a knowledge transfer perspective (Lise Halse, Kristina Kjersem, Jan Emblemsvåg) **APMS conference**
	Lean Project Planning in shipbuilding: The implementation challenge (Lise Halse, Kristina Kjersem, Jan Emblemsvåg) **EurOMA conference**

Preface

My first encounter with the Norwegian shipbuilding industry started during my Master's studies when I could study two of the shipyards within Aker Yards, (later Vard Group AS). Apart from gaining insight from the development of the lean shipbuilding concept (a mix of lean construction and lean manufacturing tools), that collaboration gave me a good starting point with my PhD research some years later.

The idea for this PhD research started at a lean construction conference in Oslo, while discussing common interests about the lean topic with Jan Emblemsvåg. This event triggered collaboration among three different research institutions: Møreforsking Molde, SINTEF Trondheim, and Molde University College. Later, The Research Council of Norway (RCN) approved the funding of the research project called Next Ship that lasted from 2011 to 2015. This project included two PhD grants, and their topics were inspired by the challenges in improving project planning and control within the shipbuilding industry. During the PhD study, I kept the project planner role as a part-time position until 2015 to benefit from the inside perspective, a highly beneficial approach when performing action research.

Working as a project planner at Vard was also a motivation for this research. At Vard, I learned that the shipbuilding industry was traditionally based on trust between project partners and tacit knowledge provided by the employees at these shipyards. Hence, until recently, planning was regarded as less important, especially for design- and engineering activities. Together with the company we decided to research for understanding why things appeared that way, and what kind of solutions could potentially be proposed.

This dissertation contains data from several companies with much of the work performed in collaboration with Vard Group AS. However, any opinions, findings, conclusions, or recommendations expressed in this dissertation are mine, and do not necessarily reflect those of Vard.

This dissertation has been evaluated by a committee consisting of Professor Iris Tommelein from University of California, Berkeley, Professor Hans-Petter Hildre from NTNU Ålesund, and Professor Trond Hammervoll from Molde University College. Their thorough evaluation and subsequent comments on earlier versions of this dissertation led to substantial improvements in all chapters. I highly appreciate those comments and I can confidently say that this dissertation would not be in its current form without their input. However, any remaining shortfalls are solely my responsibility.

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My debts are great and widely spread. To begin with, I want to thank my supervisor Jan Emblemsvåg, who made this whole project possible from the beginning. I am also very thankful for all the support and possibilities Jan facilitated for me, as well as for the guidance throughout the entire PhD research. He kept involving me in implementing LPP and inviting me to meet new case companies. All these experiences are extremely valuable for me both academically and personally.

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Thank you to Bjørn Guvåg and Lise Halse for co-supervising this PhD research.

To Vard Group AS, thank you both for giving me the opportunity to be involved in so many projects and for all support I received during the years. Arvid Sundli, thank you for your valuable comments to some of my articles and to my dissertation.

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I would like to thank all my colleagues at the production department at Søviknes: Jan Gamlem, Odd-Ståle, Kjell-Jostein, Pål-Ove, Bjørn-Arne, Jostein, Silje, Gordon, Marius, Kumar and all the rest of the team for teaching me planning in practice. Many thanks to people at the technical department: Knut-Tore, Arnfin, Nils Kristian, Steffen, George, Tina, Costin, Hermann, and all the rest of the engineers working there for involving me in your projects and for patiently answering my questions. My thanks also go to Roy-Sindre, Kenneth, Per Gunnar, Christian, Arnt Inge, Andreas, and all the other project managers at Søviknes for giving me the opportunity to be a part of your project teams.

Many thanks to all my colleagues at Vard Design, Vard Brattvåg, Vard Langsten, Vard Aukra, Vard Tulcea, Vard Constanta, Vard Braila, and Vard Vietnam.

Two people, Michal Johnsen, and Edgar Bårdsnes deserve special thanks for contributing to both my Master's thesis and to my PhD dissertation.

Special thanks to the planners in Vard Group: Isabel, Odd-Sindre, Vebjørn, Mariana, Helge, Maria, Tore-Kristian, Sveinung, Caroline, Petre Calenic, Liliana, Vasile, Geir Ole, Line, Cincu, Hugues and Peter Kiekebos. I have learned a lot about planning by being a part of this special team.

To Denise and Luci, thank you for your friendship and for your contribution to my research.

Special thanks to Gabriele for all the support, opportunities and encouragement throughout the years. I owe you.

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I would like to thank IT- and the library departments at Molde University College for a good service and support.

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I want to thank to all my friends at Føniks skydiving club for their moral support and for reminding me that free fall is what one needs to boost a moral.

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I want to thank to my friend Roxana for being a good source of inspiration and for her moral support.

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To Irina, Madalin, Petre, Oana, Adrian, Dana, Razvan, and Carla, thank you for your encouragement and unconditional support, and for inspiring me in so many ways.

My biggest gratitude goes to my mom for her unconditional love, optimism and support throughout all my life. Without your love for learning and adventures I would not be here. I owe you so much.

Kristina Kjersem Molde, 31.03.2020

List of acronyms

2D	Two-dimensional
3D	Three-dimensional
ATHV	Anchor Handling Tug Vessel
ATO	Assemble-To-Order
CAD	Computer Assisted/Aided Design
CC	Critical Chain
CE	Concurrent Engineering
CEPC	Concurrent Engineering Procurement Construction
CONWIP	Constant Work in Progress
CPI	Cost Performance Index
CPM	Critical Path Method
CV	Cost Variance
DC	Discipline Coordinator
DfM	Design for manufacturability
DfX	Design for X (assembly, service, etc.)
ERP	Enterprise Resource Planning
ETO	Engineering-To-Order
EVM	Earned Value Management
FPF	Frequency of Plan Failures
LAP	Linguistic Action Perspective
LC	Lean Construction
LCI	Lean Construction Institute
LPP	Lean Project Planning
LPS®	Last Planner® System
MTO	Make-To-Order
MTS	Make-To-Stock
OM	Operations Management
OSV	Offshore Specialized Vessel
PDCA	Plan-Do-Check-Act
PERT	Project Evaluation and Review Technique
PES	Project Execution Strategy
PM	Project Manager
PMBOK®	Project Management Body of Knowledge
PMI	Project Management Institute
PO	Project Organization
PPC	Percent Plan Complete
PSV	Platform Supply Vessel
RCA	Root Cause Analysis
RE	Required Level
Ro-No	Romanian-Norwegian
Spec	Specification document
SPI	Schedule Performance Index
SV	Schedule Variance
TA	Tasks Anticipated
TC	Technical Coordinator
TMR	Tasks Make Ready
TPDS	Toyota Product Development System
TPS	Toyota Production System
TWI	Training Within Industry
VBD	Vard Basic Design
WBS	Work Breakdown Structure
WIP	Work In Progress

Definitions of terms

Words and terms can have different definitions or interpretations and usually depend on their context. In order to develop a common understanding of the proposed research questions and findings, this section lists definitions of terms and words used in this research.

Term	**Definition**
Activity	A component of work performed during the course of a project.
ATO	Assemble-To-Order is a business production strategy where components are assembled according to specific customer orders as opposed to assembling to fill a stock level (Business dictionary).
Baseline	An approved plan for a project, plus or minus approved changes. It is compared to actual performance to determine if performance is within acceptable variance thresholds. Generally refers to the current baseline, but may refer to the original or some other baselines. Usually used with a modifier (e.g., cost performance baseline, schedule baseline, performance measurement baseline). In EVM, this is referred to as planned value (Flemming and Koppelman 2010).
Budget	The approved estimate for the project or any work breakdown structure component or any scheduled activity.
BTO	Build-To-Order is a production strategy based on building customized products once the customer order is received. BTO products usually exceed standard specifications and are designed to meet the design required by the customer (Technopedia). BTO does not allow inventories of finished goods in the system and it is used to manufacture a low volume of products on a pre-determined high-variety using a cluster of components (Gunasekaran and Ngai 2005)
CTO	Configure-To-Order is a hybrid production strategy combining make to stock and make to order operations. This hybrid model is suitable in an environment where the time it takes to assemble the end product is negligible. CTO refers to technical solutions (product or system) that have already been studied in detail and that are based on some predefined customer requirements. Most of the time in such cases, the technical solutions result from the assembly of standard sub-systems and components (ATO and MTO situations) that have been entirely defined and fully characterized (Felfernig et al. 2014).
Control	Comparing actual performance with planned performance, analyzing variances, assessing trends to effect process improvements, evaluating possible alternatives, and recommending appropriate corrective action as needed (PMBOK® 2013a).
Concurrent Engineering	A systematic approach to integrated, concurrent design of products and their related processes including manufacturing and support (Winner et al. 1988).
CEPC	Concurrent Engineering Procurement Construction - A more specific form of concurrency emphasizing the idea that engineering, procurement and construction phases must be managed and planed simultaneously in order to achieve the planned effects of concurrency (Emblemsvåg 2012).
CONWIP	Constant Work In Progress - A lean tool using signals assigned to a production line showing that a job cannot start before a place in the system has been vacated for it (Emblemsvåg 2014a).
CPI	Cost Performance Index – a measure of the cost efficiency of budgeted resources expressed as ratio of the earned value to actual cost (PMBOK® 2013a)
Discipline plan	A detailed plan for a certain discipline, for example, the painting plan. The purpose is to sequence the activities for execution and to plan manning.
DfX	Design for X – are terms and expansions used interchangeably in the existing literature where X is a variable which can have one of many possible values (design for inspection (DFI), design for manufacturability (DfM), etc.).

ETO ETO products	Engineer-To-Order is a production strategy where design, engineering and production do not commence until after a customer order is confirmed. ETO products are customer specific, highly customized items produced in low volumes through non-repetitive, yet labor intensive processes that demand highly skilled labor (Stevenson, Hendry, and Kingsman 2005).
ETO projects	ETO is a project-based approach implying that each product is delivered through a project management approach. In the context of this dissertation, ETO products are all projects where the customer is involved from the design to the delivery phases and many of the product components are customized to fit the purpose of the final product.
Estimate cost	The process of developing an approximation of the monetary resources needed to complete project activities (PMBOK® 2013a).
EVM	Earned Value Management is a project management technique for measuring project performance and progress in an objective manner (Flemming and Koppelman 2010) .
Hypothesis	The word *hypothesis* comes from the ancient Greek word *hupothesis*, meaning "to put under" or "to suppose" (Wikipedia). It is a statement created by researchers when they try to predict the outcome of an experiment or a research (Chigbu 2019)
FTO	Fabrication-To-Order is a production strategy where a product or item put together from parts that are already designed, but remain to be made, so as to meet the customer requirements (Wikipedia).
LAP	Language-action perspective "takes language as the primary dimension of human cooperative activity," applied not just in person-to-person direct (face-to-face) interactions, but also in the design of systems mediated by information and communication technology (Salazar et al. 2018).
Lead-time	Is the time estimated time to deliver the required product to the customer (Hopp and Spearman 2000).
LCI	Lean Construction Institute is an association with a vision to transform the design and construction industry with Lean implementation to provide more value to the end users and boost productivity (www.leanconstruction.org).
Lookahead plan	The level of planning between phase schedule and daily/weekly work plans, dedicated to making scheduled tasks eligible for commitment. This is done through constraints analysis and removal, breaking down tasks into operations, and collaboratively designing those operations. When constraints cannot be removed, re-planning is initiated (Ballard and Tommelein 2016).
LPS	Last Planner® System is production planning system designed to produce predictable work flow and rapid learning in programming, design, construction and commissioning of projects (www.leanconstruction.org).
Manufacturing	Comprises the whole chain of activities from research and innovation through to recycling of the provided product. Physical fabrication is only one small part of the whole manufacturing process (Roos 2016).
MTO	Make-To-Order is a production strategy that allows consumers to purchase products that are customized to their specifications. The customer select the desired product design from within a pre-defined solution space. The engineering design and specifications are completed before the customer order is received (Willner et al. 2014).
MTS	Make-To-Stock is a traditional production strategy that is used by companies to match the inventory with forecasted consumer demand. Instead of setting a production level and then attempting to sell goods, a business using MTS would estimate how many orders its products could generate, and then supply enough stock to meet those orders (Business dictionary)
Milestone plan	A summary-level schedule that identifies the major schedule milestones.
Operations management	Application of resources (capital, materials, technology, human skills and competence) to the production of goods and services (Hopp and Spearman 2000).

Period plan	Contains the most execution critical activities from the Master plan, and it is looking ahead five to eight weeks with the purpose of preparing activities for execution (follows the ideas defined in LPS' lookahead plan).
Physical progress	The actual, physical progress of work as identifiable in production. Ideally, this should be measured directly, but often it is accepted to use "guesstimates" in percentages (should not be computed).
Planning process	Those processes performed to establish the total scope of the effort, define and refine the objectives, and develop the course of action required to attain those objectives. A planning process implies actions that need to be performed by the project team in order to plan, schedule, report and control all activities within a project (Emblemsvåg 2014a).
Planning system	It refers to the software and scheduling part of the planning process (Emblemsvåg 2014b).
Product family	Refers to a group of related goods produced by the same company under the same brand. A product family supplies an array of products that are similar but meet slightly different needs or tastes, potentially attracting more customers (Wikipedia).
Product platform	A product platform is a set of common elements like underlying technical components, parts or technology that are shared across a range of the company's products. Likewise, new derivative products can be developed and launched by the company based on a common product platform (Wikipedia)
Production	In this dissertation, production refers to the physical fabrication of the product.
Production management	The job of coordinating and controlling the activities required to make a product, typically involving effective control of scheduling, cost, performance, quality, and waste requirements (www.businessdictionary.com).
Production planning	Production planning refers to planning activities at the production department (Emblemsvåg 2014b).
Project	"Is an endeavor in which human, financial and material resources are organized in a novel way to undertake a unique scope of work, of given specification, within the constraints of cost and time, so as to achieve beneficial change defined by quantitative and qualitative objectives" (Turner 1999, p.3).
Project management	Is the application of knowledge, skills, tools and techniques to project activities to meet the project requirements (PMBOK® 2013a).
Project production management	Refers to the application of operations management to the delivery of capital projects. The project production management model is based on a project as a production system view, in which a project transforms inputs (materials, information, resources) into outputs (goods and services). The model applies tools and techniques typically used in manufacturing management to assess the impact of variability and inventory on project performance (Wikipedia)
Project planning	Refers to planning a project considering all its phases (engineering, procurement and production).
Project Management Body of Knowledge (PMBOK®)	An inclusive term that describes the sum of knowledge within the profession of project management. As with other professions, such as law, medicine, and accounting, the body of knowledge rests with the practitioners and academics that apply and advance it. The complete PMBOK® includes proven traditional practices that are widely applied as well as innovative practices that are emerging in the profession. PMBOK® includes published and unpublished materials, evolving continuously. PMI's guide identifies the subset of the project management body of knowledge that is generally recognized as good practice (PMBOK® 2013a).
Project management team	The members of the project team who are directly involved in project management activities. On some smaller projects, the project management team may include virtually all of the project team members.
PES	Project Execution Strategy is about management tactics applied by ETO companies to manage, plan, control and complete a project according to customer requirements. Since not all project phases are completed at the same company,

	PES must deal with projects divided in phases executed by different internal or external suppliers.
PPC	Metric used by LPS to gauge plan reliability. The percentage of actual completions to planned completions in a daily or weekly work plan (Ballard and Tommelein 2016).
PMI	Project Management Institute is a not-for-profit professional membership association for the project management profession (ww.pmi.org).
PDCA	Plan-Do-Check-Act - the most basic improvement circle in lean. It is derived from the scientific approach to problem-solving and will over time give the best results (Sobek and Smalley 2008).
Sound activities	The activities that are made ready to be executed by analyzing and removing all constraints.
Spec.	A document that specifies, in a complete, precise, verifiable manner, the requirements, design, behavior, or other characteristic of a system, component, product, result, or service and, often, the procedures for determining whether these provisions have been satisfied. Examples are: requirement specification, design specification, product specification, and test specification.
TA	Tasks Anticipated - a metric in the LPS that measure the percentage of tasks for a target week in the lookahead plan that were anticipated in an earlier plan for that target week (Ballard and Tommelein 2016).
SPI	Schedule Performance Index – a measure of schedule efficiency expressed as ratio of earned value to planned value (PMBOK® 2013a)
STS	Ship-To-Stock is a supply strategy where components are shipped directly into the manufacturing stock without the traditional good inwards inspection and possible sample testing (Wikipedia).
Week plan	A detailed overview/plan of the tasks/activities each project member has committed himself/herself and their team to complete during the coming week.
TWI	Training Within Industry - is a program developed by the Unites States during the World War II and implemented in many Japanese companies during the 50's and 60's. TWI emphasizes the role of training the workers in understanding the working processes before changing them and it is the foundation for building and sustaining lean in any enterprise (Dinero 2005).
WBS	Work Breakdown Structure - a hierarchical decomposition of the total scope of work to be carried out by the project team to accomplish the project objectives and create the required deliverables (PMBOK® 2013a).
Work package	The work defined at the lowest level of the WBS for which cost and duration can be estimated and managed (PMBOK® 2013a)

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Abstract

This research sets out to address the project planning paradox observed in many ETO companies, where it is acknowledged that planning is essential, however, very few companies focus on the process that makes it effective. The purpose of this research is fulfilled by examining the planning process as performed by several companies within the Norwegian shipbuilding industry, a typical ETO environment. Due to the complexities in planning such projects, an action research method is applied to the research process.

The ETO literature, as well as the observed cases, reveal that most ETO companies lack focus on planning their design-and engineering activities. The challenges of planning these activities originate in the context in which these are performed, namely ETO. Concurrency, iterations, network organized projects, outsourcing, and a dynamic environment are some of the ETO characteristics that pose significant challenges when planning such projects. These challenges lead to so many variables that it makes it impossible to realistically simulate them in a model or software that can give the project team a satisfactory solution within the allotted lead-time. When the complexities are so many, we need, on one hand, to find solutions that enable project teams to deal with them (without adding an unnecessary workload) while, on the other hand, facilitating relevant information, insight and knowledge, to arrive at the right people at the right time so that they can make best possible decisions. In this way, project participants can reduce errors, avoid delays, and improve project performance.

The solution proposed throughout this dissertation is that organizing well-structured planning meetings for design- and engineering activities, which facilitate communication, commitment, and trust, allows ETO companies to deal with the challenges of planning their projects. That implies more emphasis on the planning process itself as opposed to focusing only on the technical part (scheduling software). However, very few ETO companies allocate enough time to developing a proper planning process that would allow them to deal with the inherent challenges of this environment.

This research contributes to the growing body of research on the ETO environment with a focus on the project planning process. It is also contributing to the traditional project management and Lean Construction bodies of knowledge by emphasizing the need for more focus on how project planning meetings are actually organized and led throughout a project.

Chapter 1

Introduction

1 Introduction

“The best way to understand something is to try to change it”
Kurt Levin

This PhD research is part of the Next Ship project developed in collaboration with Vard Group AS, Molde University College, SINTEF (Norwegian research institute) and Molde Research Institute (an affiliation of the college). Funded by the Research Council of Norway from January 2012 until December 2015, Next Ship was a KMB (knowledge building with user involvement) type of research project. The overall goal of the project was to increase competitiveness in a network of shipbuilding actors, by enabling organizational and operational conditions to deliver customized offshore vessels with reduced time to market and, hence, reduced costs. A secondary objective of the project was to look into the issue of why do plans fail and become irrelevant, which included this PhD research.

This chapter introduces the dissertation by providing the context of the study that is the Norwegian shipbuilding industry where most of the vessels are produced through an Engineer-To-Order (ETO) approach. It then presents the background and some of the identified gaps within the studied literature. This is followed by the research objectives and the proposed research questions, which are then linked to the studied theories. The outline of the dissertation is presented in Section 1.7 at the end of this chapter.

1.1 Context of the research

The maritime industry is crucial for Norway. Indeed, The Research Council of Norway, states that: “*Norway’s maritime industry encompasses shipping companies, shipyards, and suppliers of maritime services and equipment. The industry is at the international forefront, with competitive companies across the entire spectrum of maritime industrial activities and operations worldwide. The industry has a very high share of exports, and revenues from the export of goods and services account for a significant proportion of its value creation. The industry is adept at restructuring, which is why Norway is one of the few high-cost countries that still build ships. The industry is of major importance to local and regional value creation and employment* (The Research Council of Norway 2017, p.4). Norway’s Minister of Trade and Industry stated that the Norwegian maritime industry generated over 30,000 jobs during the last ten years and the value created by this industry was NOK 190 billion in 2014. However, the industry is facing major challenges and needs new approaches and better strategies to maintain its status (www.forkningsradet.no/maroff). One of the biggest challenges is the increasing competition from Asian companies, which, supported by their national policies, are able to produce at lower prices than Norway or other European companies (BALance 2017).

The Norwegian maritime industry has always been in a state of flux, a cyclical industry influenced by periods with high pressure on capacity and others with a low number of orders for new ships. "*Changing demand patterns, combined with new technological developments and suppliers selling to competitive international markets, means that the companies rapidly need to adjust to new market demands*" (Mellbye, Helseth, and Jakobsen 2017, p.5). Or, as Liker and Meier (2007) put it in a more generic context, the world has become hyper-competitive, and companies all over the world are struggling to keep up.

During the recent downturn, the competition intensified, forcing shipyards to improve their working processes and reduce project costs to be able to win new orders and survive. These issues have made this industry an interesting topic of discussion, and this research is motivated by trying to solve one of the major challenges this industry faces: the fact that everybody thinks that planning is important, but nobody is actually planning. This is referred to as the project planning paradox in this dissertation, and it is discussed in more detail later. For now, it suffices to acknowledge that there is a gap between what is said and what it is done in planning ETO shipbuilding projects.

1.2 Background

The majority of Norwegian shipbuilding companies focus on the development of highly customized, one-of-a-kind, complex vessels for the offshore industry (Van Bruinessen, Smulders, and Hopman 2013), fishing industry and lately also smaller cruise ships. This approach to delivering highly customized products is known as ETO where the customer is involved in the project from the design phase all the way to testing and delivery (Hicks, McGovern, and Earl 2001). Although the industry designs, engineers and builds highly complex vessels, the process from design to production is profoundly segmented in both time and organization. Moreover, the industry is characterized by relatively short product development and building time as shipbuilders must deliver each customized vessel as quickly as possible (Van Bruinessen, Smulders, and Hopman 2013).

Time to market is often essential when delivering ETO products. Most customers require short project duration because they need the new vessel on the market relatively fast. For example, a daily rate for a Platform Supply Vessel (PSV) is around US$17,300 per day, so a vessel delivered with three months delay, would incur extra costs of about US$ 1.5 million (AVEVA 2018). In the cruise vessel case, the rates are even higher since these vessels are already booked for trips from the date agreed as the delivery date. Moreover, the ETO environment is also challenged to deliver their products at lower costs since customers are no longer willing to pay high premium prices (Rudberg and Wikner 2004). Therefore, as the pressure on delivering vessels within the quality, price and lead-time constraints is increasing, most shipbuilders have started to invest in improvement programs that would help them achieve the tight constraints imposed by the market. Some of those programs aim to develop working techniques that reduce the number of resources needed in a project (e.g., modularization). Other improvement programs aim to develop better project management procedures that enable project teams to deal with the challenges of managing such complex projects. This research can be included in the latter type of program.

Results from shipbuilding projects show that more than 70% of the causes for failing to deliver as planned are due to the methods used to manage and control those projects. In the shipbuilding industry, these failures are categorized as nonconformities. Figure 1-1 illustrates the division among causes for nonconformities in one of the studied shipbuilding projects. This figure is based on numbers presented at an internal workshop organized by one of the case companies and discussed in several other lessons-learned types of meetings. All participants agreed that these numbers are representative of most of their projects. Furthermore, the participants emphasized the need for better planning methods and procedures that could improve both communication- and project management in general. The category called Methods include: project execution strategy, project management and project planning.

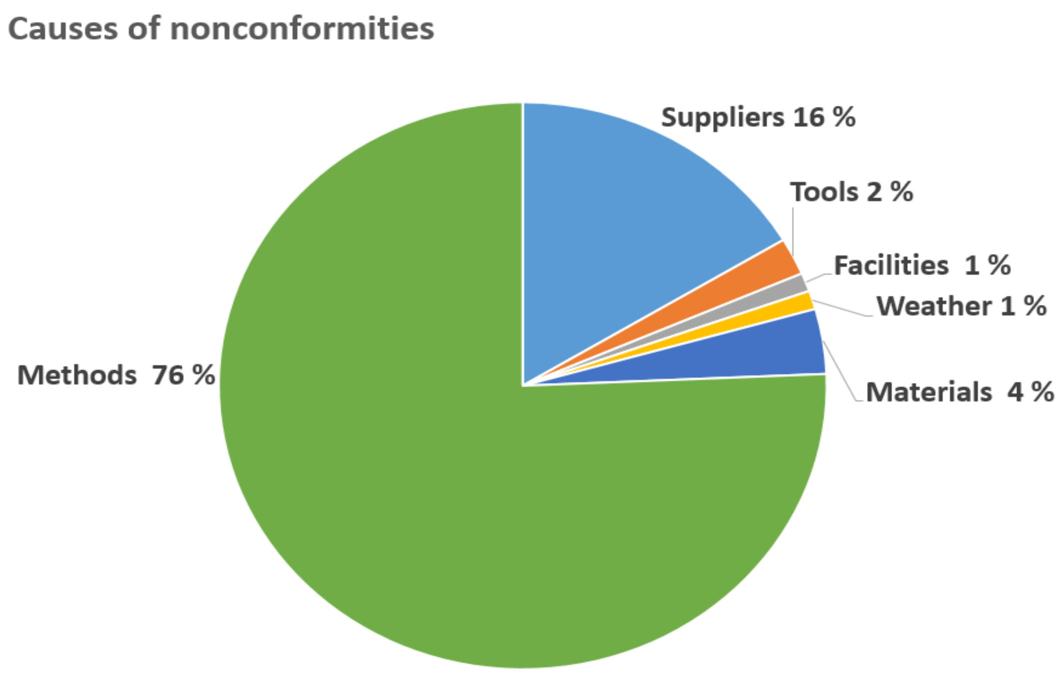

Figure 1-1: Causes of nonconformities in shipbuilding projects

Similar findings are acknowledged within the construction industry. In a study performed by Zidane, Johansen, et al. (2015), the authors identified and categorized most of the issues affecting the delivery of construction projects as illustrated in Figure 1-2. According to their study, the *management and coordination* category is the most common cause for projects failing to deliver as promised. This category comprises five subgroups: rush work, unstructured meetings, unstructured colleagues, unclear demands from the management team, and poor interdisciplinary coordination.

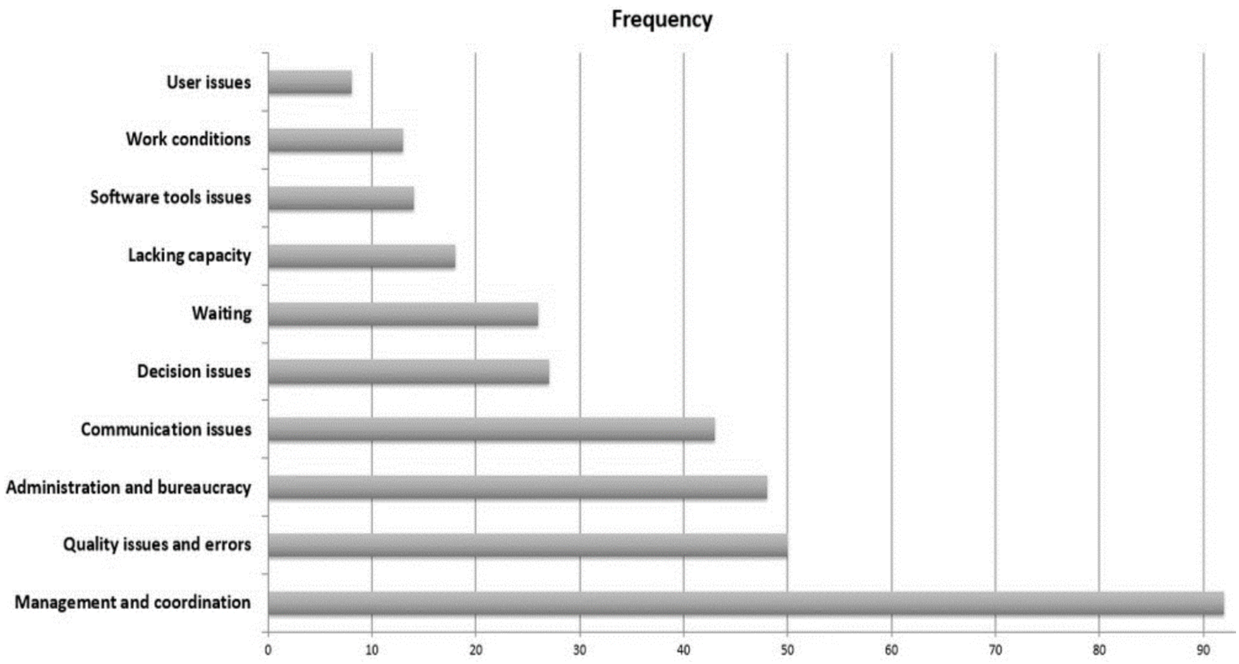

Figure 1-2: Causes of delays in construction projects (Zidane, Johansen, et al. 2015)

Based on these and other similar findings, it seems that the methods used for managing both shipbuilding and construction projects need to be improved. Since most of the products within these industries are delivered through an ETO strategy, it can be stated that there is a need for better management procedures when dealing with ETO projects. One of the processes that need to be improved is the project planning process, also the focus of this research.

Since many ETO projects are performed in distinct, but concurrent, phases performed by several different organizations, the planning of such projects is a challenging task. Both ETO literature and most practitioners agree that planning the production activities receive more attention than planning design- and engineering activities, even though the latter have a significant influence on the total cost of an ETO project. As shown by, among others, Gaspar (2013), the influence of concept, design, and detail engineering phases in a shipbuilding project is huge compared with the cost of the total project. Between 60 to 80% of the total life cycle of a vessel is determined during the concept, basic design, and detail engineering stages since all later decisions are constrained by the decisions taken during these initial phases. Figure 1-3 depicts this idea showing for example, that the cost of the concept phase is somewhere between 5-8% of the total cost of the project, while the decisions taken during this stage have an impact on 70% of the total cost of the project. By the time the production phase starts, 95% of the total costs of the project have already been decided by the concept, design, and detail engineering phases. Moreover, extracting defects becomes more and more expensive as the project develops and the vessel takes shape (Gaspar 2013).

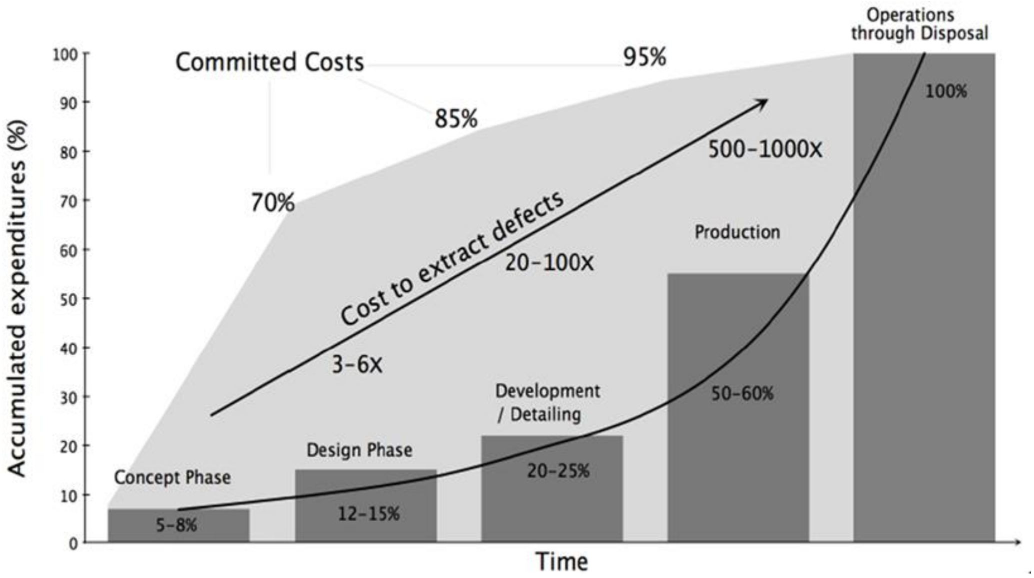

Figure 1-3: The influence of concept, design and engineering (Gaspar 2013)

Therefore, planning design- and engineering activities becomes an important element of the project planning process since delays and undetected errors during concept, design, and detail engineering phases have huge consequences for the total outcome of the project in terms of cost, quality and delivery time. This is the focus area of this dissertation.

The planning process applied by most ETO companies seems to be the most emphasized method to reevaluate or further develop. In this dissertation, the planning process implies actions that need to be performed by the project team in order to plan, schedule, report, and control all activities within a project (Kerzner 2013a). An important part of the planning process is organizing and conducting planning meetings that include issues like preparing activities for the next period, discussing root cause analysis for deviations from the plan, communicating the status of the project, and so on. In most of the observed planning meetings, it is assumed that people leading these meetings know how to organize and structure them, especially when it comes to people operating in design- and engineering departments. This research demonstrates that this is not always the case. Furthermore, as the literature review illustrates, it is also assumed that conducting effective- and efficient planning meetings is something inherently known.

In short, there is very little written about how to organize and conduct project planning meetings in the literature, whereas the practitioners assume that conducting these meetings is well-known competence. Yet, in a real project planning process, data shows this is not the case. On top of this, all parties hold that project planning is crucial for success. In other words, there is a big discrepancy between reality and beliefs, between importance and efforts, and this can be called the project planning paradox that everybody thinks project planning is important, but nobody is willing to put in the effort of organizing well-structured planning meetings.

Considering the above-mentioned aspects, it became clear that there is a need for a different planning approach that could deal with these challenges, as discussed in the next section.

1.3 Research gap

Despite constant efforts from the project teams, to keep projects on track, the literature on project management abounds on a high percentage of projects that fail to deliver as planned, see for example (Bosch-Rekveldt 2011, Flyvbjerg and Budzier 2015, Shenhar and Dvir 2007), and the reasons are many and diverse. Since most ETO companies use traditional project management tools to deliver their products, these statistics include this type of projects. Consequently, ETO companies are becoming aware of the need for better management tools and methods that can handle the challenges for planning such projects. There is a compelling need for revising the existing approaches to planning, scheduling, and control of ETO projects (Adrodegari et al. 2013), however, only a small number of scientific sources have been analyzing the problems faced by this environment (Gosling and Naim 2009).

According to Little et al. (2000), production activities in ETO projects are planned in great detail while planning design- and engineering activities is often ignored. In a similar vein, Emblemsvåg (2014b), endorses the lack of focus on planning design- and engineering activities and the need for better approaches. Therefore, one of the first gap discussed in this dissertation refers to the need for better planning processes and methods that enable the users to deal with the challenges of planning design- and engineering activities in ETO projects.

Projects carried out in an ETO environment are difficult to plan especially due to their need for concurrency among phases and activities, while dealing with a globally spread network of organizations delivering different parts of the project. The project management literature does not consider these challenges as shown in Kjersem and Emblemsvåg (2014), and the recommendations in this specific literature usually follow a standardized approach where the focus is on the scheduling part of the planning process. Moreover, the traditional project management literature stresses the need for planning in each project, but does not outline how to organize planning meetings – it is assumed that people know how to do this. Thus, the second gap addressed in this research refers to the lack of focus on the planning process reinforced by well-structured planning meetings as an approach that can deal with the challenges in planning ETO projects.

Within, the Lean Construction literature, better planning meetings are achieved through the Last Planner® System approach. Yet, the topic of how to structure and lead project planning meetings for design- and engineering activities is scarce. Hence, the project planning paradox discussed in this research refers to the idea that even though planning meetings are assumed to be an important management element, the literature on how to organize and structure these meetings is limited. In other words, there is a clear need for research on the topic.

1.4 Research objectives

The main objective of this research is to investigate how ETO projects can be better planned and controlled than with today's practices in order to achieve the proposed project goals. The second objective is to propose a better approach to organizing planning meetings for the design- and engineering activities in ETO projects.

By investigating how to improve the planning process in ETO projects, this research contributes to building knowledge within the project management-, ETO, and lean construction literatures. More specifically, the focus is on how well-structured planning meetings for design- and engineering activities can improve the project outcomes, and what this structure is. For practitioners, this research may help them identify challenges that were not considered as important from before, but have a huge impact on the way projects are planned and executed.

The gaps identified within the studied literature are presented in Chapter 2. Some of them are addressed in this dissertation, some are proposed as further research. The gaps addressed in this dissertation can be summarized through the research questions presented next.

1.5 Research questions

The objectives presented above have been operationalized into one main research question and three sub-questions. They have been defined to investigate and verify/reject associated hypotheses in order to create relevant knowledge concerning the aforementioned objectives of this research. Figure 1-4 aims to visualize the reasoning behind configuring these research questions. RQ1 is a broad, high-level type of question addressing project planning in ETO companies in general. From within the large number of possibilities to deal with RQ1 issues, and based on the reviewed literature, RQ2 was formulated to specifically address the challenges of planning of design- and engineering activities in ETO projects. Then, a closer look at the way planning meetings were organized by each project team was necessary. The research method used for understanding the way planning meetings were organized and conducted was action research. Subsequently, RQ3 was formulated based on the hypothesis that well-structured planning meetings would improve the outcome of a project. Further analysis of the way engineers organize and structure planning meetings resulted in the hypothesis behind RQ4. These research questions, together with the hypothesis for RQ3 and RQ4, are presented in greater detail in the following.

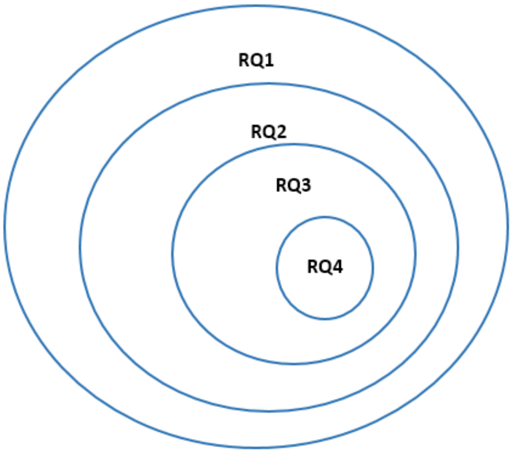

Figure 1-4: Research questions building steps

The main research question is high-level, addressing the core of the issue:

RQ1: ***How can we improve the planning process in ETO projects?***

This research question is proposed with the aim to satisfy two purposes: 1) to review a broad range of project management concepts associated with ETO companies; 2) to identify concepts that can improve the planning and control of ETO projects. The project management literature does not address the specificity of planning ETO projects like for example the need for concurrency, network organized projects or iterative nature of design and engineering activities (Kjersem and Emblemsvåg 2014). Given the large extent and potentials within this question, and based on the findings within the studied literature, a narrower research question is proposed as derived from the main RQ.

The purpose of RQ2 is to examine the main factors influencing the process of planning design- and engineering activities and to formulate propositions explaining the influence of such factors. The data collected from several companies indicate that production activities in ETO projects are at times planned and control in a better way than design- and engineering activities. This is also supported by existing ETO literature. In a comprehensive study by Little et al. (2000, p.547), the authors noticed that the "*planning of output for a factory is typically based around the planning of the production activity without significant effort allocated to the planning and management of design. Although the design activity is critical and has to be completed to specify the components and assemblies necessary to feed the requirements plan, it is typically poorly managed and causes delays in delivery to the customer.*" To investigate why this lack of focus on planning design- and engineering activities, it became evident that mapping today's challenges will provide a more holistic understanding regarding the context of such activities, allowing us to improve the situation subsequently. Therefore, RQ2 is formulated like this:

RQ2: ***What are the main challenges of planning design- and engineering activities, in ETO projects, and how can these be handled?***

One of the biggest challenges identified during the research was, in fact, the lack of focus on planning these activities. Throughout the data collection process, it became evident that most engineers rely on a scheduling software, at best, and paid little attention to how to organize and lead planning meetings so that the plan resulted in planning. Yet, it was clear that with the same training, same organization, same type of project, same software, and same scheduling approach, there could be major differences in project outcomes. This could only be ascribed to the quality of the planning meetings themselves and the quality of the people. Since this dissertation is not about organizational development, the planning meetings are the focal point. Therefore, RQ3 refers to structuring planning meetings and is formulated as follows:

RQ 3: *What planning meeting structure produces better project outcome?*

To address research sub-questions 3 and 4 scientifically, complementary hypotheses were required. The hypotheses are formulated as target-statements, which if found to be true would indicate that we have found an answer to the corresponding research question. Because the deployed research approach follows a qualitative design, the testing is not a mathematical one – and hence not a test in a statistical sense – but rather a conversational one in line with the philosophy of science suitable for such research. The hypotheses must also be formulated as an improvement over the status quo and not as the best possible solution since providing what solution is "best" is very difficult in such a setting (Chigbu 2019). In many ways, it can be thought of as a future state along the lines of future state formulations in lean. With this in mind, the following hypothesis was developed for RQ3:

Hypothesis RQ3: Well-structured planning meetings for design- and engineering activities improve the project outcome.

This hypothesis has been proposed as an outcome of the research period when a lack of structured project planning meetings proved to be a hinder for effective communication and information exchange within the project team, causing significant differences in project results. In fact, it turns out to be much more fundamental than previously believed when the research started. After all, what good is an elaborate planning system if we cannot bridge the gap between the system and the mind of the people doing the work? Furthermore, without a well-structured planning meeting, how can the project team bring individual talents to bear for the greater good of the team and the project? These rhetorical questions illustrate the fact that coordinating the people through a structured planning process is fundamental.

Project outcome refers to delivering the project within the agreed delivery date and budget. This is a key result indicator for the shipyards and their projects and therefore, a relevant measure of success also for design- and engineering activities. It is applied to both hypotheses when testing them. Moreover, due to the business-sensitive nature of these numbers, this dissertation does not present any absolute numbers on a project level but instead refers to the percentage of improvements when testing the hypotheses.

The last research question emerged from the observations that the technicalities of meetings, i.e. the structure, was insufficient to explain all the observed differences. However, while not being able to target all important elements required, as discussed in Chapter 7, the solution was to develop a broader question in order to be able to answer some of the challenges addressed in the next research question.

RQ4: ***Apart from meeting structure, what other elements are important to ensure the best possible communication and interaction between project participants to the benefit of the project outcome?***

Hypothesis RQ4: Individual communication- and interaction qualities among the project participants are important for improved project outcome

This research question was proposed as a continuation of the RQ3 as we discovered throughout the research period that there are several other factors (other than the structure) affecting the planning process and consequently the project outcome. Observing many project meetings during the six years of this study, it became clear that organizing project planning meetings is dependent on the background and interest in planning of both project managers, technical coordinators as well as company leaders. While in many ETO projects people were interested in planning, but they lack both skills and training in how to plan, in other projects people had neither interest nor the skills so projects were progressing more or less out of the old habit of "*this is how we do things here*".

The proposed research questions need to be linked to theoretical stances and in the following is presented the reasoning behind these connections.

1.6 Linking research questions and theory

All research question presented above are linked to planning approaches performed within ETO environment. Figure 1-5 visualizes these connections.

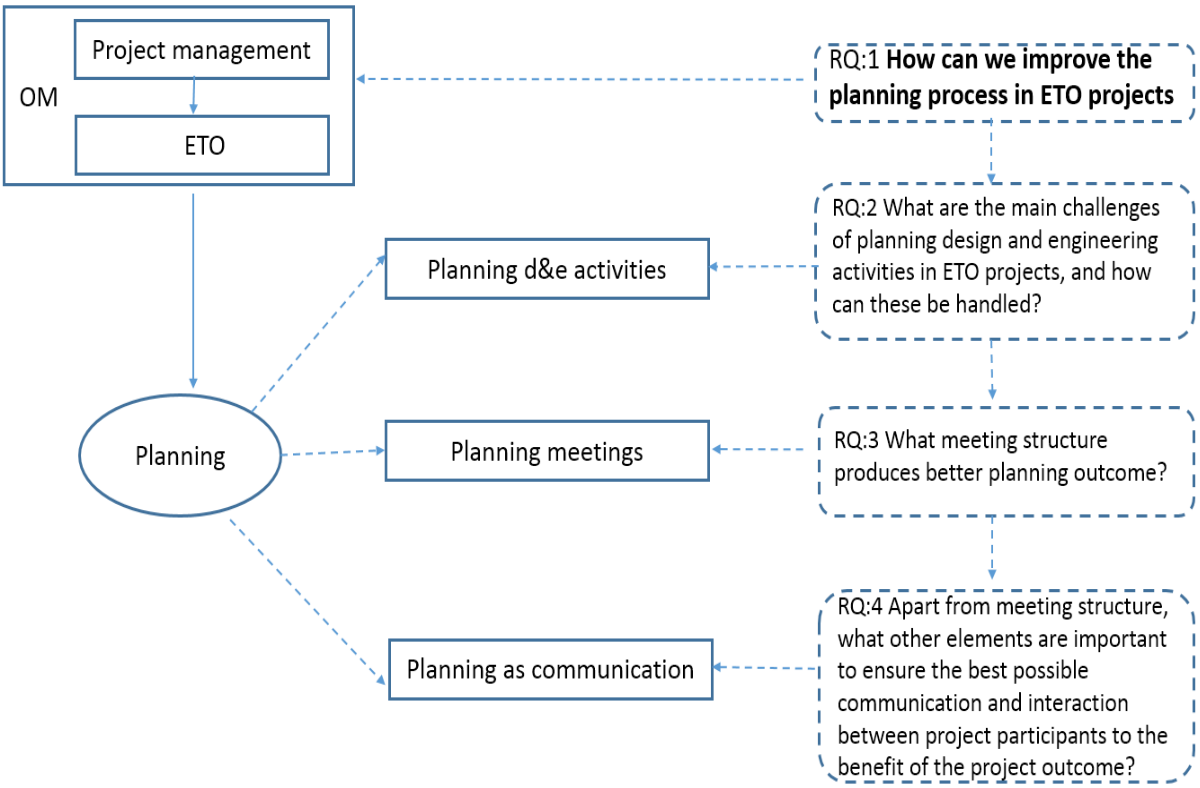

Figure 1-5: Linking RQ and theoretical background

The overall theoretical stance is operations management where project management tools are used in planning and controlling ETO projects. As observed within the theoretical and empirical reviews, planning design- and engineering activities is a challenge unsolved yet. Solutions on how to improve the planning process by focusing on the way planning meetings are structured and conducted by the project team, are proposed throughout the dissertation. The scope of Figure 1-5 is to illustrate the connections between the proposed research questions as well as the connection between those and the literature presented in the next chapter.

However, before presenting the theoretical background of this research, an outline of the dissertation is provided.

1.7 Outline of the dissertation

Chapter 1 introduces the reader to the context of the research, the research objective, research questions and other relevant introductory aspects.

Chapter 2 provides a review of the literature that fit the scope of this research such as: Operations Management (OM), Project Management, ETO and Lean Construction (LC). The arguments for choosing these theories are based on the idea that OM is the general context while project management is a type of operation within OM. Most ETO companies deliver their products through project management tactics as well as some elements from LC to plan and control such projects.

Throughout Chapter 3, philosophical aspects on the planning as project activity are presented. It addresses aspects like etymology, ontology, epistemology, methodology, ethics and an interpretation of planning as a decision-making tool. Chapter 4, presents the methodology used for developing this research. As an Action Research, this study contains large amount of data that had to be carefully analyzed in order to give the reader the arguments for reaching the proposed results.

Chapter 5, introduces two of the case companies studied during the research period. These companies exemplify the context of the research.

Based on the outcomes from previous chapters, Chapter 6 presents the findings and the answers to the proposed research questions. The results presented here rely on a systematic analysis of the data collected throughout the six years of research.

Contributions to theory and to practice as well as limitations and further research are presented in Chapter 7.

Chapter 2

Theoretical perspective

2 Theoretical perspective

"Science is a way of thinking much more than it is a body of knowledge"

Carl Sagan

This chapter provides a description of the main bodies of knowledge related to the topic of this dissertation. These theories are selected based on their qualities to explain observed and unspoken practices of managing and planning meetings within ETO projects. Figure 2-1 visualizes the context of this research as well as the theoretical stances used for identifying solutions to the proposed research questions. The overall concept is Operations Management (OM) where projects are recognized as a type of operations managed by using approaches recommended within the project management literature. ETO type of projects deliver low volume, high variety of customized products. Two of the industries using ETO approaches to most of their products, are shipbuilding and construction industries. In this dissertation, shipbuilding industry is main research context while the proposed solutions to its planning challenges are inspired from Lean Construction (LC) environment. The focus area of the proposed research questions is within the planning part of ETO projects, more specifically on how to organize and structure planning meetings. OM, project management and ETO are theoretical stances representing the context of the research, while shipbuilding, LC, project planning and planning meetings are part of the solutions to the proposed research questions.

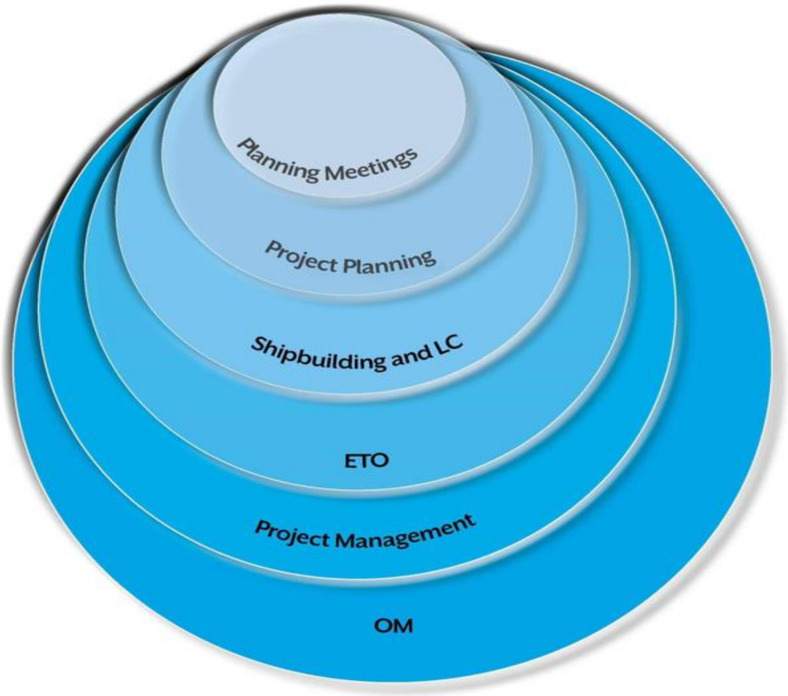

Figure 2-1: The context of the research

Since the overall field of research is OM, some of its most relevant aspects that are applicable to project-driven environments relevant for this research are presented next.

2.1 Operations management (OM)

Hopp and Spearman (2000) define operations as the application of resources (capital, materials technology, as well as human skills and competence) to the production of goods and services. OM is the management of these operations. There are several different dimensions that describe the nature of the processes within OM, among them the volume-variety and type of output: product, service, or a combination of these (Maylor, Turner, and Murray-Webster 2015). Most companies have a production function that is responsible for managing the resources assigned to the production of goods and services. The management performed by these functions is usually defined as OM, and its main emphasis is to contribute to the success of an organization by using its resources as effectively as possible to produce goods and services in a way that satisfies its customers (Karlsson 2009).

There are several types of operations: projects, jobbing, batch production, mass production, and continuous processing, as described by (Holweg et al. 2018) and depicted in Figure 2-2. This categorization is based on the variety and the volume of products delivered through each type of operation. These operations require specific types of management, even though similarities do exist. In companies producing high volume, low variety of products, the focus is on reducing cost per product. Here, most components are standardized, and a large part of the production process is open for automation and robotization. These are operations within mass- and continuous production. When the volume decreases, but variety increases, flexibility becomes more important. Products delivered through a batch and jobbing approach are produced in lots since these are dependent on switching machine settings. Companies approaching a project type of operation deliver low volume and high variety of products that comprise a high level of uncertainty because project activities involve human judgment that makes standardization impossible (Mello 2015). This is the end of the OM spectrum this research has been focused on since all case companies use a project based approach to deliver their one-of-a-kind products. Moreover, the studied literature reveal interesting gaps on the topic of planning such projects.

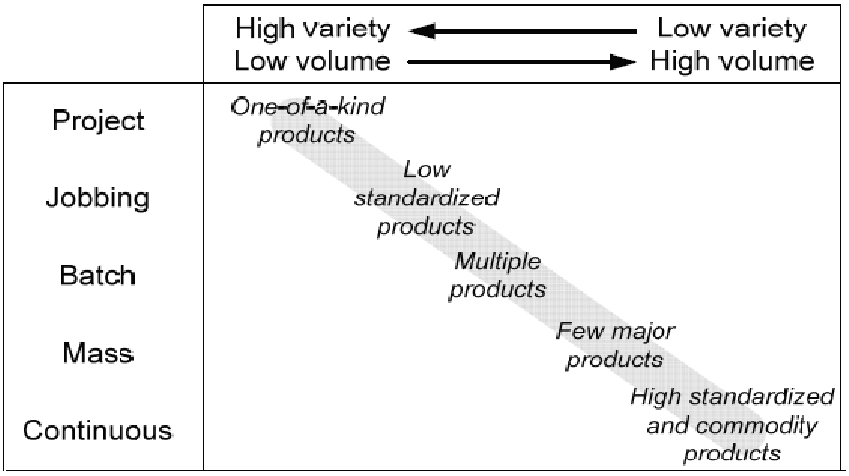

Figure 2-2: Types of operations (Mello 2015)

Developments within OM have strongly influenced project management approaches, and one of the areas of influence is planning and scheduling project activities. Since the early 1900s, these activities have gradually become more specialized and performed by different departments and management levels. A major influencer for this development was F.W. Taylor, who acknowledged that planning is a decision-making process that required collecting and sharing information. Hence, he separated the planning activities from the production unit (Baldwin and Bordoli 2014). This was an application of scientific inquiry (reduce organized systems into separate components and study each component individually) approach to production. Therefore, the holistic management approach was replaced by the management of separated functions independently within an organization (Zokaei, Seddon, and O'Donovan 2011). Also Sussland (2002), observed that managers started to focus on "plan" and "check" while workers focused on "do" and "act" part of a project as analyzed through the PDCA circle. Within the mass-production environment, this approach enhanced productivity through specialization and helped to develop a wide range of planning tools that were then included in complex ERP systems. However, when using the same approach in project-based enterprises, they have been struggling to achieve similar improvements. This type of operations lack a project planning approach that considers all project participants (Kovacic and Müller 2014) and all disciplines because many of these are performed by external suppliers (Dubois and Gadde 2002). Basically, they need a more holistic approach, where coordination is emphasized.

As an answer to this lack of holistic perspective, Koskela (2000) introduces the Transformation Flow Value (TFV) theory arguing that good management of operations in both manufacturing and construction needs to consider not only the transformation but also the flow and value aspects of production. Moreover, the same author provides relevant arguments for using TFV theory when managing design- and engineering activities both in manufacturing and in project-based type of industry. The TFV theory has become the theoretical foundation within the lean construction field (Koskela 2000), and it is gaining more interest within the OM. Nevertheless, the (PMBOK® 2013a) argues that OM is not connected to project management, and they do not acknowledge that projects are delivered through operations adapted to the project environment. Therefore, this dissertation is in line with the ideas presented by Koskela (2000) and sees projects as part of the OM stance.

There are many types of projects (e.g., internal process development projects, product development projects, improving projects, investment projects, etc.) and most of them are managed using approaches recommended by traditional project management literature. One typical setting where each product is delivered on a project-based approach is the ETO environment. However, before describing this environment, a review of the main concepts and tactics recommended by project management literature is provided since these are a fundamental approach within this environment.

2.2 Project management

Projects have played an essential role in delivering the innovation that drives our society today. Numerous researchers agree that there is a significant increase in the number of organizations applying a project-based process to their business, e.g. (Kerzner 2009, Morris, Pinto, and Söderlund 2013, Murray et al. 2013, Shenhar and Dvir 2007). Thus, "*Projectification*" (Jensen, Thuesen, and Geraldi 2016) has become a core process in both governmental and private organizations, increasing both the formalization of projects as well as the number of project-organized companies. To support this expansion, several associations have developed own recommendations and body of knowledge like Project Management Institute (PMI - the American standard), Association for Project Management (APM), PRINCE 2 (the UK standard). Their aim to "*provide a baseline for organizational practice and individual competence or knowledge assessments*" (Geraldi, Maylor, and Williams 2011, p.967).

While these traditional project management bodies of knowledge offer a basic initiation into the project management profession, they do not fully meet the requirements for addressing the complex problems of today's projects (Geraldi, Maylor, and Williams 2011, Shenhar et al. 2001). In fact, according to Flyvbjerg and Budzier (2015, p. 22), "*five out of ten energy projects, seven out of ten dams, nine out of ten transport projects and ten out of ten Olympic Games do not meet their cost targets*". They argue that one of the main reasons for such failures is that both project-, program- and portfolio leadership try to model complexity and forget to understand simplicity (Flyvbjerg and Budzier 2015). Others state that traditional approach to project management is based on clear and certain contexts and do not consider ambiguity and uncertainty that affect most of the projects today (Marle and Vidal 2016).

Morris and Pinto (2004), argue that many projects fail to deliver the promised objectives due to the inadequate definition of the work required to deliver those objectives. They also argue that "*too much of the project management writing addresses only the basics of time, cost, and scope management (or people and organizational issues) and fails to address the day-to-day nuances that become so important in practice*" (Morris and Pinto 2004, p.xi).

To summarize, there is an impressive number of books and articles presenting research on project management and reasons for failing to deliver within the agreed constraints. However, before analyzing these aspects further, it is essential to define some of the most important terms used within project management literature like e.g., project, project management, project planning, and other significant expressions within the domain of project management. This is necessary for two reasons: 1) there are important nuances in various definitions and 2) they are central factors affecting the process of planning a project. This is done next.

2.2.1 What is a project?

There are many definitions of a project, and the most cited one is from the guide published by PMI called "A guide to the Project Management Body of Knowledge" (PMBOK®), which establishes general standards within project management. They define projects as a "*temporary endeavor undertaken to create a unique product, service or result*" (PMBOK® 2013a, p.3). The strength of this generic and simple definition is its applicability, but its strength is also its weakness in that it fails to address aspects that are important in understanding the way project management is performed. Therefore, for this dissertation, the definition provided by Turner (1999): "*a project is an endeavor in which human, financial and material resources are organized in a novel way to undertake a unique scope of work, of given specification, within the constraints of cost and time, so as to achieve beneficial change defined by quantitative and qualitative objectives"* (Turner 1999, p.3) suits best. This definition identifies some of the challenges related to the management of ETO projects and fits the purpose of this research.

Furthermore, projects can be characterized by several features, and Gray and Larson (2006), propose the following:

- Have an established objective
- Have a well-defined start and endpoint
- Involves several departments and professionals
- Delivers a unique product or service
- Have specific requirements on time, cost and performance

Each project is usually delivered by a team using several different management techniques defined as project management, so a brief definition on project management is needed.

2.2.2 What is project management?

The term “project management” appeared in academic literature sometimes in the 1950s, however, textbooks on the topic began to appear mid-1960s (Johnson 1997). Nowadays, there is countless literature on project management analyzing all kinds of aspects related to types, of projects, leadership, planning, risk, uncertainty, and so on. Many authors define project management in a way that fits their perspectives.

PMI defines project management as “*the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements*” (PMBOK® 2013a, p.47). However, for the scope of this research, the following definition by Kerzner (2013a, p.4) seem to fit the context of this dissertation: “*project management is the planning, organizing, directing and controlling of company resources for a relatively short-term objective that has been established to complete specific goals and objectives. Furthermore, project management utilizes the systems approach to management by having functional personnel (the vertical hierarchy) assigned to a specific project (the horizontal hierarchy)”*. This definition highlights a more holistic view of the project management, creating the basis for the arguments used in the discussion and conclusion chapters of this dissertation.

PMBOK® (2013a) identifies five managing phases within a project:

1. **Initiation** - defines a new project or a phase from an existing project and get the authorization to start the project or the phase
2. **Planning** - establishes the scope of work in the project, refine objectives and establish the course of action necessary to achieve the desired outcome
3. **Executing –** the work performed in order to complete the activities defined by the project specifications
4. **Monitoring and controlling** - track, review and regulate the progress and performance during the execution of the project. Identify areas where changes are needed and initiate the corresponding process
5. **Closing** - finalizes all project activities in order to formally close the project or phase

These processes are interrelated and the output of one process is the input in the next one, and each process interacts with each project phase (PMBOK® 2013a).

Usually, there are several different projects within an organization, but they do not operate as closed entities. Every project is dependent on information from the rest of the organization as well as from external organizations. Most projects have a project organization composed of several coordinators, planners, and other specialized entities. Often, at least in shipbuilding and construction, engineers and other key people work on several projects at the same time making planning/coordination more complex than what much of the literature seems to imply when discussing the project organization in isolation from the rest. This is discussed next.

2.2.3 Organizing projects

Traditional project management literature proposes four types of organizations that deal with projects: **functional (line)** organization, organization by **project** (project-based), **matrix organizations,** and **network organizations**. The functional organization type uses existing functional hierarchies to manage their projects. Coordination is maintained through the usual management channels. A project-based organization uses independent project teams that function as separate units from the parent organization. The role of the parent organization is to establish administrative and financial control procedures concerning each project. A matrix organized company is a hybrid organizational form in which a horizontal project management structure is interconnected with the normal functional hierarchy (Gray and Larson 2006). The matrix type is designed to optimally utilize the available resources by encouraging individuals to work on multiple projects while being capable of performing normal functional duties (Larson 2004). Figure 2-3 visualizes a matrix organization where line management provides human and technological resources to each project with the organization.

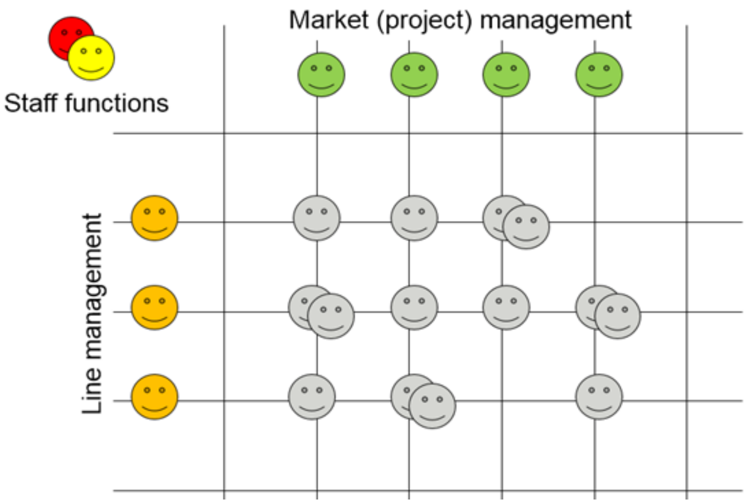

Figure 2-3: Matrix organizations (Emblemsvåg 2013)

Another type of project organization is a **network organized project**, which is described in Gray and Larson (2006) as an alliance of several organizations with the scope of creating products or services. This collaborative structure involves several other organizations connected through a hub organization that is responsible for the coordination of the whole project. Among the advantages of such organization: cost reduction, high level of expertise, and flexibility. The disadvantages can be (Gray and Larson 2006):

- Coordination breakdowns. It is more challenging to coordinate a larger number of professionals from several different companies, especially when the project work requires close collaboration and mutual adjustments
- Loss of control. The core team is dependent on other organizations they do not have any authority over
- Conflict. Different participants that do not share the same values, priorities, and culture. Trust can be difficult to build when interactions are limited, and people represent different organizations

Network organized projects are usually guided by complex contractual agreements, consortium deals, and nonbinding partnerships, or even facilitated by third parties. That implies the need to consider divergent and multiple perspectives and interests, which in turn emphasizes the complexity of managing such projects by creating even more diverse networks and relationships that need to be managed (Alderman et al. 2014).

Hence, the organization's operating context is fundamental to its project management's successful performance. More often than not, the management team underestimates or completely ignores, this factor because organizations have not adapted themselves to new organizational structures as quickly as the business has evolved. This is another important reason for the large proportion of project failure (Nieto-Rodriguez 2012). Nevertheless, even though many ETO companies work in network-organized projects, the project management literature seems to lack planning processes adapted to this type of organization as shown in (Kjersem and Emblemsvåg 2014). Moreover, the complexity of today's project is increasing and affects the way projects are managed, as argued next.

2.2.4 The increasing complexity of projects

The scope and scale of projects have amplified, especially due to technological advances, which in turn increases their complexity. Alderman et al. (2014, p.xvi), provide some reasons for this evolution:

1) Products and systems to be delivered and the problem of integrating a wide array of complex technical systems, some of which may involve new and novel technologies
2) Managerial problems of "making sense" in the face of new and unfamiliar domains of knowledge management and learning within and between projects of this type

3) Organizational capabilities, some of which need to be transformed to deliver these products and systems, and the problem of integrating a wide range of communities of practice across both internal and external boundaries

Other reasons for increasing project complexity are the rapid changes in the environment and increased time pressure (Williams 1999). However, according to Bosch-Rekveldt (2011), a common understanding of the concept of project complexity is lacking, and there is a need for more research on the subject. Another source of complexity in projects is also the management process, as argued by (Alderman et al. 2014). Their research shows that until recently, most projects have been conducted within a rather stable organizational context with quite a low degree of uncertainty and ambiguity and have not adapted to the occurrence of new forms of management and leadership suitable to high levels of variability and uncertainty (Alderman et al. 2014). These aspects were observed and confirmed in most of the case companies that were part of this research.

Moreover, the project management literature focuses on finding better means to control intrinsic project uncertainties with respect to quality, cost and time (Koskela and Howell 2002) by applying "best way" solutions that do not consider the context of the project (Thomas 2000). Consequently, managing today's projects "*is reflected in the often messy, chaotic and politicized experience of project participants*" (Alderman et al. 2014, p.20). According to Ivory and Alderman (2005), project participants are not preoccupied to develop more effective management tools; they are more interested to identify means to deal with the *"irresolvable ambiguity often manifested in firefighting problems and interventions at the level of detailed project activities*" (Alderman et al. 2014, p.20). One area affected by increasing project complexity is planning such projects, since critical possibilities, opportunities, and difficulties can only be recognized through careful planning (Elvin 2007). In the following, are described some of the most relevant project planning approaches as presented within the traditional project management literature. The term "traditional" refers to the recommendations found in PMBOK® and other similar reference books.

2.2.5 Planning in traditional project management literature

Given the high number of handbooks on project management, e.g. (Kerzner 2013a, Meredith and Mantel 2012, Morris and Pinto 2004, Morris, Pinto, and Söderlund 2013, NASA 2011, Nicholas and Steyn 2012, PMBOK® 2013a, PRINCE2 2009), one would expect that there is a large amount of knowledge on how project management can deliver each project within the established frame. However, as stated above, the literature on project management is abundant on examples of projects failing to deliver the planned objectives. Then one can wonder whether the traditional project management approach is suitable for today's projects at all. Then, has it ever worked? That said, among the answers is that nowadays, projects are performed in very dynamic environments, involving multiple stakeholders having different standpoints and facing different technological challenges. Furthermore, due to the dearth of literature on actually executing planning meetings in a structured and successful way, upon which this research is founded, it seems that the basics of human interaction are ignored. The focus is on tools, methods, and high-level processes, assuming that people know how to plan and work together effectively.

The majority of books on project management, e.g. (Kerzner 2013a, PMBOK® 2013a, PRINCE2 2009) agree that the most important responsibility of a project manager is to plan the project. PMBOK® (2013a, p.55), defines planning as "*those processes performed to establish the total scope of the effort, define and refine the objectives, and develop the course of action required to attain those objectives*". In Morris and Pinto (2004, p.13), project planning is about "*determining what needs to be created to deliver the project objectives and within what constraints*". Then, PRINCE2 (2009, p.61), sees planning as the "*act or process of making and maintaining a plan*" where the authors emphasize the importance of effective planning, regardless type or size of the project. Also, Fernandez and Fernandez (2009) found that the traditional project management literature approaches the planning process as a linear strategy where dependent, sequential phases are executed according to the project plan. This approach is at odds with the industries this research focus on since their concurrency is a necessary requirement for winning contracts.

The PMBOK® (2013a) recommends the following activities to be executed by the planning team: plan scope management, collect requirements, define the scope of the project, create the WBS. Then define and sequence activities within each WBS, estimate resources and duration for each activity, develop schedule, plan cost management, estimate cost, determine the budget, plan quality, develop communication plan, develop human resource plan, identify risk and perform risk analysis, plan risk mitigation, plan procurement and stakeholders management (PMBOK® 2013a). Moreover, the traditional project management approach asserts that project success can be achieved by focusing on planning, controlling and managing risks. Yet, numerous companies applying these recommendations reveal poor performance in many aspects (Laufer et al. 2015).

One of the leading root causes of project failure to meet its objectives in terms of budget, time, and customer satisfaction can be traced back to the planning phase. Although most project managers agree that planning is an essential activity for a successful project, project planning in many organizations is not well understood (De Reyck 2010). Eckert and Clarkson (2010) found that many companies complain about problems with their planning processes without analyzing the root causes of these problems. In most cases, the thought behind these complaints reflects managers' poor efforts, and if only the manager tried a little harder, the plans would be fine. Having said that, Eckert and Clarkson (2010) disagree with such complaints and argue that "*planning is a diverse and complex activity where different aspects that need to be planned do not map onto each other in a straightforward way, so different thinking and methods are needed to do it better*" (Eckert and Clarkson 2010, p.153).

Due to today's management approaches (phase development systems, project office, etc.), most projects are oriented toward planning upfront, then following that plan. While companies reward teams for following the plan, any deviation is considered a weakness. In other words, rigidity is rewarded, but when change occurs*, "our brittle systems are unequipped for it and managers certainly do not welcome it*" (Smith 2007, p.x). Moreover, throughout the PMBOK®, it is stated that the project team should take into consideration the contextual perspective of each project (cultural, social, political, etc.), however, "*the project management process rarely mention the project context, let alone how to act, react or interact in such context*" (Bosch-Rekveldt 2011, p.17).

In a similar vein, Laufer and Tucker (1987, p.263) identified three major flaws of project planning and control:

- **Focus** – scheduling is overemphasized while the planning process is neglected
- **Role** – control overshadows action planning
- **Process** – decision-making in a proper way gets almost all the attention, while the necessary steps prior to the following it are ignored

The same authors conclude that such a traditional approach results in a change in roles where "*instead of the advanced formal planning setting the course of action, it is its execution that shapes the so-called formal plan"* (p.263). Thus, for the planning process to become more effective, applied methods need to be changed, strategies need to be modified, expectations should be adjusted (e.g., attitude to uncertainty) and the overall philosophy of project management should be reconsidered (Laufer and Tucker 1987). This research is in line with these findings arguing that the way planning meetings are structured needs to be improved.

As shown above, one of the flaws of project planning is that scheduling receives more attention than the planning process itself and in many cases, planning and scheduling are used synonymously, even though they are not. Scheduling is part of the planning process (Mubarak 2010), which also contains activities like estimating, reporting, monitoring, control, and above all, good communication (Baldwin and Bordoli 2014). In the following, the terms scheduling, estimating, reporting, monitoring, and control as applied within the traditional project management literature, are presented and discussed.

2.2.6 Scheduling in project management literature

Activities within a project plan are allocated an estimated budget, human resources, materials, and duration necessary to complete that activity within project constraints. This information, together with predecessors- and successors activities, logical relationships leads, lags, resource requirements, imposed dates, constraints, and assumptions are used in generating the project schedule (PMBOK® 2013a). Thus, scheduling is defined as the process of determining the time and sequence of activities in a project and their assembly to give the overall completion time (Mubarak 2010). In other words, the "*project schedule is a project plan that embodies the key outcomes of the planning process - objectives, scope, technical approach risk mitigation, resource requirements"* (Simpson 2010, p.29). Most of the project management literature provides activity-based scheduling, which is based on a network of activities that follow a logical sequence and have a determined duration. There is a huge amount of available literature on scheduling and almost all of it discuss bar charts and networks of activities. That means scheduling (time planning) is overemphasized while methods planning (how to carry out the work) is neglected (Laufer and Tucker 1987).

Most handbooks on project management describe methods and procedures on how to create a schedule based on techniques like Project Evaluation and Review Technique (PERT), Critical Path Method (CPM), Work Breakdown Structure (WBS), Critical Chain, etc. These methods are all based on a push driven system, except for the Critical Chain method that can be used both in the push and pull systems (Tommelein 1998). The push tactic follows pre-determined start and completion dates to push work into production regardless of whether the activity is ready to be performed or not, or if the readiness of the working team is at an acceptable level (Mossman 2005). These techniques help to create a plan which scope is to determine whether deadlines can be met, and if not, which actions can be taken to remedy this (De Reyck 2010) assuming that all necessary resources, materials, information, equipment, and space are available at the planned time. This is not always the case (Tommelein 1998).

According to Luh, Ko, and Ma (2009), project scheduling techniques like PERT or CPM are not suitable for planning the design- and engineering activities. They argue that these methods "*improve the process flow only by crashing the critical activities, but they do not consider iterations and feedback loops that are characteristics of engineering design, and they ignore the concurrency and overlapping of the design process*" (Luh, Ko, and Ma 2009, p.44). Similar findings were presented by Huang and Chen (2006), who identified significant difficulties in estimating project duration when using traditional PERT and CPM tools. Many design- and engineering activities have mutually dependent information requirements, where the input of one activity is the output of another one, and *vice versa*. In some complex projects, these dependencies are difficult to identify, which means that many companies do not invest sufficient time in exploring them carefully. Thus, the project team rarely questions customary sequences and overlaps of the planned activities (Eckert and Clarkson 2010).

Moreover, traditional scheduling does not provide any indication about the status of upcoming work (how many of the upcoming planned activities can be performed as planned), and thus, it limits the project team's ability to identify the necessary corrective actions before deviations are encountered. Yet, corrective actions differ from project to project and may create even more problems if the decision process does not consider the status of the upcoming work (Mitropoulous 2005). Scheduling is often performed in a planning software like Primavera, Microsoft Project, etc. (Flanagan et al. 2005), and it is based on estimates of activity duration, budget and time of execution.

The overall result of the issues above is that activities are being performed several times, but the schedule (and plan) assumes that it should be done only once. Naturally, most projects face cost overruns and delays. This was also ignored during the estimation process. A brief description of the estimating process is presented next since this has a considerable effect on the outcome of the planning phase.

2.2.7 Estimating activity duration and activity budget

PMBOK® (2013a, p.539) defines the term estimate as "*a quantitative assessment of the likely amount of outcome, usually applied to project costs, resources, effort, and duration.*" When estimating the duration of an activity, the estimator assesses the number of work periods needed to complete an activity within the project constraints. Estimating costs implies an approximation of the monetary resources needed to complete an activity while estimating resources refers to an approximation of the quantities of material, human resources, equipment or supplies necessary for the same activity (PMBOK® 2013a).

PMBOK® (2013a) and among others Kerzner (2013a) recommend that the estimation process should be executed by functional managers that would use a large volume of historical data as a base for these estimations. Moreover, activities that cannot be estimated with a reasonable degree of confidence should be decomposed into more details. Additionally, these books recommend using planning software for estimating resources, durations, budget, etc. for activities within a project. At the end of the estimating process, the data is then used for creating the baseline of a project. The baseline is defined by PMBOK® (2013a, p.529) as the approved version of a project plan "*that can be changed only through formal change control procedures and is used as a basis for comparison.*" Usually, reporting the progress on each activity starts only after establishing the project baseline, which implies that estimating is an important activity, especially during the initiation phase of the project.

Another essential part of the planning process is the reporting part where each project participant evaluates their own previous week's/month's results and report them to the project manager (or other project leaders as agreed in the contract). There are several types of reporting methodologies, but for the scope of this dissertation, it suffices to present Earned Value Management (the most acknowledge system globally).

2.2.8 Reporting and Earned Value Management (EVM)

Gathering information to create reports used in project monitoring and control is termed as performance measurement. Performance reporting involves measuring the actual results of a specific project over a given period (day, week, month) and compare these results to the budgeted amount (money, duration, resources) established at the beginning of the project (baseline) (Harpum 2004b). The scope of reporting is to ensure that stakeholders are informed on the use of resources compared with the planned objectives.

The reporting activity is performed by constantly updating the project plan with data from actual execution and compare it to the baseline that is constructed based on the estimated time, budget and duration of each WBS or activity. Reporting is performed through forecasts, status, progress reports (Lesko and Hollingsworth 2011), which are sent to the established entities (customers, project leaders, supervisors, etc.) as agreed in the project contract. PMI recommends EVM, a reporting method based on budget and schedule tracking approach. This is a standard tool used within the planning system for measuring the progress of a project within traditional project management literature (Erdogmus 2010). EVM compares the baseline of the project with reported physical results, the resources consumed, and the remaining hours to the completion per activity (Sumara and Goodpasture 1997). EVM is applied in the process of managing different types of project-organized industries and involves three important dimensions (Flemming and Koppelman 2002):

1) The planned value expressing the baseline of the project
2) The actual cost incurred when converting the planned value into earned value
3) The earned value reporting the physical progress of the planned activities and remaining budget

Among the critics to implementing EVM, Kim and Ballard (2000), argue that: 1) the method assumes that each activity is independent, but they aren't; 2) managers can manipulate work sequence when releasing work, even when these are still uncertain; 3) managers try to decrease the actual cost of work performed to make a positive cost variance. Another critique of EVM is that it is restricted to the financial evaluation of progress (with all limitations money yields when used as a common measure of all things) (Cândido, Heineck, and Neto 2014). The same authors argue for using measurement techniques that are grounded in the physical and qualitative aspects of project progression to create viable tools. Additional, weakness within EVM is that projects may show "*budget productivity and be on the earnings plan, but not be doing the right work in the right way at the right time*" (Ballard 2000, p.2-8).

However, EVM can be a tool useful in measuring the progress of the project. Results from its use in combination with PPC as presented in (Emblemsvåg 2014b) show that EVM can work when used at a higher planning level (work packages that are measurable and do not contain too many details, provided that users received a customized training in using the method). Besides, EVM is increasingly becoming a requirement in contracts among industrial partners. EVM is also part of the monitoring and control process during the execution of a project.

2.2.9 Monitoring and control

PMBOK® (2013a, p.86), defines monitoring and control as "*the process of tracking reviewing and reporting the progress to meet the performance objectives defined in the project management plan. The key benefit of this process is that it allows project stakeholders to understand the current state of the project, the steps taken, and budget, schedule, and scope forecasts*". Monitoring and control activities also include project meetings where project team members and relevant stakeholders are invited to participate to be updated on the general project status. PMBOK® (2013a), identifies three types of project meetings:

- Information exchange meetings
- Brainstorming, option evaluation, or design
- Decision-making meetings

The project management standard recommends not to combine these types of meetings, and to prepare them well in advance. Designated project participants should create minutes of meetings and store them as part of the project management plan (PMBOK® 2013a). However, throughout the whole PMBOK®, meetings are recommended as part of many phases of a project (e.g., scheduling, plan cost management, procurement, etc.) and these can be face-to-face, virtual, formal- and informal meetings without further explanations on how to actually conduct these meetings. Furthermore, PMBOK® state several places throughout the book that "*project teams may hold planning meetings*" (e.g., p.148, p.198,) (PMBOK® 2013a) to develop cost management plan, scheduling, and so on, without specifying what a planning meeting is, what is its purpose actually and how to conduct it.

Most books on project management see for example (Flemming and Koppelman 2010, Gray and Larson 2006, Kerzner 2013a, Lewis 2011, Morris and Pinto 2004) acknowledge the importance of monitoring and controlling the evolution of each project, however, they do not explicitly recommend project planning meetings as part of the process. Instead, they recommend periodic project meetings where different issues regarding the project should be discussed without referring to when and how planning meetings should take place. Moreover, they all assume that by simply using EVM reporting, projects are completely monitored and controlled, including design- and engineering activities, which supposed to follow the same procedure as production activities.

The interesting finding here is that project management literature fails to emphasize the importance of meeting each other – the implicit assumption seems to be that formal reporting will suffice. Yet, in other parts of the literature, authors like Bohm (2003), Deshpande (2013) and Sosa, Eppinger, and Rowles (2007) highlight the need for meetings to be able to grasp the richness of the real-life and also to convey tacit knowledge. Even more interesting is that none seem to investigate or even mention the importance of proper communication through planning meetings. This critical notion is especially targeted for further elaboration throughout this dissertation.

2.2.10 Communication in traditional project management

In the traditional project management literature, one of the actions to be performed by the project team is to create a communication plan defined as "*a component of the project that describes how, when and by whom information about the project will be administered and disseminated*" (PMBOK® 2013a, p.532). However, this is more of an informative process where project participants receive updates on the status of the project and in turn inform the project manager about the status of own activities that are executed by his/her team.

PMBOK® (2013a), state that planning the communication process is a central task for ensuring the ultimate success of any project. They recommend that the project team should create a plan for recipients of specific types of information. Furthermore, they also highlight the importance of identifying all stakeholders and create a register with the necessary data. Sources of information in a communication plan can be (PMBOK® 2013a):

1) Project organization charts

2) Project organization and stakeholder's responsibility
3) Discipline departments and specialties involved in the project
4) Logistics of how many persons will be involved with the project and at which locations
5) Internal information needs (e.g., when communicating within organizations)
6) External information needs (e.g., communicating with media, public or contractors)
7) Stakeholder information and communication requirements from within the stakeholder register.

A missing source of information to the communication plan is the one from planning meetings where activities for the next period are discussed since these affect the status of the project.

PMBOK® (2013a) recommends several ways of transferring information within the project team, however, these are dependent on the type of information and its priority, sensitivity and confidentiality, project environment and available technology. As communication methods, the book recommends using techniques from brief conversations to extended meetings or from simply written documents to extensive materials (e.g. schedules and websites that can be accessed online). The communication model recommended by PMBOK® (2013a) follows four steps:

1) Encode – thoughts and ideas are transformed into language by the sender
2) Transmit message – the sender uses communication to send information to another person (a receiver). The transmitted information may be compromised by various factors like distance, unfamiliar technology, inadequate infrastructures, cultural differences and lack of background information
3) Decode - the receiver translates the information into meaningful thoughts and ideas
4) Feedback/Response – the receiver has decoded the information and then encodes thoughts and ideas into a message that is transmitted back to the original sender

These steps need to be considered when discussing and creating the communication plan while incorporating the vital aspects of responsibilities amongst the sender, and receiver.

Within its communication section, PMBOK® (2013a) recommends organizing either face-to-face or online meetings as an appropriate way to update and communicate project information and respond to various requests from the stakeholders. These meetings have the purpose of resolving problems or making decisions and should be well organized following a formal prearranged time, place, and agenda. The information from these meetings is then distributed to the rest of the stakeholders (PMBOK® 2013a). An interesting aspect here is that the book refers to a more formal communication performed at the project manager level, who also has the responsibility to organize the communication plan and update it continuously. Nonetheless, the information in and from planning meetings is not considered as an important part of the communication plan.

Another interesting characteristic of project planning is that despite being able to define specific design activities within a project plan, it does not consider the information required from the rest of the project participants that enables completion of these activities with little or no waste. Hence, design- and engineering activities are often delayed or incomplete due to failing to plan the information flow (Tilley 2005). The following section provides a discussion on some of the traditional approaches to planning these activities.

2.2.11 Traditional planning of design- and engineering activities

Unlike production, where materials move through the factory, design and engineering move and exchange information through the office, which is difficult to see because of its intangible nature. It is also difficult to measure. Duggan and Healey (2016, p.2), state that "*In the digital edge, information is shuffled and moved instantly, not only throughout the office but also globally, outside the office. It is hard to see, hard to wrap our arms around, and even harder to decide what to do with it.*" This is one of the reasons why production activities are easier to plan compared with design and engineering, which might explain why there is a lack of good planning and management approaches for these activities (Little et al. 2000).

In most projects, planning is an important tool that supports the interdependencies among different design- and engineering disciplines, especially when deadlines for meeting customer requirements are short (Wesz, Formoso, and Tzotzopoulos 2013). Design activities in a project are usually diverse and involve different tasks and skills, and apparently, very similar projects can involve different processes (Eckert and Clarkson 2010). Reinertsen (1997) identifies three relevant characteristics of design- and engineering activities:

1) Customer requirements appear during the project and managing these successfully plays an important role in preventing rework
2) Design activities are not repetitive, which implies a lot of variability in the process and very little reliability on the design- and engineering activities
3) Design- and engineering activities tend to expand according to the available time and results in delays quite often

These findings are reinforced by Eckert and Clarkson (2010) who found that most of a typical day for an engineer is used for day-to-day activities such as attending meetings, replying e-mails, or solving unexpected problems. These issues challenge the planning of design- and engineering activities as most of the plans consider that an engineer spends all working hours on producing drawings (Eckert and Clarkson 2010).

Moreover, engineers, in general, are mostly interested in delivering the perfect solution and do not want to worry about the planning process. Yet, engineers create plans for their own part of the project, but they often resent the constraints that project team place on them, especially when they feel that they have not been consulted about the scope of their activities or the path planned for delivering them. Many companies find it difficult to get engineers to commit to planning their activities or to estimate budgets or durations for each activity (Eckert and Clarkson 2010). Besides, most companies do not reward estimates that are close to reality; they reward the quickest ones. A good illustration of such a situation is when e.g., two engineers estimating the same activity, one says that one week is what is needed, the other state that s/he needs three weeks. When the first one is not finished after one week, s/he had to develop a rescue plan that can help him/her get back on track at the expense of other activities. S/he is praised for finding a way to solve a problem. The second engineer is never praised for delivering as planned (Eckert and Clarkson 2010). Thus, overcoming a culture of underestimating-and-rescuing is a challenge in many companies, resulting in a dominant firefighting culture (Bohn 2000).

A central project activity is the procurement part as this can be perceived as both a successor and a predecessor for the design- and engineering activities in a project. The procurement team needs information from the design team about the required performances of the items/equipment to be purchased. The design team needs information from the procurement team on the dimensions and features of the items to be purchased. However, project teams have paid very little attention to the uncertainty of the procurement activities even when these take considerably longer time than estimated in most projects. Furthermore, the duration for the procurement activities is based on deterministic values inspired by past projects and *ad-hoc* assumptions, apparently without taking into consideration multitasking and commitment from the suppliers (Elfving and Tommelein 2003). Meanwhile, in most ETO companies, engineers and planners complain that the company did not learn from past projects, from the mistakes they made in planning those projects. Yet, in their study, Eckert and Clarkson (2010), found out that none of their case companies had a proper lessons-learned system in place.

Austin et al. (2000) argue that design activities should be planned around information flow instead of deliverables if a coordinated and effective solution is to be found. Nowadays, the most common practice used in planning design- and engineering activities is to focus on the deliverables (e.g., drawings and bills of specifications) identified at the start of each stage in the design process. Actually, many contracts contain a separate drawing list with drawings and delivery dates. These activities are then planned backward from the date when these deliverables are due to be delivered to the customer or to the next phase of the project. Such an approach assumes that the information needed for each drawing is available and communicated among project participants either informally or formally through design reviews. Network analysis and the CPM are most used methods for planning and scheduling for construction projects, but they are not appropriate for design- and engineering activities that are incomplete and iterative in their nature (Austin et al. 2000).

Subramanian, Songer, and Diekmann (2000) summarize quite well why traditional project management methods do not fit today's projects, and that is because they do not provide specific information regarding which process has a delay or risk to become a bottleneck. Using these traditional methods, deviance from the plan is identified only after its occurrence. A specific type of project where the traditional project planning and control approach is not working as expected is the ETO project (Cannaas et al. 2018).

Nevertheless, all the project management terms described above are practices identified within the studied ETO environments. That is because most of the shipyards manage, plan, and deliver each vessel as an individual, highly customized project. The existing literature on ETO agrees that this is a complex environment that challenges the planning and control of these projects. Therefore, a description of the ETO environment and its characteristics follows next.

2.3 Engineer-to-order (ETO)

When examining scientific publications addressing research on ETO, it appear that there are many different ways to denote it, e.g. "ETO supply chain" (Gosling and Naim 2009), "ETO product" (Elfving, Tommelein, and Ballard 2004), "ETO strategy" (Powell et al. 2014), "ETO companies" (Hicks, McGovern, and Earl 2000), "ETO projects" (Kalsaas, Bonnier, and Ose 2016), "ETO production strategy" (Adrodegari et al. 2015), "ETO systems" (Viana, Bulhões, and Formoso 2013), "ETO markets" (Cigolini, Pero, and Sianesi 2014) and many other terms that are not relevant for this dissertation. A more recent term is "ETO business model" as presented by Emblemsvåg (2020). The terms applied when referring to ETO, are indeed connected to the unit of analysis used by the authors in their researches. For the purpose of this dissertation, the term ETO production strategy seems to fit best to the context and the identified challenges. Note that other terms including "ETO environment", "ETO companies", "ETO product" and "ETO project" are used when referring to different aspects of the research.

Sharpe, Smith, and Knight (2015), define ETO as a production strategy where significant changes to the fit, form, and function of the product are done in order to meet specific requirements from an individual customer. The ETO strategy is recognized through three main characteristics: low-volume of highly customized products delivered on a project-based approach (Haartveit, Semini, and Alfnes 2012). Since most companies applying an ETO strategy use a project-based approach to deliver their products, they also use ideas and concepts recommended by the project management literature to manage each of these projects. However, based on the reviewed literature, there is no clear definition of the term "ETO project". Hence, in this dissertation, the term "ETO project" is used with the scope of describing the whole process of planning and delivering a highly customized product. It includes planning of the design-, engineering-, procurement-, and production activities while the customer actively participate in designing and approving each project step as well as every feature of the final product.

The number of companies using an ETO strategy is growing at a fast pace since this approach provides companies with increased agility and flexibility that allows them to respond to rapid market changes (Grabenstetter and Usher 2015). Therefore, most ETO projects result in difficult and complex multilevel product structures and systems that often contain components that are engineered to order (Hicks, Song, and Earl 2007). This challenges the whole process of delivering exactly the required product. Yet, it seems like the development of theories or paradigms is slow, and according to Gosling, Naim, and Towill (2013a), there is a lack of dedicated research to the ETO strategy. This is reinforced by Willner et al. (2014), who revealed that literature on product development had been published for decades, while the majority of literature on ETO has been published mostly within the last ten years. Thus, the aim of this research is to contribute to the existing literature on ETO production strategy and the management of such challenging projects.

There are many types of challenges when managing ETO projects, and many of these are more or less specific to this environment. Some of its most relevant characteristics as well as their effect on the planning process are presented next.

2.3.1 ETO Characteristics

Duchi and Schônsleben (2017) established that for many ETO customers, "*customized*" implies sophisticated products that cannot be defined in advance by any product configurator[1]. That is because, unlike other types of production (MTS, MTO, ATO), each ETO product is designed and engineered gradually, often through continuous collaboration with the customer, getting more and more attributes while the project advances. However, a different type of

[1] The configuration type they refer to is using software to pick up pieces that can be assembled together to form the desired product.

configuration is used by some ETO companies. The engineering team prepares several possible solutions in advance and present them to the customer who can then select from a lower variety of possibilities, and the agreed solution is already easier to integrate with the existing design (Petersen, Lu, and Storch 2007). Yet, this approach was not common among the companies that were part of this research, as shown in Chapter 5.

Bertrand and Munstlag (1993) describe the ETO environment as dynamic, uncertain, and complex. The dynamic aspect is a result of the fluctuations within the sales, as ETO companies are dependent on confirmed customer orders before starting the project. For ETO companies, it is difficult to forecast the number of orders for the near future and make it difficult to prepare resources and capacity in advance. The uncertainty aspect refers to the amount of information needed to complete a task compared with the existing information. There are three uncertainty-factors specific ETO environment. 1) The product specifications, which are not completely defined from the beginning of the project affecting the decision process on needed capacity, lead-time, and price. 2) The mix- and volume uncertainty that makes it difficult to create a detailed demand forecast for the materials and components needed in the near future. This challenges also planning and booking of capacity and resources. 3) The process uncertainty, which is dependent on the customer’s specific requirements on the features of the final product (Bertrand and Munstlag 1993).

When it comes to the complexity aspect, Bertrand and Munstlag (1993), have also identified three main factors: 1) structure of the goods flow, 2) multi-project environment, and 3) customization of materials and components. The structure of the goods flow both the non-physical one (e.g., design, engineering) as well as the physical one (e.g., production) lead to difficulties in assessing the progress of design- and engineering activities. Progress on the procurement of a large number of components and materials needed in an ETO product is also difficult to assess. The multi-project environment factor refers to ETO companies where there are several projects (at different completion stages) to be planned, controlled, and coordinated at the same time. The customization of materials and components refers items that have to be purchased at an early stage of the project due to long lead-time from the suppliers (Bertrand and Munstlag 1993). All the characteristics presented above are summarized in Table 2-1.

Table 2-1: Summing up ETO characteristics based on (Bertrand and Munstlag 1993)

ETO characteristics	**Factors**
Dynamic	Fluctuation on sales Difficult to forecast Difficult to prepare resources and capacity in advance
Uncertain	Product specifications defined throughout the project Mix and volume uncertainty Process uncertainty
Complex	Structure of the goods flow (physical and non-physical) Multi-project environment Customization of components

Unlike with other forms of production, the design of an ETO product is not finished until after the detail engineering process has been completed and any additional as-built documentation has been delivered together with the product to the customer. Thus, the product differentiation starts at the design phase, and each product is designed to satisfy specific customer needs (Grabenstetter and Usher 2015). From this perspective, Jin and Thomson (2003), identify three additional characteristics of the ETO environment:

1. Customer is involved in the design and configuration of the final product
2. Production planning is connected to the details of the customer order
3. Material ordering and production scheduling depend on the pace of engineering development.

These characteristics challenge the planning process due to a low level of information at the contractual stage as well as providing continuous changes as product specifications are finalized. Moreover, engineering activities clarifying features of the product can take a large part of the project duration while long lead-time components must be ordered as soon as the contract is signed, sometimes before that and with limited information available. Hence, it is necessary to schedule design- and engineering activities together with the production and procurement. Project planning must also consider different production techniques since a variety of methods are used, and they might need different scheduling tactics (Jin and Thomson 2003).

Another important characteristic of ETO projects originates from the nature of the concept where the customer is involved from the design throughout the whole project deciding almost every feature of the final product. Thus, many drawings and 3D models are revised several times, going through an iterative process, which is briefly discussed in the following section.

2.3.2 Iterations in ETO

All design- and engineering activities are usually completed by considering the results from the previous steps and might be subject to change through an iterative process. Iterations, a key feature of the design- and engineering activities, refer to the repetition of any activity due to arrival or discovery of new information (Smith and Eppinger 1997). According to Fernandez and Fernandez (2009), an iterative process consists of a number of repeated phases that enclose a feedback loop after a group of phases has been completed. The end of an iteration might contain a partial solution if the customer asks for such an approach. Many ETO companies use these iterative processes to improve or converge to a design solution (Reinertsen 1997) or for solving engineering optimization problems (Safoutin 2003) while considering customer requirements.

During the design stages, most ETO projects require the production of incomplete or preliminary drawings in order to improve both the design problems and alternative solutions (Ulrich and Eppinger 1999). Most iterations originate from customer change orders, some from errors in design/engineering, changes in components, and errors in production. Another key driver of iterations for design- and engineering activities originates from the need to coordinate projects across the organization. Many engineers might be involved in several projects at a time, and this limitation of resources requires that many design activities are based on early assumptions (Jarratt, Eckert, and Caldwell 2011). That implies that downstream activities are also based on incomplete information, increasing the risk of rework, and it demonstrates that complex iterations can originate from the interaction between rather simple processes (Shapiro et al. 2015, Wynn, Eckert, and Clarkson 2007). Other iterations can originate in the changes ordered by the customer during the project (Sriram et al. 2013). These changes can be small (e.g., a diagram revision that takes only a few minutes to complete) or quite big involving redesigning the final product, which requires a large team of engineers working for months or years (Jarratt, Eckert, and Caldwell 2011). Figure 2-4 depicts several types of iterations that can appear at different stages throughout the project.

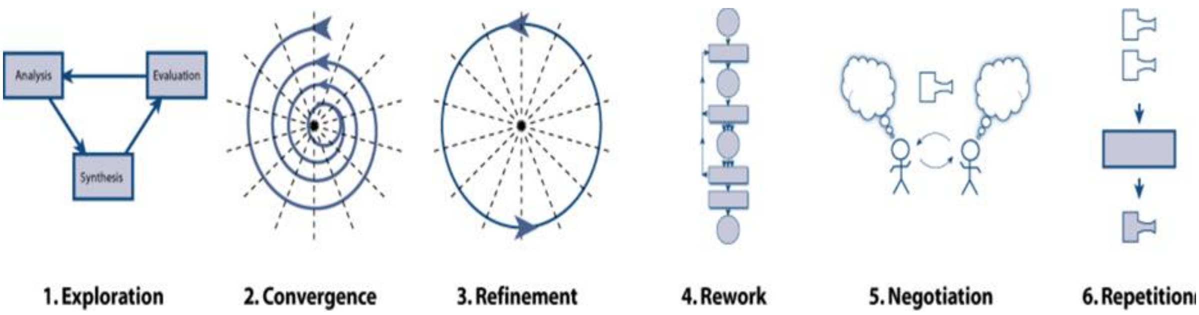

Figure 2-4: Visualization of iteration types (Wynn, Eckert, and Clarkson 2007)

Wynn, Eckert, and Clarkson (2007) identified two different perspectives on how project teams perceive iterations. For example, project managers perceive them as an "*undesirable characteristic that increases risk, lengthen cycle time and exacerbate complexity*" (p.4) while engineers see iterations as an essential and absolute necessary aspect of designing and engineering activities. Inspired from construction projects, Ballard (2000b) identifies positive and negative iterations and argues that the latter is mainly waste and should be reduced by - among other techniques - "*managing the design process differently than traditionally*" (Ballard 2000b p. 10). Nevertheless, in an ETO environment, very few people within the project have a good understanding of the entire product, hence, they will have problems identifying change-propagation throughout the product (Eckert et al. 2006). All these changes result in different types of iterations, making it difficult to anticipate all the negative ones and eliminate them while the project progresses.

Most of the iterations imply an extra cost for the project (e.g. engineering-, procurement-, and production hours), a cost that is not always estimated at the beginning of the project. The cost of iterations together with the cost of managing them is usually considered indirect cost, and even though they affect the total productivity of the project, such costs are not taken into the sale price (Elfving, Tommelein, and Ballard 2004).

In some projects, iterations are taken into consideration during the planning process, as many project teams expect to encounter such practices during the project. Wynn, Eckert, and Clarkson (2007) observed in their research project that only a few companies scheduled a number of iterations, while others used some poorly integrated plans where buffering was a central aspect of the process. However, a critical aspect when using buffers is not to be repeated at many levels because it may inflate the schedule and limit better resource allocation. Eckert and Clarkson (2003) also observed that Gant-based sequential scheduling could not manage the uncertainty in the activity order meaning that design- and engineering activities cannot be scheduled in detail. Consequently, monitoring and controlling progress in a project was difficult to achieve mostly because there was no baseline for comparison. Even in some simple projects, detailed planning documents were too expensive to update following the re-planning due to iterations (Eckert and Clarkson 2003).

The conclusions presented by Wynn, Eckert, and Clarkson (2007) pinpoint to the fact that iterations are difficult to be described due to the inherent uncertainty of design- and engineering activities and the interdependency between such activities. "*Iteration is ubiquitous in design and critical in determining the dynamic behavior of design processes. However, no simulation model or modeling framework can capture the full complexity of iterations* (Wynn, Eckert, and Clarkson 2007 p.11). In other words, planning iterations is a challenging task. Since iterations are difficult to introduce in any planning software, but they need to be managed and scheduled, better communication and maneuverability are needed during the planning process so that these iterations are included and dealt with.

Iterations become increasingly costly when companies rely on outsourcing of design- and engineering activities, another important characteristic of ETO. In fact, companies are heavily dependent on subcontractors and suppliers of building materials, and according to Dubois and Gadde (2000), over 75% of the total cost of a project is used for purchasing services and materials. Therefore, outsourcing (or subcontracting) is a significant aspect within the ETO environment due to the temporary nature of a large portion of the work, making fixed employment very difficult if not economically impossible. This is briefly discussed in the next.

2.3.3 Outsourcing in ETO companies

Delivering high-value ETO products often involve multiple companies worldwide (Hicks, McGovern, and Earl 2000, Willner et al. 2014), since their complexity requires collaboration among several specialist companies (Gosling et al. 2015). It is widely acknowledged that "*today's engineering environment can involve geographically dispersed teams working under challenging cost and timing constraints*" (National Research Council of Norway 2002, p.5). Moreover, most ETO products are used in projects where time-to-market often is vital for the customer due to financial costs or promises to the next link in the supply chain, so it is not unusual that customers impose large cost penalties for delays. Thus, lead-time precision and project completion are important issues for ETO companies (Grabenstetter and Usher 2014). To increase their cost efficiency, most ETO companies outsource phases or activities to other specialized organizations. Schönsleben (2004), identifies some of the reasons:

- **Quality:** individual companies may not possess the necessary technologies or processes or may not have mastered them successfully enough to accomplish the expected standards of quality
- **Costs:** some of the technologies and processes are not feasible from an economic perspective when considering the low demand (the breakeven point)
- **Flexibility:** large variations in demand which implies that companies' own competencies and capacity cannot be adapted quickly enough
- **Delivery:** some processes are not always as rapid as needed or are unstable over time

The arguments presented above are also discussed in Semini et al. (2018), who studied the Norwegian shipbuilding environment and its outsourcing strategies. They identified four different outsourcing strategies applied to build vessels (Semini et al. 2018): 1) Complete

Norwegian production; 2) Norwegian block outfitting; 3) Norwegian dock outfitting; 4) Norwegian quay outfitting.

Each strategy has different implications especially for engineering, coordination of all organizations involved in the project in terms of quality, delivery time, the total cost of the project, etc. (Semini et al. 2018), including the project planning process (Kjersem, Jünge, and Emblemsvåg 2017). One consequence of outsourcing is that the local project team converts into a geographically distributed organization with many different groups that need to be involved in the decision process (Hoegl, Muethel, and Gemuenden 2012). Moreover, these organizations must communicate inside their own companies and with their own suppliers in order to decide future actions. This results in a long- and complex chain of information that affects the planning- and reporting process to a high degree.

Apart from iterations and the rest of the characteristics presented above, planning ETO projects is also influenced by factors like concurrency of project phases, capabilities at the production site and tools used for designing such products. These are presented next.

2.3.4 Concurrent Engineering (CE)

Generally, "*production and engineering have traditionally been considered as linear in the sense that engineering is performed before the production takes place*" (Wikner and Rudberg 2005, p.634). Hence, design- and engineering activities are usually based on a sequential approach (Koskela 2007) where an initial design is formulated and then sent to the production who physically makes the product. This linear method generates many challenges due to the lack of communication between production and design teams in regards to product requirements versus production boundaries (Whiteside et al. 2009). CE was developed to avoid these challenges, and its scope is to meet the need for continually shorter lead-time while taking into consideration input from all project participants or stakeholders (National Research Council of Norway 2002).

ETO companies, which are usually preoccupied to shorten the lead-time, realize that "a *central point in improving the lead-time is to recognize that design, procurement and manufacturing have significant interdependencies*" (Elfving, Tommelein, and Ballard 2004, p.8). National Research Council of Norway (2002, p. 17), states that CE is the "*most practical method"* to improve the engineering processes and shorten the delivery time.

The first definition of CE as a concept comes from a document written by Winner et al. (1988, p.5), in a military project report. They define CE as a "*systematic approach to the integrated, concurrent design of products and their related processes, including manufacturing and support. This approach is intended to cause the developers and the outset, to consider all* *elements of the product lifecycle from concept through disposal, including quality, cost, schedule and user requirements*".

Letens, Farris, and Van Aken (2011) revealed that the development of CE as a building technique is not as advanced as it might seem. They present a report showing that although 75% of aerospace companies and 62% of the industry as a whole report using CE, only 16% confirmed that they had been able to fully implement CE across the company. Some of the reasons are, according to Haque and James-Moore (2004), laying on the lack of focus on value for customer and effectiveness. Therefore, a CE implementation process needs to be approached as a "*multi-objective decision-making process*" (Luh, Ko, and Ma 2009, p.57). Nevertheless, Andristos and Perez-Prat (2000) and Pieroni and Naviero (2006) state that the shipbuilding industry seems to be more interested (compared with other industries) in implementing CE due to the strong competition on shorter lead-time.

Effective CE is dependent on good collaboration among project participants, commitment to planning and implementation, along with dedicated resources (Zidane, Bjørkeng, et al. 2015). A true CE approach is dependent on an open communication structure and the ability for all project participants to get necessary information just in time (Kristensen et al. 2003) as well as effective coordination and a dynamic planning process (Emblemsvåg 2012). However, the studied literature on project management does not provide procedures or methodologies where the planning process considers the challenges posed by a CE approach to project management. Moreover, the topic on CE and its challenges for planning and managing design activities seem not to be approached directly within lean construction literature (presented later in this chapter) either. To explicate the idea behind CE, a brief comparison of sequential versus concurrent approaches is beneficial. Figure 2-5 illustrates both strategies as well as some of the advantages of using CE.

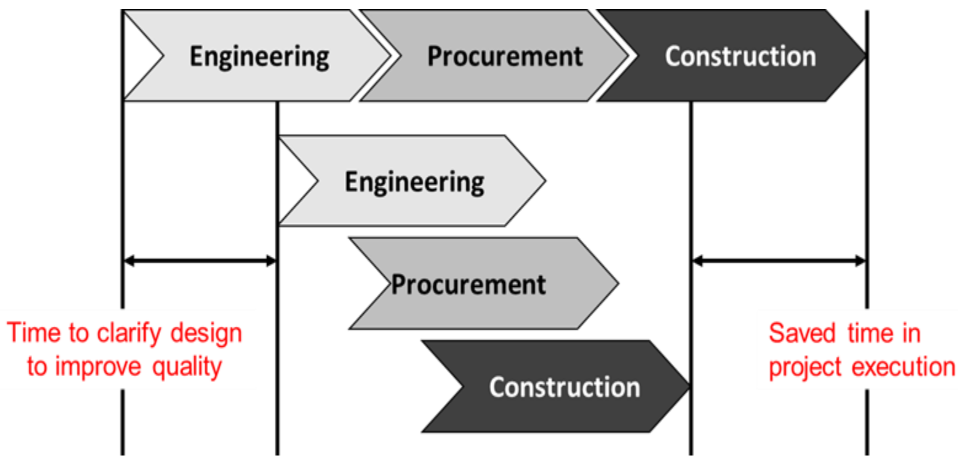

Figure 2-5: Sequential- vs. Concurrent Engineering, Procurement, Construction (Emblemsvåg 2012)

The sequential building approach is simple and follows a well-established logical way of thinking: first design and engineer the project, then buy the equipment and the materials and then build the vessel. This traditional way is still used in shipbuilding projects in the Far East. Through the CE approach, the building period is reduced by producing parts of the vessel as soon as they are finished on the drawing or the modeling phase (Emblemsvåg 2012).

CE as a method argues for the need to analyze design/engineering, procurement and production as a whole, in an integral manner. Such need is identified within the shipbuilding and construction industry where these phases are typically planned separately. Elfving, Tommelein, and Ballard (2004), argue that these phases are very interdependent and there is a need for a better integration if project teams want to shorten the project lead time.

CE rests on five main features: 1) reduces lead-time, 2) requires overlapping of activities, 3) is dependent on close collaboration between project participants, 4) applies a concurrent evolution of system and component decisions, 5) is dependent on critical sequencing (National Research Council of Norway 2002).Table 2-2 presents a comparison between CE versus linear/sequential engineering.

Table 2-2: Concurrent & sequential engineering (National Research Council of Norway 2002)

Concurrent Engineering	**Sequential engineering**
Parallel design of product and processes	Sequential design
Multifunctional team	Independent designer
Concurrent consideration of product life cycle	Sequential consideration of product life cycle
Total quality management tools	Conventional engineering tools
All stakeholders input	Customer and suppliers are not involved

There are both advantages and disadvantages when using the CE approach. The benefits of implementing CE derive from its focus on design- and engineering activities as these determine between 60 to 80% of the total production costs of the final product (Dowlatshahi 1994, Gaspar 2013). Taking into consideration most life-cycle issues during the design- and engineering activities while ensuring that design is “right-first-time,” usually leads to cost savings, products that match customer needs and are of high quality (Kamara, Anumba, and Cutting-Decelle 2007). Another benefit of CE is that it can reduce the number of iterations as these can be caused by “*constraints of downstream stages overlooked in upstream stages*” (Koskela 2007, p. 18), thus saving time. In Thamhain (2004), several other benefits of CE are presented: high-level of organizational transparency, detecting of design problems early in the project, provide a systematic approach to multi-phased project execution.

Among the risks associated with CE, Kerzner (2013a) identifies the following: 1) discovering problems late in the project, and 2) starting production before sufficient information on the drawings are available for review. Nevertheless, many companies start implementing CE without fully understanding the required level of effort and the risk (Willaert, De Graaf, and Minderhoud 1998). Those companies forget that CE requires a collaborative culture based on organizational power-sharing that is often difficult to achieve at all levels within a company (Thamhain 2004).

Willaert, De Graaf, and Minderhoud (1998), argue that CE can be considered more as a management and engineering philosophy than a tool. This idea is explained in the findings and discussion chapter of this research. As the main scope of CE is to reduce the lead-time through minimizing the need for iterations due to mistakes, rework and alike, the Design for Manufacturability approach aims at reducing the production cost. This is presented next.

2.3.5 Design for manufacturability (DfM)

Just a few years ago, the profit margins in the ETO environment were quite high, however, today, customers are no longer willing to pay premium prices, challenging producers to deliver at lower prices and high quality (Rudberg and Wikner 2004). Additionally, an increased focus on environmental issues led to laws and regulations that force companies to consider the whole life-cycle of each product, including the afterlife. A relatively new design approach has been proposed in many ETO projects, and that is “Design for X” (DfX). DfX is a generic term for concepts like design for manufacturability, design for assembly, design for service, (Gosling et al. 2015) as well as design for environmental impact, design for maintainability, reliability, etc. (Kuo, Huang, and Zhang 2001). DfX applies to many different disciplines, and the subject is discussed in numerous papers since the late ‘90s (Kuo, Huang, and Zhang 2001). It is not the scope of this research to provide explanations on each type of DfX. Yet, some of the case companies show more focus on reducing their production costs by applying a DfM concept to their projects. That had implications on the planning process, as discussed in Chapter 6.

A successful DfM implies that some of the component suppliers should be involved in the project at an earlier stage (planning, design, detail engineering) so that they can advise on appropriate specifications that can contribute to shorter lead-time and lower production costs (Gosling et al. 2015). Among the advantages of using DfM are: lower production costs, higher quality, quicker time to market, lower capital equipment, fewer parts to purchase from suppliers, as discussed in (Anderson 2008). The same author summarizes the importance of

DfM with the following slogan: "*Functionality gets us in the game; Quality and reliability keep us in the game; Manufacturability determines the profit*" (Anderson 2008, p.24).

According to McManus, Haggerty, and Murman (2005, p.5), engineer's job in a DfM approach is to "*give manufacturing and supplier management fewer parts in the design, designed with high quality so they fit the first time, and made with manufacturing processes that are robust/repeatable and provide a high yield*". Nevertheless, this is easier said than done because it is difficult to execute, but the result is a design that can be built efficiently, reaching the targeted cost (McManus, Haggerty, and Murman 2005). Moreover, a successful DfM implementation is reliant on the outsourcing strategy applied by the company as the selected suppliers might have technologies and tools that need different approaches at the design stage (Hamidi and Farahmand 2008).

Implementation of any DfX approach requires additional effort during the design and engineering phases and Duchi et al. (2015) conclude that ETO companies are challenged to identify the tradeoff between customization and operational efficiency. Another challenge in implementing DfM is the fact that traditionally, engineers are not taught DfM or CE during their college classes. They learn how to design for functionality and most of the time are trained to design parts of a product or system. Most of the design courses do not talk about how parts of the product are produced, and the students rarely follow a whole design to completion process that can give them feedback on the manufacturability of their design (Anderson 2008).

In industries where the cost of production is very high due to for example, rigorous quality requirements, effective design can significantly reduce production costs by allowing the production to give their input at the design phase. Hence, successful implementation of DfM is dependent on "*recognizing and acting on, the realization*" that different cultures within design and production exist, and the major obstacle created by this difference is an effective communication (Harpum 2004a). DfM emphasizes the idea of doing things right the first time because design and engineering cost less than changes applied during the production phase (Anderson 2008).

For the project planning process, DfM implies that project planners have to consider the limitations, methodologies, and production facilities at the companies producing parts of the final product. However, from the studied literature, it looks like the project management literature does not approach DfM challenges for the planning process.

Another element affecting the planning process of design- and engineering activities is the use of technologies like 3D modeling as presented next.

2.3.6 Technology – 3D modeling

In Norway, 3D modeling is slowly replacing 2D drawing techniques, especially in ETO companies. Andrade, Montiero, and Gaspar (2015, p. 7), observed a certain "*resistance to install and try brand new technologies due to the strong traditional aspect*" of the shipbuilding industry. There are still several drawings that are performed in 2D, and many shipbuilders use 3D modeling techniques in different ways (Andrade, Montiero, and Gaspar 2015):

- In the concept phase, 3D is used for visualization of the prototype to estimate and calculate the price of the vessel
- In basic design and detail engineering phases, 3D is used for refining all the characteristics of the vessel (steel thickness, engine power, etc.). Extensive work is done to document the approvals from the customer and classification societies. Some documentation from suppliers is imported from 2D into the model
- In building and assembly phases, 3D is used for creating production drawings that are used at the production site. 3D helps integrating information from all suppliers
- In commissioning phases, 3D is used to visualize the model of the vessel and evaluate its performance. It also creates the as-built model

Figure 2-6 provides a sample of a 3D model to visualize levels of detail and complexity when working in such software. 3D modeling offers benefits in terms of productivity, increased capability to generate design alternatives faster than in 2D, elimination of errors that result from the inconsistency between drawings, and current practice. However, to maintain a fast response time, 3D modeling requires specialized functionality (Sacks, Eastman, and Lee 2004), which implies that engineers develop specialized skills in certain types of disciplines (e.g. structure, piping, electro, accommodation). Thus, most projects use more engineers and modeling hours per project.

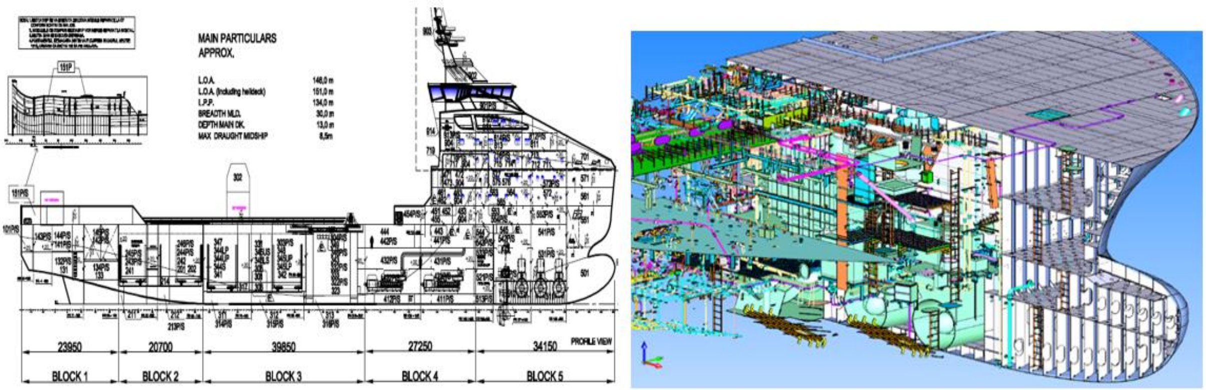

Figure 2-6: 2D vs. 3D models. Source (Vard Group AS)

The introduction of 3D modeling software challenges project planning and control as these activities are performed at different departments than the one delivering the model. In fact, in many companies, the planning team starts planning the building sequence long before the model is even started. Moreover, these two departments use different software to manage their work like, e.g., the production uses Primavera, Microsoft Project or Excel while the technical department uses software like AutoCAD, Siemens, Outlook, etc. However, even when some of the planning and 3D software can exchange data, this is usually done statically and becomes outdated soon after the transfer (Morais, Waldie, and Larkins 2014).

Another identified challenge is that measuring productivity and value in engineering activities by using traditional methods inspired by the industrial manufacturing environment is not directly applicable when measuring progress of 3D modeling activities. One of the factors affecting such measuring methods is the difficulty of measuring input and output from design and engineering activities. That is because design- and engineering activities provide a service, not a physical product (Sacks and Barak 2005) that can be assessed after completion. Moreover, making a drawing in a model can take five minutes while gathering the information or taking a printout can take days, weeks, and months in some cases. Together with their iterative nature, it complicates the process of measuring progress for design and engineering activities. This is a seldom topic in the project management literature (Emblemsvåg 2014a).

Many companies are developing 3D modeling software that is integrated with planning or finance software, so-called Product Life-Cycle Management (PLM). Still, the literature on that is scarce or commercial in nature. It is also found that most shipbuilding companies still use spreadsheets, 2D CAD drawings, documents editors and presentation tools for planning and controlling purposes lacking a good integration among systems (Andrade, Montiero, and Gaspar 2015). Some of these aspects are discussed in the finding chapter as they have an important role in planning and controlling design, engineering, and procurement activities.

2.3.7 Other ETO challenges

The main scope of presenting all these ETO challenges is to establish the complexities within the ETO environment as they have a strong influence on the management processes and planning design- and engineering activities. Indeed, it could be argued that effective collaboration, and therefore, effective execution of meetings, is perhaps the most reliable way of improving the performance of the design- and engineering activities. This is because encapsulating all the challenges in an ETO project realistically is too difficult for a system or software. The human mind with knowledge – explicit and tacit – can best grasp all the issues, but they need to interact effectively.

ETO approach can differ from company to company or from product to product. In a comprehensive literature review presented by Gosling and Naim (2009), the authors discuss the commonalities and differences between different types of ETO approaches. The commonalities are: ETO companies operate in a project-based environment producing low-volumes of unique products. Among the differences between ETO approaches can be the re-usage of the same design versus creating a new one for each product. Another difference is sector-specific like for example in construction, where the team completes the project on a new site each time, whereas in shipbuilding the product is manufactured at the same sites (Gosling and Naim 2009). The first commonality implies that each ETO company must apply its own project management strategy to deliver their products. Yet, in Kjersem and Emblemsvåg (2014) the authors argue that the project management literature does not sufficiently take into consideration the challenges within the ETO environment at least as they manifest themselves in the shipbuilding- and construction industries.

Gosling et al. (2015) identified several other challenges in managing ETO projects:

- **Incorrect specifications** that are a result of the combination between late changes from the customer, design errors, lack of information on the drawings, delayed drawings
- **Labor shortages** appear because many workers work in several projects simultaneously
- **Information exchange** is about getting the correct information at the right time
- **Demand uncertainty** is about suppliers that are uncertain about getting the contract and they do not start the production before things are clarified. Companies search for several other suppliers and that creates again uncertainty
- **Integration with other trades** is difficult to achieve due to fragmentation of the suppliers, inconsistent project teams and trades that ignore the other's requirements

The authors propose a set of principles to address some of these challenges through information transparency, echelon elimination, time compression, and synchronization principles (Gosling et al. 2015).

An additional challenge in managing ETO projects originates in estimating the real cost of the final product as this must be done in the sale phase, without having complete information on the evolution of the whole project. An almost precise cost-estimation must be generated during the bidding phase or the conceptual and design stages. However, most of these estimates cannot adequately price the cost of requirement changes during the project execution (Hooshmand, Köhler, and Korff-Krumm 2016). Moreover, procurement within ETO production starts only after the customer together with the designer and supplier have approved the pricing, the design, and the delivery date. Lead-time for the materials and components vary depending on the complexity of the product and the extent of outsourcing (local or overseas) (Gosling, Naim, and Towill 2013a). Some of the components or materials can be (to a certain degree) unique, and the customer is involved extensively during the design process for these components as well. Nevertheless, customer involvement is not only a challenge; combined with competence from the design team, it can result in really innovative products as revealed by Hammervoll, Halse, and Engelseth (2014).

Grabenstetter and Usher (2015), argue that planning ETO projects is challenging in terms of creating a schedule and sequencing the activities during the design and engineering phases when using the same type of thinking like in other types of production (e.g., MTS or ATO). The challenge is to determine an accurate schedule "*within a complex transactional process for jobs that have not been designed yet*" (p.201). However, despite the need for better sequencing, there is a lack of research on the scheduling of design- and engineering activities in ETO projects (Grabenstetter and Usher 2015). In a survey of thirty-nine ETO companies, Little et al. (2000) found that only one case company was undertaking planning for their design activities. Even though design- and engineering activities are critical and have to be completed parallel with the procurement of materials and components, it is poorly managed and often causes delivery delays (Little et al. 2000).

Figure 2-7 attempts to summarize the elements affecting planning of ETO projects. All these elements are discussed above.

Figure 2-7: Types of challenges in ETO projects

As argued throughout these subchapters, traditional project management literature does not discuss challenges in planning ETO projects. Most of the studied companies use concepts and approaches recommended by the traditional project management literature, but these need to be adapted and further developed in order to deal with the requirements posed by the ETO environment. An industry where ETO is also a norm in the construction industry. Challenged by the lack of good planning and control over their projects, many constructors started to use lean ideas that could help them overcome these shortcomings. This resulted in the development of the Lean Construction concept and the Last Planner® System, which are presented later in this chapter. Before that, a short introduction to some of the relevant lean concepts is provided. The scope of presenting these concepts is to appreciate better some of the other planning approaches discussed in this dissertation since they have an essential role in defining solutions to the planning challenges identified in this research.

2.4 Lean Thinking

The term "lean production" was coined during the late '80s when a team of researchers started to compare performances between Japanese, American and European companies and discovered a high level of productivity and quality within the Japanese automotive industry (Womack and Jones 2003). One company that reveal excellent results is Toyota, which developed two superior ways of designing and producing high quality products: Toyota Production System (TPS) and Toyota Product Development System (TPDS). During the last 30 years, lean production has become a popular and widely known concept that was identified by many users with a set of tools and techniques. However, as the understanding of the concepts increased, lean became a fundamental business philosophy, that cannot be reduced to a set of rules or tools. "*It is a sophisticated system of production in which all parts contribute to a whole. The whole as its roots focuses on supporting and encouraging people to continually improve the process they work on"* (Liker 2004, p.34). In other words, a system thinking perspective throughout the value stream (Ballard et al. 2007).

The lean ideal is to deliver a product that fits customer needs, at the right time, and with no waste. Toyota developed TPS in their pursuit to solve all kind of problems encountered during company's growth. They defined several principles to follow when solving these problems and (Liker 2004, p.38) summarize some of them as follows:

1. Base your management decision on a long-term philosophy, even at the expense of short-term financial goals
2. Create continuous process flow to bring problem to surface
3. Use "pull" systems to avoid overproduction
4. Level out the workload

5. Build a culture of stopping to fix problems, to get quality right the first time
6. Standardize tasks are the foundation for continuous improvement
7. Use visual control so no problems are hidden
8. Use only reliable, thoroughly tested technology that serves your people and processes
9. Grow leaders who thoroughly understand the work, live the philosophy and teach it to others
10. Develop exceptional people and teams who follow your company's philosophy
11. Respect your extended network of partners and suppliers by challenging them and helping them improve
12. Go and see for yourself to thoroughly understand the situation
13. Make decisions slowly, by consensus, thoroughly considering all options – implement decisions rapidly
14. Become a learning organization through relentless reflection and continuous improvement.

These principles are not meant to be followed blindly nor to be interpreted literally without adjustments. They are a good starting point in establishing own principles that are right for each organization and help them achieve the desired performance level. Imitating Toyota by implementing some of the TPS tools is not lean. Lean implies understanding the root cause of any problem and apply the appropriate tools to solve it without compromising the established principles (Liker 2004).

In the reminder of this section, the main lean implications for this dissertation are presented by starting with the importance of executing a complete PDCA circle, a core planning process.

2.4.1 Plan Do Check Act (PDCA)

Sobek and Smalley (2008), argue that one of the fundamental lean thinking tools is the PDCA cycle, which has been at the heart of TPS from the beginning. The PDCA method consists of different steps where the first step ("Plan") involves identification, understanding, and analyzing the problem in order to understand the root cause of it, develop a possible solution and an implementation plan. The second step ("Do") concerns putting the plan into action. During the third step ("Check"), the effects of the implementation are measured and compared with the target. In the fourth and final step ("Act") two options are possible; either that the success of the implementation is confirmed, or that remedial action needs to be carried out if the solution failed to meet the requirements. Solving a problem at Toyota implies a lot of time and effort in analyzing the root cause and finding a solution. That is because they see that the whole planning process is critical to the learning and continuous development of the employees (Sobek and Smalley 2008). The philosophical foundation of PDCA is explained by Liker and Franz (2011): 1) Deeply question every process so that problems are brought to the surface and carefully defined. 2) Understand the root cause. 3) Develop countermeasures that are viewed as provisional until proven otherwise. 4) Plan implementation in greater detail. 5) Run the experiment. 6) Closely monitor and analyze what is going on in the experiment. 7) Learn from what happens and turn that into further actions. PDCA is essential in a successful planning process not only in production but also in design- and engineering activities. An intrinsic element of a PDCA circle is finding the root cause of each deviance.

2.4.2 Root Cause Analysis (RCA)

RCA is a method of resolving issues at the root rather than at the superficial, obvious levels (Bicheno 2004). One of the most used techniques in identifying the root cause of a problem is the “five whys,” which requires that the team ask “why?” several times until the real cause of failure is identified. The five whys technique is simple and can be understood as a questioning attitude by not accepting the first immediate reason without searching for the real answer. The philosophy behind it is to treat problems like opportunities for learning by taking full benefit of understanding the real cause of the problem. Lean literature agrees on the idea that RCA has given the Japanese automotive industry the edge on quality, reliability, and high productivity (Bicheno 2004). Nevertheless, applying this method when planning ETO projects is easier said than done since, in many cases, people tend to understand it as a way to place the blame. In fact, people need training in using the method as an opportunity to improve. RCA is a central element in any planning meeting and is part of the solutions proposed in this research.

2.4.3 Efficient meetings

Within lean literature, meetings are always well organized, and their scope is to contribute to solving problems by making well-informed decisions. There are several prerequisites for efficient lean meetings (Liker 2004):

- Clear objectives established before the meeting (clear tasks and deliverables)
- The right people at the meeting which implies that all invited people need to show up
- Prepared participants implies that everyone knows what should prepare for the meeting and do that before the start of the meeting

- Effective use of visual material
- Separate information sharing from problem-solving. Share information as much as possible before the meeting so that the focus of the meeting can be on problem-solving
- The meeting starts and ends on time

These principles have been recommended by lean literature for quite a while, however, most of the studied meetings fail on most of these points. In many cases, the scope of the meeting is unclear, people are not well prepared, and meetings transform into an information-sharing place instead of solving problems (Liker 2004). These issues are also observed in the cases studied in this research, especially when planning ETO projects. Even though these principles do not address planning meetings specifically, they can be used to establish a frame from which well-structured planning meetings can be built upon. Therefore, the solutions presented later in this dissertation use the elements above as a fundament for determining well-structured project planning meetings.

2.4.4 Training challenges

One less discussed aspects of TPS is its origin in the Training Within Industry (TWI) program developed by the United States during World War II and implemented in many Japanese companies during the ‘50s and ‘60s. TWI emphasizes the role of training the workers to understand the whole working process before changing it – the foundation for building and sustaining lean in any enterprise. “*Simply put, TWI provides the necessary skills that make everyone in the organization thinking lean – if your employees know and practice TWI skills, your organization will be practicing Lean Thinking everyday*” (Dinero 2005, p.xvii). TWI also recommends a framework for training employees in non-repetitive jobs, even when the methods cannot be standardized in detail. Nevertheless, training in how to implement and use new tools or concepts in a company is often underestimated (Liker and Meier 2007) and that includes training in how to plan and execute planning meetings, the focus in this research.

Lean literature acknowledges that implementing new concepts or just keeping up a state of mind focused on continuous improvement requires proper training of the employees. Yet, many companies lack an effective approach to training own people. Most of these companies argue that they have different types of training programs that are created by professionals who have good material and know what they are doing. However, when employees explain the way they learned their jobs, the picture is different. The interviewed employees have learned their jobs in a relatively unorganized way because the training courses are interesting, but often do not have a close relationship to the day-to-day jobs. It seems like companies are not so keen on effective training methods since these are not perceived as critical for the survival of the company (Liker and Meier 2007).

Training is a central part of the lean implementation process. As (Womack, Jones, and Roos 1990, p.99) state: "*It is the dynamic work team that emerges as the heart of the lean factory. Building these efficient teams is not simple. First, workers need to be taught a wide variety of skills […] then they needed encouragement to think actively*."

The importance of proper training is also a core element in the solutions proposed in this dissertation since both the studied literature and many of the interviewed engineers reveal a lack of training in how to plan and execute project planning meetings.

There are many tools and concepts developed within the lean thinking philosophy, but they are not subject of this dissertation. However, the successful application of different lean ides in other types of industries like service, healthcare, construction, have resulted in development of domain-specific lean applications. One of the most representative domains is lean construction, which is described next.

2.5 Lean Construction (LC)

The LC concept was developed during the '90s when practitioners from the construction industry started to use ideas, methods, and tools developed within the lean thinking environment. The movement was marked by a research report written by Koskela (1992), where he argues for the need to establish a theoretical foundation for managing production in the construction industry. The same report was the starting point for the creation of the International Group for Lean Construction (IGLC) in 1993. The scope of the group is to bring together researchers from practice and academia in the Architecture, Engineering, and Construction (AEC) industry. Indeed, there is a need for a radical renewing of their practices in order to respond to the global challenges ahead (iglc.net). As good results started to be obvious, and the number of practitioners increased, a new organization was born - Lean Construction Institute (LCI) founded in 1997 by Glenn Ballard and Gregory Howell. LCI aims to disseminate new knowledge about the management of work on projects and improve the outcome of the construction industry through lean approaches (www.leanconstruction.org).

Some of the ideas behind developing LC are inspired by manufacturing where concepts like flow, variability, and queuing theory were modeled and used to understand the flow in mass production processes (Bertelsen et al. 2007). In "Factory Physics," Hopp and Spearman (2000) developed a set of laws that explain how flow systems behave by means of queuing theory and analyze the effect of variability on the production performance. However, these models were not easy to directly implement in the construction industry, so Koskela (2000) proposed the TFV theory. The transformation aspect refers to productivity measured as input in relation to the output. The flow aspect deals with moving information and materials through a network of production units, each of which processes them before releasing them downstream (Kim and Ballard 2000). The value aspect refers to products or services delivered according to customer requirements (Fauchier and Alves 2013). To deal with the TFV aspects, the construction community needed a system thinking perspective throughout the whole project execution, so they started to apply lean concepts that could help them achieve better management of construction projects.

Applied to construction projects, lean ideas change the way a project is managed during the building process. LC extends from the objectives of a lean production system (maximize value and minimize waste) to specific techniques and applies them in a new project execution process. The reliable release of work between disciplines in design, procurement, and production ensures value is delivered to the customer and waste is reduced. LC is particularly useful on complex, uncertain, and quick projects as it challenges the belief that there must always be some trade-offs between time, cost, and quality (Ballard and Howell 2003). Sacks et al. (2009) summarize the most relevant LC principles:

- **Reduce variability**. It refers to both reducing the variability of product characteristics as well as reducing the temporal variability of production flows
- **Increase flexibility**. It refers to work station capability (use multi-skilled teams) and capacity (reduces setup or changeover times) as flexibility reduces cycle times and simplifies the production system
- **Select an appropriate production control approach**. LC recognize that most production and control systems are mixed push-pull approaches so they recommend choosing the best method for each stage of production (e.g. schedules are push systems while LPS is the pull part)
- **Standardize**. Refers to establishing product features that can be standardized and continuously improved
- **Institute continuous improvement**. It is about the deliberate, institutionalized and systematic form of improvement that goes beyond simple learning
- **Use visual management**. A way to combine standardization and continuous improvement. It enables workers' perception on project status and on measures of improvement

- **Design the production system for flow and value**. It refers to the fact that design should support production control and continuous improvement
- **Verify and validate**. It is about all design of products that should be verified against specifications and validated against customer requirements
- **Go and see for yourself**. Stresses the importance of site visits for those who usually do not practice the concept (e.g. estimators and managers)
- **Decide by consensus, considers all options**. LC recommend an extended circle of decision-makers so that a wider knowledge base is ensured within the decision process. The probability of finding the best practical solution is increased

This list of LC principles is not exhaustive, yet, they represent some of the most significant ideas behind the tools developed within the LC environment. Besides, LC community advocates, since early ‘90s, the need for a change in the way traditional project management plans and measures activities in a project.

2.5.1 Project planning from LC perspective

The traditional theory of project management, management-as-planning, acknowledges that planning is an essential activity of project management. Yet, from the perspective of classical communication theory, its execution is perceived as one-way communication/orders from the management team (Koskela et al. 2006). Since this is not working well, Ballard and Howell (2003) demonstrate that an important planning principle is that those who are to do the work should plan how to do it. This principle also applies to the design- and engineering activities where each specialist builds on each other’s work and must understand the conditions of satisfaction of another when completing a drawing, a calculation, or other specific work (Ballard and Koskela 2009).

Ballard (2014) identified another central aspect of the planning process, which is that project management literature treats planning as a technical process where the focus is on creating a plan and then control it. He argues that such a mechanistic view neglects the social aspect of planning and he states: “*In traditional practice, management is all about planning, and plans can be perfectly realized—if it just weren’t for the people! This assumption of perfect planning explains the dominance of sequential processing in all types of work, not only projects. It is assumed that coordination can be imposed on those doing the work, as opposed to being achieved through their own actions. When things go wrong, that is blamed on ‘human error.’ It’s people who are said to screw up perfect plans”* (Ballard 2014, p.3). This assumption of plans developed as “realistic best” implies that everything goes according to the plan, even though in most cases it does not. This approach is also identified as a major reason for project failing to deliver the planed outcome (Flyvbjerg 2013).

2.5.2 Role and attributes of the planning process

Research performed by Laufer and Tucker (1987) on several construction projects revealed that project planning was affected by the factors like:

- Motivation for planning may come from outside sources (customer requirements, and legal considerations)
- The internal motivation is often control rather than execution
- The importance of control is affected by the separation between execution and planning, which in practice becomes a way of reporting what has happened

An important observation here is that by applying such approach to project planning, leads in a total misunderstanding of the role of planning, which is transformed from initiating and directing before it takes place, to influencing, and regulating activities while in progress and to follow-up and status reporting (Laufer and Tucker 1987). In other words, planning is focused on scheduling and reporting forgetting the planning process which role is to support the preparation for executing the plan.

Laufer et al. (1994, p.54) identified the following attributes of a proper planning process:

1) Is a decision-making process
2) Is a process of anticipatory decision-making (to decide what and/or how to perform actions due at some point in the future)
3) Is a process of integrating interdependent decisions into a system of decisions
4) Is a hierarchical process evolving from general guidelines to objectives, to the elaboration of means and constraints that lead to a detailed course of actions
5) Is a process that includes parts or all of the chain of activities comprising information search and analysis, development and design of alternatives, analysis, and evaluation of alternatives and choice making
6) Is a systematic employment of standardized and formal (to varying degrees) planning procedures
7) Function as a documented presentation in the form of plans

The authors argue that the more of these elements are present in a project, the more readily the process is recognized as a planning process. They define planning as a process that accomplishes most of the seven elements presented above, and they identified (based on cases from the construction industry) several requirements for an effective project planning (Laufer et al. 1994). These requirements are further analyzed by Fauchier and Alves (2013), who evaluated them through the planning principles that must be addressed by each successful planning process:

- Addresses numerous purposes and various users (hierarchical principle)
- Involves several plans and various users (comprehensive principles)
- Involves several timings and various time horizons (continuity principles)
- Involves several participants and various modes of preparations (cooperation principle)

One tool that combines many of the roles and attributes presented above is the Last Planner® System developed since early 1990's within LC environment. This tool is an enabler of the project planning process, not the whole of it.

2.5.3 Last Planner® System (LPS)

Ballard (1999a), argues that planning is a process where project objectives are established together with the desired sequence of events for achieving those objectives. Control is defined as a process that causes events to estimate the "*desired sequence, initiate re-planning when the established sequence is no longer feasible or no longer desirable, and initiates learning when fails to conform to plan*" (p.7). Within dynamic environments where the production system is uncertain and varies from project to project, reliable planning cannot be performed in detail long before the activities being planned. Therefore, establishing what, when, and how much work to be done by a design team or a construction squad "*is rarely a matter of simply following a master schedule established at the beginning of the project*" (Ballard 1999a, p.7).

Since changes during the project execution are an inevitable aspect of a project and over-specification becomes irrelevant, then why do people put so much effort into planning each small detail and then try to follow that plan at all cost? The project management literature explains this through the decomposition of complex projects into smaller activities in order to minimize risk, control the scope of work, and enable progress measurement. However, continuous changes during the project execution lead to reconsider the scope of work as an ongoing task, defining "*project scope only as far as we currently truly able to comprehend and prioritize it from the perspective of value realization and risk mitigation*" (Koskela et al. 2006, p.6). A reliable planning process takes into consideration the fact that plans can change, materials are often late, and that influences the whole project. When planning is unreliable, bottlenecks occur and are pushed downstream.

LPS resulted from the ideas presented above and it is seen as a planning tool intended to provide the element missing from the traditional project management toolkit (Ballard and Howell 2003). Observations within the construction industry revealed that only half of the activities on weekly work plans were actually completed as planned (Ballard 2000) and that the plans for the next week were not adequately predicting the future state of the project. Moreover, the scheduled activities were pushed onto foremen/supervisors based on what should be done without appropriate consideration of what can be done. Supervisors "*were treated as doers to be directed, not as planners/managers whose commitment was required*" (Ballard 2014, p.4) and that implies a mismatch of information between what the plan showed compared with the situation on the floor.

Consequently, Ballard (2000) proposed an expanded basic vocabulary for the planning and control domain that traditionally was based on "should" and "did" terms. The new vocabulary included "can" and "will" terms in order to recognize "*the importance of making what should be done ready so it can be done when needed, and the importance of reliable promising as a coordination mechanism between supervisors of independent teams*" (Ballard 2014, p.5). The result was LPS, a tool that emphasizes the idea that supervisors do have managerial responsibilities, which implies that they should not simply be told what to do (Ballard 2014). The role of "will" and "did" terms is to create reliable promising among the project participants through including in their daily work plans only activities that are well defined, are sound, proper sequenced and sized to the capacity of the performers. Figure 2-8 illustrates the idea behind LPS, which sees planning as a continuous updating process based on the PDCA circle, commitment, and reliable promises (Ballard 2000).

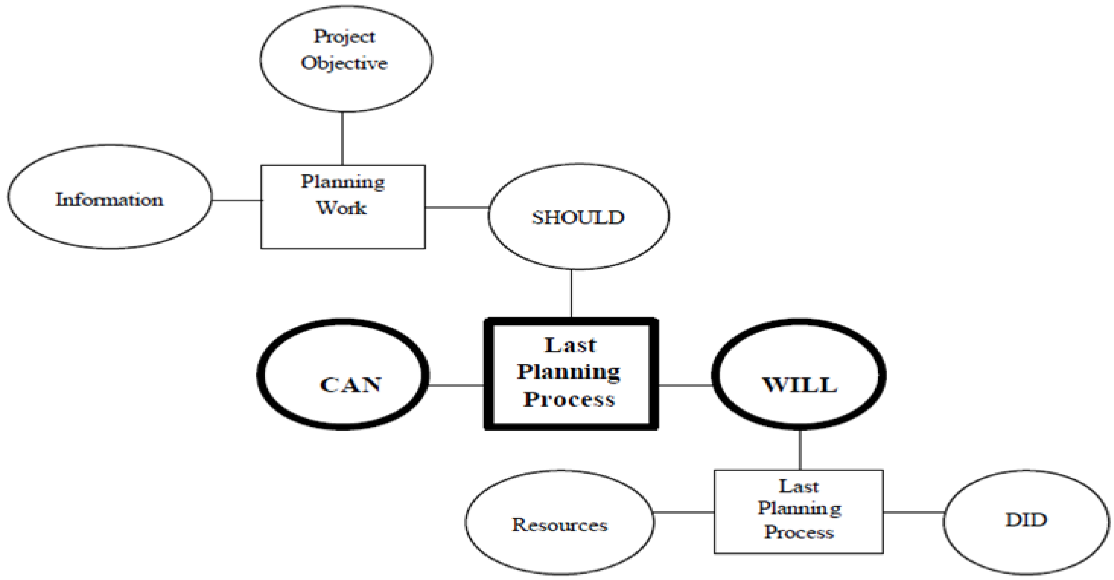

Figure 2-8: LPS(Ballard and Howell 2003)

The foundation and starting point for LPS is to achieve a common agreement among project participants concerning which tasks to be allowed on the daily- or weekly plans. LPS allows on those plans only activities that are fully ready to be performed regardless of department, discipline, or company (Ballard 2014). A closer analysis of the reasons for failure to complete activities as planned identified seven categories of constraints that affect the execution of these activities. Figure 2-9 visualizes the constraints for production activities in a project.

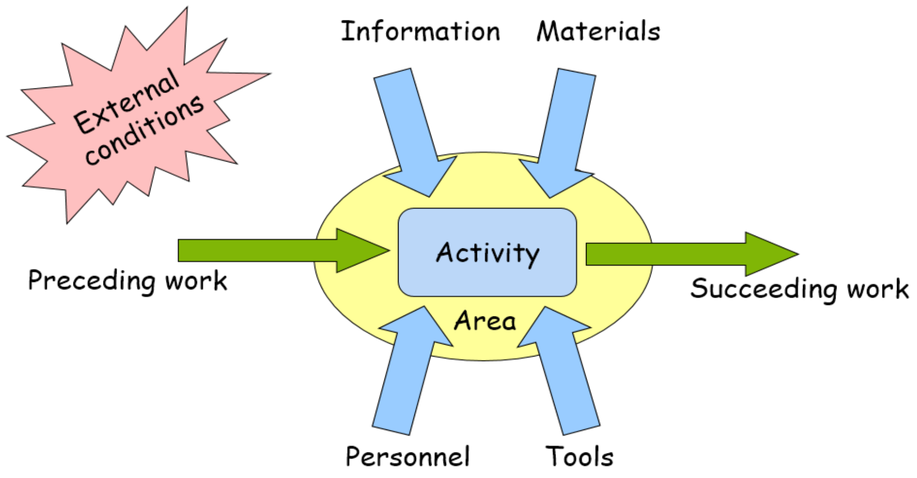

Figure 2-9: The seven constraints in production (Bertelsen et al. 2007)

Among the constraints during the production phase, were identified: preceding activities, materials, personnel, tools, information, space/area and external conditions (weather, laws, authorities) (Koskela 1999). For design- and engineering activities, the identified constraints are preceding work, technical documentation, personnel and external conditions (authorities, classification societies) as shown in Figure 2-10. However, within the studied LPS literature, there are no defined constraints to be used for planning procurement activities.

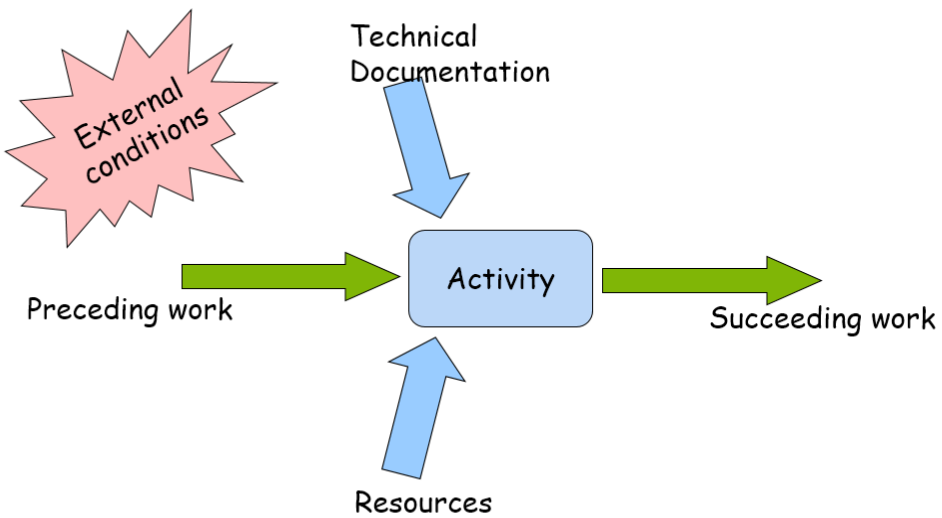

Figure 2-10: Constraints in engineering activities (Emblemsvåg 2012)

LPS emphasizes the elimination of constraints before starting to perform an activity, thus becoming a proactive tool in preparing (making ready) the conditions for completing each activity as planned. This is a pull approach, an essential element of LPS.

The pull approach was developed as a core concept within lean manufacturing and is often associated with the just-in-time type of production (Kalsaas, Skaar, and Thorstensen 2015). Within the management theory, two main approaches to managing production flow are defined: push and pull. Push is the approach where work is released into production based on pre-established delivery dates. The pull approach, on the other hand, is an approach where work is released into production based on the state of the process (Ballard 1999a). Push is the main approach in the traditional project planning where the plan is decided at the management level assuming infinite capacity, i.e., SHOULD disregard CAN. In LPS, the pull approach emphasizes the importance of CAN that should override SHOULD (Ballard 1999a).

A pull mechanism produces materials according to demand, yet, applying pull techniques for design- and engineering activities can be challenging, and some of the reasons are (Ballard, Hammond, and Nickerson 2009):

- Great uncertainty of ends and means reducing the ability to anticipate the sequence of future tasks
- Increase the speed of execution that reduces the time needed to prepare for the activity to be executed
- Work complexity as design and engineering activities are interdependent and necessitate a different type of planning, assignment, and execution

Furthermore, implementing pull techniques for such activities is also affected by the traditional management approach to plan design and engineering activities using push techniques (Ballard 1999a). That is why a combination of push and pull techniques appear to be a useful approach in planning as it is discussed in the Lean Project Planning subchapter.

Another central element of LPS is anchored in the PDCA circle that stimulates the continuous review of goals, plans, and results to promote continuous improvement and better fit the project environment (Fauchier and Alves 2013). Completing a PDCA circle during planning meetings can help the team not only prepare for the next period but also to identify causes for non-completion, analyze the root causes and decide actions to get back on track (Emblemsvåg 2014a). Conceptually, LPS has four hierarchical levels plus one learning loop. These levels are presented in Figure 2-11 together with the basic vocabulary for planning and control as well as actions performed at each planning level.

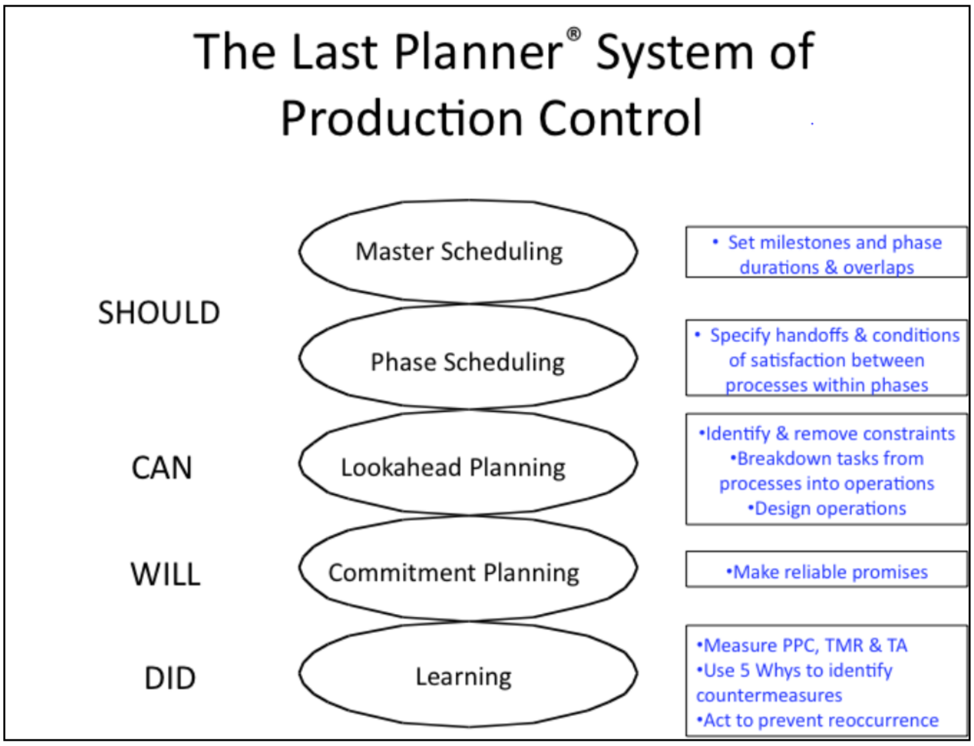

Figure 2-11: Last Planner System (Ballard and Tommelein 2016)

LPS increases plan reliability by dividing planning into distinct phases that focus on different levels of detail. The idea behind such division is that the further out the team plans, and the more details they plan to, the more unfitted the plan will be. Moreover, as the project evolves and it becomes known who will execute what work and when, through collaboration the team can acquire input on plans from the other teams, and subsequently commitments from those doing the work. Thus, each planning level was developed as a countermeasure to the different problems that surfaced during the creation of LPS (Ballard 2000).

Ballard and Tommelein (2016, p. 10) outline the principles and rules guiding LPS:

- Keep plans (at every level of detail) in public view at all times
- Keep master schedules at milestone level of detail
- Plan in greater detail as the start date for planned tasks approaches
- Produce plans collaboratively with those who are to do the work being planned
- Re-plan as necessary to adjust the plan to the realities of the unfolding future
- Reveal and remove constraints on planned tasks as a team
- Improve workflow reliability in order to improve operational performance
- Do not start tasks that you should not or cannot complete. Commit to perform only those tasks that are properly defined, sequenced and sized

- Make and secure reliable promises, and keep your promises (as opposed to waiting as long as possible and hoping someone else speaks up first)
- Learn from breakdowns (unintended consequences of action taken)
- Underload resources to increase the reliability of work release
- Maintain a workable backlog (tasks ready to be executed) to buffer against capacity and time loss

To sum it up, LPS is a collaborative and commitment-based planning tool where "last planner" is a general term that makes a distinction between the people responsible for executing the plan and the people responsible for producing plans for others to execute. The role of LPS is to increase planning reliability by decreasing workflow variability, through recognizing and removing activity constraints, identifying root causes for non-completion of plans and monitoring its improvement by using adequate measuring tools (Olano, Alarcon, and Razuri 2009). However, the foundation and starting point for LPS is based on getting agreement at the company level that only activities that are fully ready to be executed (sound activities) are to be allowed on the daily or weekly plans, regardless what department, company or discipline is to perform the activity (e.g. engineering, procurement, welding). This rule takes into account both technical and social aspects of planning where the latter is achieved through reliable promising (discipline coordinators/supervisors make only those commitments that they expect to keep) (Ballard 2014). The main theory serving as a foundation of LPS is the linguistic action concept, and it is briefly discussed in the next.

2.5.4 Linguistic action perspective of LPS

As LPS is dependent on reliable commitment, a mechanism that needs to be addressed is how these commitments are managed in planning meetings (Viana, Formoso, and Isatto 2016). This is an important difference between traditional project management where planning is based on issuing orders and LPS where planning is based on making and keeping commitments (Koskela and Howell 2002b). Therefore, (Koskela and Howell 2002b, Macomber and Howell 2003) advocate that the Language-Action Perspective (LAP) is an appropriate theoretical approach that can explain the effectiveness of LPS in coordinating project activities by making and keeping commitments, particularly at the operational level when supervisors meet to assess the last week's performance and negotiate the next week's activities to be completed.

The idea of LAP started with an original definition on management by Flores (1982) when he states that management is "*that process of openness, listening, and eliciting commitments,* *which includes concern for the articulation and activation of the network of commitments, primarily produced through promise and requests, allowing for the autonomy of the productive unit*". This definition emphasizes the fact that people are the core capability as they organize themselves to deliver what they promise to the customer (Macomber and Howell 2003). From that, Winograd and Flores (1987) developed the LAP as a theoretical approach that emphasizes what people do when they communicate, how the act of language is used to create common realities and how activities are coordinated through language. Later, Macomber and Howell (2003) argue that LAP provides the missing explanation on how LPS facilitate and achieve commitment among project participants. That is achieved through "*managers acting in LPS articulate and activate a routine of conversations that lead to commitments connecting "horsepower work" with the project's promise to the client and coordinating the wherewithal for the fulfillment of that promise*" (p.3). People using LPS learn to coordinate actions by identifying their unique network of commitments and activating it in the routine planning cycles. Project teams using LPS learn how to deal with situations when their confidence is misplaced. Moreover, managing a network of commitments ensures more reliable promises and is connected with the management of physical work where waste is reduced by more reliable workflow (Macomber and Howell 2003).

Within LAP, it is assumed that people act through language, a different perspective than the more traditional one, which assumes that people process information in order to make decisions. Thus, the LAP considers language not only as a way to transmit information, but also, by generating a situation, language creates a consensual domain that in turn encourages more actions through language (Viana, Formoso, and Isatto 2016). The theoretical foundation of LAP is the Speech Act Theory developed by Austin (1975), which can be used to understand and categorize the type of actions performed through language.

Performing a speech act (not a sentence or a word) is the minimal unit of communication and these acts are performed by following certain rules for the use of linguistic elements like making statements, giving commands, asking questions or making promises (Searle 1976). However, when talking about LAP, many would translate it as a domain dedicated to everyday coordination of action, even though people in projects do more than just coordinate action. Therefore, Macomber and Howell (2003) explore in their work five important issues that affect the overall functioning of a project: 1) Coordination of action; 2) Assessment; 3) Discourse as the basis for making sense; 4) Trust between coworkers; 5) Mood. A brief clarification on each of these issues is provided as they are an intrinsic part of LPS.

Coordination of action

All projects require human endeavors, and each participant brings their own experience and background to the project together with capacities like learning, improvisation, assessment, cooperation, flexibility, and intentionality. These capacities have an important role when dealing with uncertainties and challenges within a project. And because people have past, present, and future, it allows them to create a sense of history and temporality that unite them in keeping commitments (Macomber and Howell 2003).

Each project is invented through the act of language. Flores, inspired by John L. Austin and John Searle, defines a grammar of action containing five basic linguistic acts (Macomber and Howell 2003), which role is to conduct project activities through conversations built on this grammar. Table 2-3 depicts the five linguistic acts, their definitions and explanatory examples on each one of them (Macomber and Howell 2003).

Table 2-3: Linguistic acts: grammar of action (Macomber and Howell 2003, p.4)

Action	Example	Definition
Declaration	“We will put a man on the moon and bring him back safely in this decade”	Creating a space of action, not to be confuse with a promise
Request	“Please, deliver the submittal on Thursday”	Calling for a statement of commitment
Promise	“You can have the crane at noon”	Statement of commitment to provide something specific by a specific time
Assessment	“We are making good progress”	Offering an opinion with or without any basis for the assessment
Assertion	“All tasks were completed as promised”	Statement of fact. Includes an offer to provide evidence

Projects are first organized as conversations, which often begin as speculative in nature, leading to *declarations* of roles and *requests* for people to take those roles. Promising to accept those roles make people act accordingly. Planning is a conversation that lasts throughout the project duration and is a result of team members’ assessments of risk, opportunities, and value. It is here where reliable promising takes place. Planners at each level assess the reliability of promises and propose actions when necessary. Assertion on the delivered work is performed by the customer (Macomber and Howell 2003).

Assessment

Within LPS, a group of experienced people is in position and they are responsible for making assessments on how they as a team perform the project. They make these assessments in real-time and recommend actions to adjust or re-plan activities that are in trouble. By distributing this capacity for assessing, the project team has a superior ability to control (Macomber and Howell 2003).

Discourse as the basis for making sense

Contextualization of the project by sharing stories of the project, is important for people to become a team because the way the team describes the project becomes the way it is perceived (Macomber and Howell 2003).

Trust

Solving problems that appear during a project is seldom a solitary effort and sharing the gain, and the pain is dependent on the trust level within the team. While in the everyday life, our ability to get help in solving problems is determined by the strength of our social network, in the project setting there is no time to gradually develop such strong social network. Therefore, the availability people give to each other in a project context is related to the trust they have in those other individuals (Macomber and Howell 2003). A good definition of trust is provided by Macomber and Howell (2003, p.7) quoting (Solomon and Flores, 2001): "*Trust is a matter of making and keeping commitments, and the problem of trust is not loss of confidence but the failure to cultivate commitment making*". Without the precondition of trust, people do not commit to delivering as planned and do not make offers to help the team (Macomber and Howell 2003). LPS cultivates trust through involving the last planners in the planning process and giving them the possibility to commit and deliver as promised.

Mood

There are several types of moods and can be categorized as positive or negative moods. Both of them can affect the project team in different ways: the inappropriate positive ones by failing to recognize danger or urgency, the negative ones by creating resignation and lack of involvement. However, when left unattended, the mood of the team will drift. LPS practitioners recommend dealing with moods by reshaping the assessments that created a negative mood by revealing the often unexamined background and history of the mood (Macomber and Howell 2003).

After scrutinizing these five LAP elements that affect the overall functioning of a project, Macomber and Howell (2003), conclude that LPS is a "*brilliant project management innovation*" that creates the routines for the constant communication and activation of the network of commitments among project participants at every level. Through LAP, people produce an evolving set of reliable commitments in response to a continuously- updated assessment of the project status that connects the last planners to the promise of the project and coordinates its completion. The five elements discussed above, influence how people work together and shape the results of a project. Understanding these elements will also help create better project leadership, training programs, innovation and use of systems for managing projects (Macomber and Howell 2003).

The LAP foundation, as applied to LPS, focuses on coordination and achieving commitment among project participants through the planning projects by using the LPS elements. However, one perspective missing from the elements presented above is the importance of organizing planning meetings as a place where coordination and commitment are achieved. A well-structured planning meeting needs to consider coordination, assessment, open communication, trust and mood of the participants. The solutions proposed later in this dissertation are inspired from these recommendations.

As stated earlier, LPS uses several tools to measure the progress of the planned activities. They are part of the monitoring and control process, and some of them are presented next.

2.5.5 Performance measurement in LPS

Control is about measuring and evaluating project team performance and about taking correcting actions when deviations from the plan occur (Laufer and Tucker 1987). Nevertheless, while the traditional management literature defines control as monitoring against schedule and budget estimations, "*lean construction defines control as causing events to conform to plan"* (Daeyoung 2002, p.14). In other words, the traditional approach is reactive, whereas LC is proactive in nature.

During the years, several performance measurement metrics were proposed and applied within LPS: Task Anticipated, Tasks Make Ready, Percent Plan Complete, Frequency of Plan Failures, Percent Required Completed or Ongoing, Required Level (Samad, Hamzeh, and Emdanat 2017). A brief description of the first four metrics that are the most established ones in measuring the effectiveness of LPS implementation (Ballard and Tommelein 2016) suffice for the scope of this dissertation.

Tasks Anticipated (TA) proposed by Glenn Ballard in 1997 as a tool to measure the performance of the lookahead planning in anticipating the activities to be prepared and committed to three to five weeks in advance. Tasks Make Ready (TMR) is a tool also applied at the lookahead planning level for measuring the number of activities prepared for completion. It is a ratio of activities with all their constraints removed within two-three weeks before these activities are planned to be started (Samad, Hamzeh, and Emdanat 2017). Percent Plan Complete (PPC) represents the number of completed activities as a ratio of the total number of activities planned for a particular project team in a given period (day, week, etc.). Figure 2-12 provides an example of the evolution of PPC over seventeen weeks.

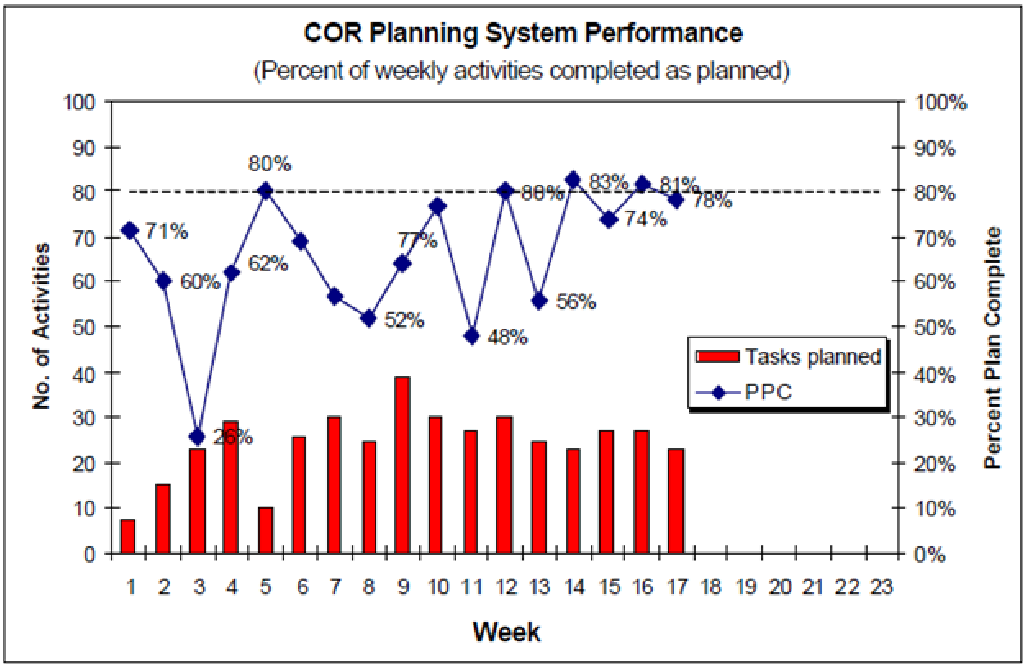

Figure 2-12: Percent Plan Complete (Daeyoung 2002)

PPC can have a value between 0 and 100 % where every number under 100 means a failure in the planning process in the sense that all commitments are not met. It is important to specify that PPC does not provide a measure of how efficient the activities are executed. However, it measures the reliability of the production system – how well people keep their promises. Furthermore, while PPC is calculated, a re-planning is made, indicating the executed activities and those forecasted but not completed. The result of this re-planning is the calculation of a new date for finishing the project (Daeyoung 2002). After PPC is calculated, and the current situation is visible, it is important (together with re-planning) to pay attention to planning reliability indicators and perform a root cause analysis.

Frequency of Plan Failures (FPF) is about categorizing root causes for non-completion of planned activities. Project teams establish several categories before the project starts, and those should reflect the broadness of plan failure that might be expected during the project execution. When necessary, these categories can be refined to bring additional insight to the causes of deviations. In time, the chart will reveal the extent to which root causes were identified, and countermeasures are taken to avoid reoccurrence. However, categorization without analysis does not prevent the reoccurrence of deviations as argued in the PDCA circle, which is not completed before measures to avoid that are taken (Ballard and Tommelein 2016).

While the first two metrics are focused on the proactive preparations of the planned activities, PPC and FPF are "post-production" measures of the reliability of weekly work planning (Samad, Hamzeh, and Emdanat 2017). Usually, these metrics are easily implemented at the production level; however, measuring readiness and progress for design- and engineering activities seems to pose different challenges as argued later in this dissertation.

Reporting of PPC is done in project meetings where the "last planners" inform each other on the status of their activities as well as on the planned activities for the next period. However, before committing to the next period's activities, the last planners must confirm the soundness of the planned activities (no unresolved constraints, proper sequence and appropriately sized). During these meetings, commitments are documented on the commitment plan. According to Ballard and Tommelein (2016), participants in these meetings are required to:

1) Come prepared in order to avoid unnecessary waiting time for the rest of the participants
2) People can make requests to other participants, and in order to say yes to a request, people must have the ability to say no. That is because when people cannot say no to a task or request, they cannot make a promise either

These requirements have an essential role in ensuring successful project planning meetings, as discussed in the findings chapter.

2.5.6 Monitoring and control

Throughout their report, Ballard and Tommelein (2016) describe several types of monitoring meetings in the project using LPS: lookahead planning, pull planning sessions, weekly meetings, and daily huddles. Through the lookahead planning, project participants identify and work on eliminating constraints for activities planned to be executed five-eight weeks ahead. If constraints cannot be eliminated before the due date, the task is rescheduled for a later date when constraints are removed. The frequency of these meetings is decided by the context and type of project. Pull planning sessions are used for creating a plan for doing work at any level of work breakdown and in any time horizon, as well as for establishing the activity sequence. Pull planning comprises the identification and description of the milestone or key event that the team will be pulling in order to prepare for the next stage of the project (Ballard and Tommelein 2016).

Weekly planning is also called commitment planning and involves last planners meeting to decide the next week's activities. These can be arranged by following the project needs either each week, bi-weekly, or even every day when necessary. Lookahead planning and weekly planning are steered by the design project manager for the design team and by the project general superintendent for the production team. Daily huddles are stand-up meetings organized every day by groups of interdependent project participants in order to share what commitments they have completed and which ones need more time or help to be finished. These daily meetings are short and can be done within the design team, production team, or supervisors (Ballard and Tommelein 2016).

LPS meetings on smaller projects are most of the time based on Post-it notes, papers, pencil, and a photocopier, while on larger projects MS Excel or similar spreadsheets can do the job alongside current planning software used by each company (Mossman 2005).

Based on the literature reviewed for this research, an interesting gap in implementing LPS is the lack of a clearer understanding of the fact that LPS is an additional tool to the planning process within a company. As Ballard and Tommelein (2016) argue, LPS is not replacing project controls (establishing cost, time and other performance targets), but it is used for steering project performance towards the objectives set by project controls.

LPS has been implemented on several Norwegian shipyards, however, incompletely and there is a need for more research on how it was implemented and what the barriers on complete implementation are. Several articles are describing the implementation of LPS in design and engineering activities, yet, incomplete and not within the shipbuilding industry. For example, Fosse and Ballard (2016), present the implementation of LPS elements for the design part of a construction project in Norway. However, the team adopted only one planning level and did not focus on analyzing root causes when deviations occurred. The duration of the project was nine weeks totally, meaning that they could actually plan all activities at the beginning of the project (Fosse and Ballard 2016).

Based on the studied literature, one of the things missing from the literature on implementing LPS is a better description of how planning meetings should actually be structured and conducted by people in charge. This is an issue that inspired the research questions in this dissertation and it is discussed in the findings chapter.

Even though LPS provides good results when implemented in the production part of a project (Ballard 2000, Emblemsvåg 2014b, Formoso and Isatto 2009, Hanson and Wicken 2008, Mossman 2005), it seems like implementing it for design- and engineering activities is more challenging (Emblemsvåg 2014a) as presented next.

2.5.7 LPS planning meetings

The studied literature about LPS reveals only a few scientific publications about how to organize and conduct LPS planning meetings. In an attempt to implement LPS for managing design activities in construction projects, Kerosuo et al. (2012) propose a method for organizing LPS planning meetings. They start with evaluating the existing planning meetings based on traditional project management recommendations that were of a more reactive nature leading to poor communication, unclear requirements and regular misunderstandings. Table 2-4 depicts the two types of meetings and the differences between them.

Table 2-4: Traditional meeting vs. LPS meetings (Kerosuo et al. 2012)

	Traditional meetings	**LPS meetings**
Agenda	Formal agenda of traditional meetings based on a firm's responsibility and rule-type conventions	Emerging agenda based on short term planning and look-ahead planning
Tools	1) Meeting agenda 2) Minutes of the previous meeting 3) Design stage update 4) Overall design schedule	1) Overall design schedule 2) List of tasks fixed in the previous meeting 3) List of design tasks for next two weeks in each design discipline presented in the excel sheet
Execution of tasks	Completed or not completed tasks	Increase in the number of completed or nearly completed tasks
Interdepen-dency between tasks		Designers' concern on the interdependency of tasks
Temporality	Reactive task orientation	Proactive task orientation

To address these challenges, the team developed and tested LPS meetings with a design group and they report several preliminary improvements, e.g., better communication and collaboration among project participants. The proactive approach to planning resulted in a new type of conversation that helped designers find better solutions because it enabled knowledge sharing among different disciplines when needed (Kerosuo et al. 2012).

Further, a more detailed description on the proposed agenda for LPS meetings is presented and compared with the traditional approach, as shown in Table 2-5. Many of the issues presented here confirm the lack of focus on the planning process when applying the traditional project management approach.

Table 2-5: Comparing agenda in traditional meetings vs. LPS meetings (Kerosuo et al. 2012)

Agenda of a design meeting		Agenda of a LPS meeting
1)	Opening the meeting, the chair and the secretary	1) Opening the meeting
2)	Minutes of previous meeting.	2) Current stage of the tasks committed in the previous meeting
3)	Open tasks in the previous meeting.	3) New tasks for the next two weeks.
4)	Entering the separately hold meetings in the minutes.	4) General discussion
5)	Site, permission and authority issues.	5) Date of the next meeting.
6)	Design approvals and user needs.	6) Closing of the meeting
7)	Current state and progress of the design in terms of overall schedule.	
8)	Main contractor affairs.	
9)	Safety at work.	
10)	Customer affairs.	
11)	User issues.	
12)	Other issues.	
13)	Summary and plan for the future.	
14)	End of the meeting and setting the date for the next meeting.	

However, even though the preliminary results were encouraging, not all members of the design team were willing to adapt the LPS meetings as a permanent working method. Among the reasons for such rejection were issues like confusion related to the division of labor and the fact that the old way of working was deeply embedded within the company (Kerosuo et al. 2012). The article does not describe the training procedures applied by the research team when implementing LPS meetings, but their results are confirming some of the findings presented in Chapter 6 of this dissertation.

The rest of the literature studying LPS meetings follow more or less same type of arguments focusing on introducing the LPS elements with little attention to discussing the underlying elements that ensure peoples involvement and willingness to change old, ineffective working processes. Moreover, several attempts to implement LPS in planning design- and engineering activities have proven unsuccessful as shown next.

2.5.8 LPS in design and engineering

The Lean Construction community acknowledges that design- and engineering activities involve "*thousands of decisions, sometimes over a period of years, with numerous interdependencies, and under a highly uncertain environment. A large number of participants are involved, such as architects, project managers, discipline engineers, service engineers, and market consultants. Each category of professionals has a different background culture, and learning style*" (Freire and Alarcon 2002, p.248). Later, Male, Bower, and Aritua (2007) identified several challenging characteristics of the design- and engineering activities within the construction industry:

- Requirements are often not clearly specified, and interpretation of problems are subjective
- The process is multidimensional, highly collaborative, and represents the interests of many stakeholders
- Problems become gradually clearer as solutions advance

However, planning design- and engineering activities is barely explored and exemplified. In many companies, planning and control activities are substituted by chaos and firefighting that cause poor communication, lack of adequate documentation, deficient and missing input information, uneven resource allocation, erratic decision making and lack of proper coordination between disciplines (Freire and Alarcon 2002). The way design- and engineering activities are planned, fails to deal with the inherent complexity and uncertainty because it lacks the capacity to ensure the required amount of information needed to complete such activities (Tzortzopoulos and Formoso 1999).

Most of the solutions proposed for dealing with these challenges are based on LPS (Ballard and Howell 2003, Hamzeh, Ballard, and Tommelein 2009, Letens, Farris, and Van Aken 2011, Orihuela, Orihuela, and Ulloa 2011, Reifi, Emmit, and Ruikar 2013, Tilley 2005). However, Kalsaas (2013), and Emblemsvåg (2014a) agreed that LPS is not able to handle advanced design and engineering work and needs a better instrument to measure physical progress for such activities. Solutions proposed by these two authors are inspired by offshore drilling construction and shipbuilding respectively, proposing some interesting improvements to the LPS. Kalsaas (2013), proposes an Integrated Project Engineering Delivery System, while Emblemsvåg (2014a) introduces an approach called Lean Project Planning (LPP). A brief description of LPP is provided in the next section of this chapter. These attempts to improve LPS proved that this tool needs some adjustments in order to respond in a better way to challenges like CE, DfM, 3D modeling, and globally dispersed design/engineering teams.

However, based on the literature studied for this research so far, no one has provided a satisfactory approach for planning design- and engineering activities.

2.5.9 Peculiarities of construction and shipbuilding

Many of the challenges in successfully adapting tools and methods from other industries to both construction and shipbuilding industries are triggered by the peculiarities of those two environments (Emblemsvåg 2014b). According to (Nam and Tatum 1988, Warszawski 1990) construction industry is characterized by four peculiarities that distinguish it from the manufacturing :

1) One-of-a kind nature of projects
2) Site production
3) Temporary multi-organizations
4) Regulatory intervention

While these peculiarities are largely discussed in the lean construction environment, according to Emblemsvåg (2014b), no study of peculiarities in shipbuilding has been conducted. Therefore, based on Koskela (1992), explanation on the peculiarities in construction, as well as experience within the industry, Emblemsvåg (2014b) applies those peculiarities to the shipbuilding industry.

1) One-of-a kind nature of projects – most of the vessels produced within the Norwegian shipbuilding industry are unique
2) Site production – this is where construction and shipbuilding industries differs. While construction is carried out at the final site of the constructed product, vessels are built at the same site
3) Temporary multi-organizations – both industries outsource (subcontract) large parts of their projects
4) Regulatory interventions – there are codes and regulations that both industries must follow during the execution of each project

Since these peculiarities can be applied to a certain extent to both industries, it seems that they deal with similar challenges in planning their projects. As discussed in Chapter 7, this indicates that what works for construction should also work for shipbuilding and *vice versa*, so that the results of this research should also be relevant for the construction industry.

With this in mind, a planning tool developed and implemented in the shipbuilding industry is presented next. This tool is in fact a combination of elements from the traditional project management practice, lean- and lean construction concepts. It occurred from the fact that LPS had many great advantages over EVM, but the contracts in many shipbuilding projects stipulate a reporting process that resembles EVM requirements. Thus, combining the two concepts became a solution that could improve both the planning- and the reporting processes.

2.6 Lean Project Planning (LPP)

The description provided here is mainly the theoretical part of LPP as its practical application is explained in the case description chapter. LPP is a management model that has been implemented at Vard since 2009 (Emblemsvåg 2014b, Halse, Kjersem, and Emblemsvåg 2014). LPP is based on the following concepts (Emblemsvåg 2014a):

1) Lean thinking ideas like the PDCA circle, root cause analysis, and TWI
2) Elements from LPS like planning levels, and PPC
3) Elements from project management like estimating budget and duration, and EVM

These elements are described previously in this chapter. A brief description of the way they are combined within LPP is provided next and it is based mainly on (Emblemsvåg 2014a, 2014b) since the author developed, tested, and wrote scientific papers about LPP.

2.6.1 LPP way of working

LPP method distinguishes the planning process part from the planning system part. The planning process part is based on LPS, EVM, and lean ideas focusing on collaboration, open communication, and involvement from the project team. Figure 2-13 depicts the LPP framework. The Project Plan is, in fact, the project's database as recorded in the scheduling software, and it is usually seen only by the project planner for general analysis purposes. The plan that is first prepared and is a part of the contract signing is the Milestones Plan. This plan contains key events of the entire project from the contract signing to the delivery of the final product. The next plan is the Discipline Plan created through a collaboration between the disciplines and subcontractors involved in the project. Together, Milestones Plan and Disciplines Plans generate the Master Plan that shows the whole project execution horizon. Work packages within these plans are quite general and have a long duration. A more detailed plan is created at the Period Plan level containing work packages with a duration between five to eight weeks: in other words, a lookahead plan per discipline (Emblemsvåg 2014b).

The Period Plan serves as a connection-level between LPS and EVM as here the level of detail is best suitable for a reliable reporting within EVM. By focusing five to eight weeks ahead, the Period Plan gives project organization the possibility to avoid deviations from the plan by removing any constraint before the activity supposed to start. The work packages within the Period Plan are defined so that they can be used within the EVM planning and reporting procedures. Each supervisor reports on weekly the status of their work packages: Percent physical complete on each activity, remaining hours and, if necessary, a new finish date in case of delays from the plan. During the reporting process the seven preconditions (Preceding work; Resources; Information; Materials; Space; Tools; External conditions) for an executable/sound activity are analysed, making people aware of eventual problems that can cause delays. After completing the reporting process, the project planner creates project reports (containing e.g. EVM elements, deviations, re-planned work, and other relevant issues) that are sent to the whole project team as well as to the high-level management (Emblemsvåg 2014b).

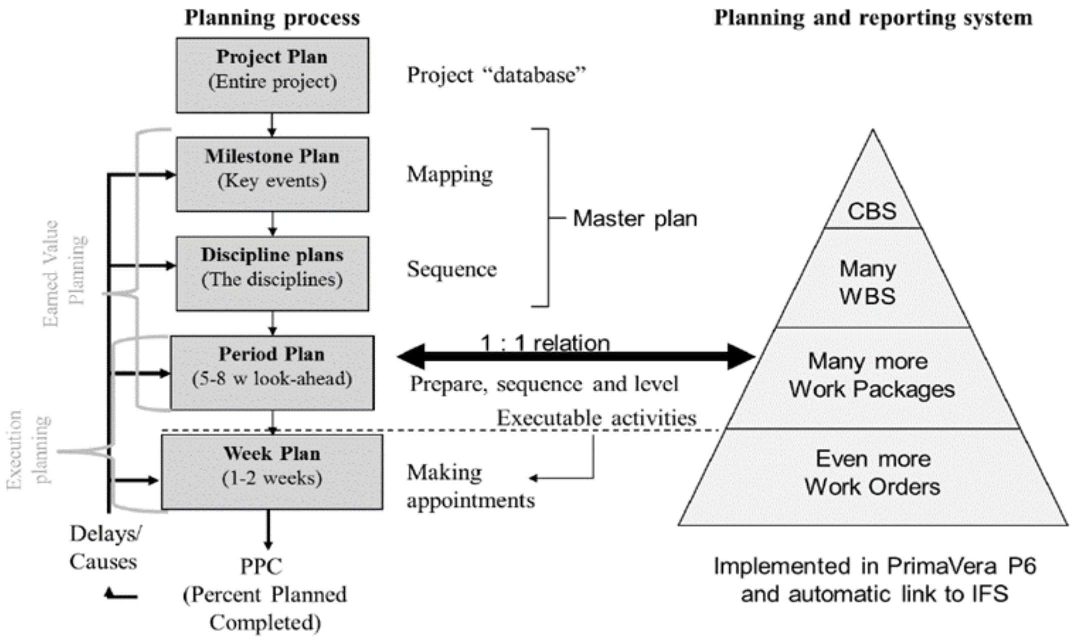

Figure 2-13: Lean Project Planning (Emblemsvåg 2014b)

The Period Plan is further developed into a more detailed plan that is called Week Plan. This is a dynamic list of activities, more than a plan, created and followed by each supervisor who reports the completion of planned activities during the weekly lean meeting. Week plans contain sound activities pulled by foremen from the Period Plan and put together in manageable packages for their crew. Each package is a line on the week plan, and despite their simplicity, these plans have several important functions (Emblemsvåg 2014b):

- They are tools for communication and coordination as no amount of detailed activities in a planning software can replace communicating with each other. It is here the communication part of the planning process is most visible as people participating in the lean meetings are to discuss and inform each other on issues regarding the status of each activity
- They support the project in achieving commitment from the participants by discussing and solving project issues during the weekly meetings. It also helps to determine eventual sequencing problems
- They must be updated weekly and that gives project team the possibility to deal with eventual deviations much faster. RCA of any deviation is an essential part of weekly meetings

Week plans are presented and reviewed every week during lean project meetings where project manager, technical-, discipline-, and production coordinators, project planner, and all relevant suppliers are requested to participate. These lean meetings are steered by the technical or production coordinators and have the purpose of enhancing communication and commitment among project participants. Each lean meeting has a duration of one to one and a half hour and follows established rules like (Emblemsvåg 2014a):

- Attendance is not voluntary (all invited people must participate)
- People must come prepared to the meeting. Occasionally, department leaders join these meetings (supervisors are evaluated on the way they are prepared for the meetings)
- People have to inform the rest of the team the status of their own activities, causes for deviations and measures for recovery of deviations (this is important for other disciplines that might need to re-plan some of their activities) as well as which activities are planned for execution for the next week or two
- People must follow the rules of the meeting and are invited to come with suggestions for improvement

The software used for planning a project represents the system part of the LPP. Cost Breakdown Structure (CBS), Work Breakdown Structure (WBS), and work packages are defined to a certain level and tracked through the system. The planning software (e.g., Primavera or Microsoft Project) is linked to the software used by the financial department and reported hours in one software are transferred in the other software, controlled and attested by people in charge for this activity (Emblemsvåg 2014a).

2.6.2 LPP principles

There are several principles that are at the core of LPP (Emblemsvåg 2014a, 2014b):

1) Plans should be detailed closer to the date for executing the activity. It reduces the need for re-planning and increases the maneuverability, as effort and time are not wasted on updating detailed plans well beyond realistic horizon for realistic plans
2) Those that know the job must do the planning. This means that foremen, supervisors, and discipline coordinators do not get the plans and start to execute them. They are an essential part of the process of planning, doing, checking and acting
3) The planner facilitates the planning process, manages the planning software, analyzes reports, and send them to the project management team. The planner does not set updates, duration of an activity, or hours needed for completing an activity. The discipline coordinators and supervisors do this
4) The Constant Work in Progress (CONWIP) found in lean manufacturing is adopted to a project environment by combining push and pull strategies in project planning. The push part is secured through the use of EVM, which stresses the dates for completion by using performance measures to motivate workers to deliver as planned. The pull strategy is secured through the seven conditions for sound activities used by LPS

These principles were developed and implemented on several projects within Vard Group by involving people in testing, failing, learning, and continuously improving the LPP method (Emblemsvåg 2014b). Some more explanations on how pull, push and CONWIP concepts are combined within LPP are presented next, as this is in fact a core component that distinguishes LPP from other planning methods developed the last few years.

2.6.3 CONWIP elements in LPP

Pull and push concepts are defined earlier in this chapter, so a definition of CONWIP is necessary. Spearman, Woodruff, and Hopp (1990) define CONWIP as a generalized form for Kanban[2] and also relies on signals or cards. Whereas Kanban is used to signalize the production of a specific part, CONWIP signals are assigned to a production line and are not part number specific. These part numbers are allocated to a card at the beginning of the production line, and their numbers are matched with cards from a backlog list. Using CONWIP, a job will not start unless a place in the system has been vacated for it and when implemented

[2] Kanban is a lean concept used as a signaling card system.

correctly, the system will attain a maximum throughput without excessive flow time or work-in-progress (WIP) (Spearman, Woodruff, and Hopp 1990).

The push part of the LPP refers to establishing the main project plan at the management level, and the project participants create own plans within the given frame. The pull part is accomplished through preparing activity for completion and eliminate constraints while the project progresses as advocated by LPS. The CONWIP part of the LPP resides in creating and maintaining a backlog of activities ready to be completed when unexpected or disrupting events occur, and planned activities need to be re-planned. To secure the backlog of sound activities, it is important to keep a steady focus on removing constraints for activities on the period plan (Emblemsvåg 2014a).

2.6.4 Production vs. project planning

LPP recognizes the difference between production planning and project planning as these terms are most of the time used interchangeably differing only in that production planning refers to the production part of a project. It also implies that they are more or less similar. However, project planning is the process of planning a complete project while production planning refers to planning all the activities in a workshop for a given calendar period. "*Production planning is therefore essentially portfolio planning focusing on flow, and since it encompasses a single workshop it can be more detailed, whereas project planning concerns a project and focuses primarily on coordination*" (Emblemsvåg 2014b, p.5). This aspect is not approached in traditional project management literature as the project planning is treated mostly like production planning without focusing on planning design- and engineering activities.

Another core idea behind LPP is to find the right level of detail for each of the plans. Emblemsvåg (2014a), considering the level of uncertainty in an ETO project, recommends to "*train the organization to live with this uncertainty and then rely on the expertise of supervisors and coordinators to maneuver to find the best solution for given circumstances*" (p.6). The focus here is on planning as a communication process among all project participants from the lowest to the highest level of decision-making pyramid. Living up to this statement, the training process for implementing LPP was based on involving people throughout the development phase. People at the shipyard were willing to test and improve these training methods (Emblemsvåg 2014b), and that implies commitment and interest in continuous improvement.

Like LPS, LPP is also focusing on improving the communication within the project team. Therefore, a short review of its approach to the topic is presented next.

2.6.5 LPP and communication

According to Bohm (2003), communication is the act of "*making something common*" and Habermas (1998), claims that the scope of communication is to coordinate actions in order to achieve an agreement, without reservations. A successful speech act (as a communicative action) must satisfy four conditions (Habermas 2000):

1) Must be **true** for participants insofar as it represents something in the world
2) Must be **comprehensible**
3) Must be **truthful** (express something intended by the speaker)
4) Must be **right** (conforms to socially recognized expectations)

However, as Huxley (2000, p.370) argues, consensus is not implicitly achieved, "*but it must be created by identifying sources of systematically distorted communication in systematically unequal social structures, and by creating ideal speech situations in self-reflexive, communicatively competent, and rational human subjects can achieve consensus on matters that affect their lifeworlds*". This statement implies requirements of critique, explanation, understanding, and interpretation of the speech as these elements are the foundation of a normative transformation (Huxley 2000). Or, as Ballard (2014) put it, "*if you can't say "no", you can't make a promise.*"

The implication of the statement above is profound for this research. To systematically satisfy these conditions in a project-based environment it requires a special type of interaction since it involves large teams of people and even teams of teams. In other words, it is very unlikely that this will take place without being actively managed. With this in mind, some types of communication are investigated next.

2.6.6 Types of communication

In projects, communication can take several forms. Bohm (2003) describes four types:

1) Ordering (a special form of dissemination) – a person tells another person what to do. It should be the last resort of communication as it is ineffective for the overall system
2) Teaching/presenting (a special type of dissemination or dialogue depending on the approach) – a person presents subject matters to an audience. However, teaching without practical use of the theory is one of the least effective ways to communicate knowledge, as people tend to receive and remember less than 40% of what they are taught, sometimes only 25%

3) Persuasion and discussion (argumentation) – people who try to convince others about their points of view. In some cases, persuasion can be understood mostly as one-way communication, while argumentation is a more two-way conversation. Both types can be intensive and frequent focusing on the same objective: to influence and convince the others

4) Dialogue is about persons engaged in exchanging a stream of meanings out of which will emerge some new understanding of the subject. Dialogues are multi-directional, synchronous, and sometimes quite intensive, but for most people, the dialogue is perceived as a conversation.

Based on these thoughts, Emblemsvåg (2014a) argues that planning must be primarily based on dialogue and secondary on the discussion when needed. However, the traditional project planning is based more on ordering and persuasion, as pointed by Ballard (2000), because planners and the ones executing the work are separated not in time and space, but in person. Hence, LPS and its communication perspective were adopted within the LPP (Emblemsvåg 2014a). Figure 2-14 visualizes the four types of communication in projects.

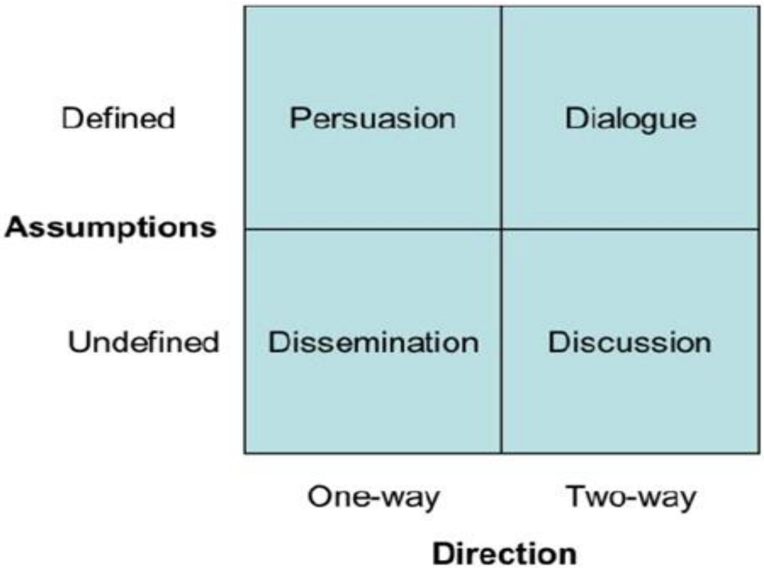

Figure 2-14: Use of language in corporations (Emblemsvåg 2014a)

In many of the planning meetings observed during this research, project participants were using either discussion or persuasion types of communication. The lack of dialog and better communication among project participants was often a topic when discussing improvement programs in most case companies. This is also discussed by Ballard (2014) who argues that planning processes fail due to competing interests and lack of collaboration among project participants. Well-designed planning processes take into consideration both the social- and the technical side of such an endeavor. One way to improve the social aspect of the planning system is to improve communication among project participants (Ballard 2014). Therefore, LPP was created as an arena for communication and socialization through planning meetings by using the SECI model as one of its pillars.

2.6.7 SECI model in LPP

LPP's foundation lays in the non-linguistic model that can improve the communication and commitment within a project even when the original incentives or motivations are subsequently removed. LPP uses weekly lean meetings as a fundamental part of the planning process. These meetings ensure better coordination and socialization by using commitment, knowledge transfer, and learning Emblemsvåg (2014a). The same author explains this approach by using the SECI model developed by Nonaka and Takeuchi in 1995, which is visualized in Figure 2-15 as adapted in LPP by Emblemsvåg (2014a).

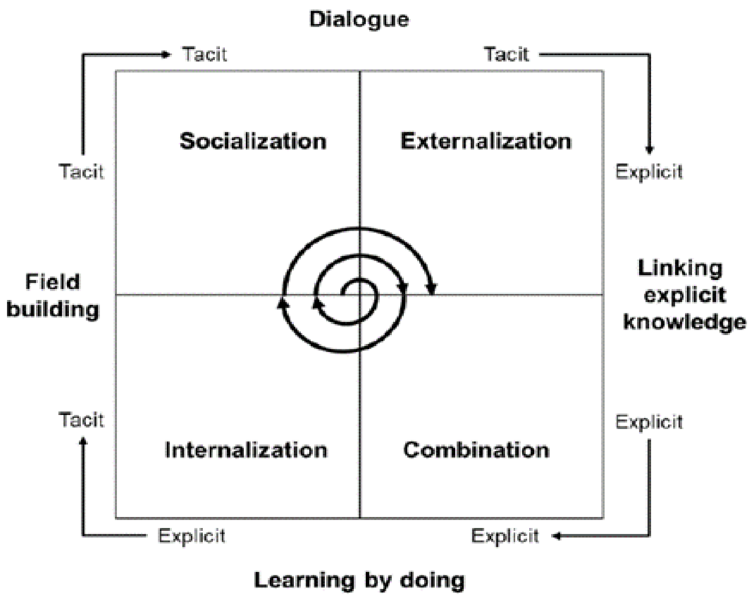

Figure 2-15: The SECI model as adapted by (Emblemsvåg 2014a)

SECI is the abbreviation for Socialization, Externalization, Combination and Internalization, the four processes needed for acquiring knowledge and communicating it further. It was developed as a way to explain how people acquire knowledge and to help them understand the importance of tacit knowledge in managing companies (Normann 2006). The whole process is well explained in Nonaka and Takeuchi (1995), and it is not the scope of this research to go in more detail about them. However, the four elements are briefly described next as applied within LPP's weekly planning meetings (Emblemsvåg 2014a).

1) **Socialization –** is the phase that recognizes that from the organizational point of view, knowledge resides in people and only in people. In LPP, socialization is achieved regularly through weekly lean meetings where people exchange information about the status of own activities and learn about the status of other teams' activities. This is fundamental to the elicitation of tacit knowledge, something traditional planning approaches totally ignores. Due to the complexities of design and engineering activities, tacit knowledge is arguably particularly important in order to understand what the actual status is, what can be done and what can we expect.

2) **Externalization** – is the phase where people convert tacit knowledge to explicit knowledge by communicating and discussing project issues. The main approach here is dialogue, and people use mainly storytelling, metaphors, and analog techniques

3) **Combination** – is where people mix tacit knowledge with the newly acquired information and create new insights. In LPP, this is an essential part of the planning meetings because one important scope of the meeting is to analyze what was planned, handle deviations, and decide what to be executed next.

4) **Internalization** – is the process where people truly comprehend the explicit knowledge and create their own understanding and add it to their own tacit knowledge. One approach to support internalization is learning by doing as proved through the TWI program developed by the USA during the '40s throughout the '60s. This method was and is still used by Toyota in training its people to really understand own working processes (Dinero 2005) as addressed in section 2.4 of this dissertation.

These principles were used in developing LPP to increase the maneuverability of planning and thereby deal with unexpected issues during project execution. The argument used by Emblemsvåg (2014a, p.202) is that a high degree of maneuverability will create flexibility and speed of reaction because "*without high degree of maneuverability, flexibility will degrade in internal flexibility to save costs and keep control without offering any real value to the customers*". The concept of maneuverability within the planning process is inspired by the challenges faced when planning ETO shipbuilding projects. These are explained by Emblemsvåg (2014a):

- Detailed plans made early in the project are meaningless as conditions change and plans become obsolete. Detailing must, therefore, be an ongoing process as we approach execution.
- Planning must be conducted by last planners which imply that top-down planning on a number of issues is not only impossible but also damaging as they lack the necessary insight to make proper decisions.

- Many important aspects of planning are impossible to be defined on a plan, so planning must focus on communication and elicitation of tacit knowledge.
- Challenges in planning activities at the operational level cannot be handled by advanced modeling software. Activities at this level, particularly in design- and engineering activities, are so rich in information that makes it impossible for any software to analyze them in the short decision window.

Concluding the argumentation for increased maneuverability in project planning, (Emblemsvåg 2014a) discusses the fact that technology can help, but many of the complex software and systems are usually directed towards internal operations within an organization. Such focus tends to create isolation, confusion, and collapse. Therefore, LPP is based on the idea that the planning process is more important than the plan itself, and it is essentially a process that facilitates communication among project participants (Emblemsvåg 2014a).

2.6.8 LPP in ETO projects

LPP is a natural evolution from LPS adapted to the needs identified within the shipbuilding industry (Emblemsvåg 2014b). Adding EVM is an improvement as long as management understands that there are some limits to it and, as with any other system, people can misuse it. LPP proved to be a successful fusion of LPS and EVM in more than ten projects where the approach was implemented. Nonetheless, Emblemsvåg (2014a) recognizes its weakness:

- It needs to emphasize the role of managers and coordinators and to develop better training methodology.
- The links between period plan and week plan are not defined explicitly, and it is based on heuristics as opposed to a structure. It can make planning somewhat unclear for outsiders and is an issue to consider for further research.

As stated earlier, LPP was mostly implemented at the production phase, and only partially tested on the design- and engineering activities of a project (Emblemsvåg 2014a). Among the reasons for that are (Emblemsvåg 2014b):

- The iterative nature of most design- and engineering activities
- It is difficult to define design- and engineering activities as precise as needed by EVM.
- Measuring progress on design- and engineering activities is challenging (when is a drawing or a model complete if iterations have a chain effect from one activity to another?).

- Engineers work on several projects at a time, and they often overpromise completion of activities.
- Engineers have less training in planning own activities or work according to a plan than production people have.

In other words, LPP also needs to be improved and adapted to deal with the challenges of planning the design- and engineering activities in ETO projects.

Another interesting gap encountered during the implementation of LPP was the lack of structure of the lean meetings. This gap originated as a criticism from the project participants who were involved in several projects at a time and discovered that each production coordinator used his/her own meeting structure. Based on the reviewed literature, LPS does not recommends a specific planning meeting structure either. Hence, determining the right structure for planning meetings is a factor that can contribute to a better implementation of both LPS and LPP, as discussed in Chapter 6.

2.7 Gaps from the reviewed literature

The theoretical standpoints presented in this chapter indicate several gaps that are mainly related to the lack of published research on the challenges related to planning projects within the ETO environment. Some of these gaps are addressed throughout this dissertation, while others are subjects to further research.

One of the first gaps identified is the lack of research on the ETO environment in general (Willner et al. 2014) and on planning design- and engineering activities within ETO projects (Kjersem and Emblemsvåg 2014) in particular. Therefore, the aim of this research is to contribute to the literature on planning design- and engineering activities in ETO projects. In Chapter 6, is provided a summary of the challenges identified during the research period.

After reviewing the challenges in planning ETO projects, the literature seems to lack a description of a planning process that can handle concurrency of project phases, need for DfM, and the inherent iterations of design- and engineering activities in the context of network organized projects with globally spread project participants. Since most ETO companies use a project-based approach to deliver their products, which is the topic of this research, it seems customary to use traditional project management approaches to plan and control such dynamic and challenging projects. In other words, companies have taken an approach developed in one context and applied it to another without sufficiently considering the differences. Not surprisingly, the statistics presented earlier in this chapter show that this traditional approach is not working. Hence, this research aims to contribute to the development of better planning processes, which fit the challenges within ETO environment.

As shown throughout the reviewed literature, several gaps were identified:

1) Lack of research on ETO environment in general
2) Lack of research addressing the process of planning design- and engineering activities in ETO projects
3) Lack of research on organizing planning meetings in general and in how to structure and conduct such meetings in particular. In addition to a lack of focus on planning design- and engineering activities, there is also a gap in describing good planning meetings, including their structure, that fit the challenges of such activities
4) Lack of research addressing the more subtle elements that are necessary for conducting successful planning meetings that ensure communication and good interaction among project participants. Indeed, the entire communicative element between people in these meetings seem to be largely ignored in some approaches or significantly underdeveloped in others

These are the gaps addressed throughout this research, and they serve as a foundation for the four proposed research questions in this dissertation.

2.8 Summary of the theoretical background

The literature used as background for this research became a large chapter with many different concepts. That is partly due to the complexity of ETO projects and the fact that most practitioners use traditional project management tools even though these are not always the most effective ones.

The purpose of reviewing OM-, project management-, and ETO literature is to set the theoretical context for this research. Inspired by OM, traditional project management applies similar concepts when planning projects regardless of the context and specific challenges within each project, even though by definition, each project is unique. There are numerous references within both literature and practice showing that using these approaches is not working since most projects are either delayed, cost more than planned, or deliver lower quality than expected as shown throughout this chapter.

PMBOK® treats some aspects regarding the planning of the procurement part of the project, but make no distinction between design/engineering and production activities. The book uses a formal approach based on a predictable, fixed, rather simple, and specific model to manage these kinds of activities even though their needs differ to a great extent. In other words, a positivist approach, as discussed in the next chapter.

Projects delivered through an ETO approach tend to be complex in nature, leading to deep and complicated product structures that are driven by customer requirements. These products often contain several customized components, which also implies the supplier's involvement in the design- and engineering activities. Throughout this chapter, were presented several aspects influencing the planning process in ETO projects like iterations (including change orders), outsourcing, network organized projects, CE, DfM, 3D modeling, incomplete specifications, labor shortage, and uncertainty. All these aspects influence especially the planning process for design- and engineering activities since their outcome requires a different focus from the project team.

After presenting a large, but not exhaustive, number of ETO challenges and showing solutions used within the lean construction environment, this theoretical background presented LPS as a planning tool where commitment and reliable promises among project participants are the norms. The LAP foundation of LPS argues that communication and the way it is performed within a project is an essential success factor. A similar conclusion is achieved by LPP, which through its somehow standardized lean meetings, emphasizes the role of communication through dialogue, reliable commitment, and learning by doing (as in SECI model). The idea behind adapting EVM as a progress measuring tool (in addition to PPC) was to give the management team the possibility to follow up on the project and to deal with challenges before they become a problem. Another emphasized idea in LPP is to create high planning maneuverability that comes from dynamic communication among project participants and not from the planning software.

The studied literature within project management, ETO, lean, and lean construction show little or no attention to the way planning meetings are organized, structured, or conducted by the project teams. Moreover, most literature recommends organizing project meeting in one or another form, but none of them describes planning meetings as a communication channel in ETO projects. This research aims to contribute first of all to the ETO literature and to the way projects are planned and executed in this environment. It also contributes to the literature on project management by bringing attention to the need for well-structured project planning meetings that can improve the communication between participants. Another contribution is to the LPS by proposing an extension of its implementation process that needs to contain good training on how to plan and organize well-structured project planning meetings for design- and engineering activities.

Before presenting the methods used to collect data necessary to answer the proposed questions, a brief philosophical perspective of the research is presented.

Chapter 3

Philosophical aspects of research

3 Philosophical aspects of research

“*There are no facts, only interpretations*”

Friedrich Nietzsche

Philosophy of science is preoccupied with analyzing the methods of inquiry used in various sciences by questioning assumptions that researchers might take for granted (Okasha 2002). Ontologies, epistemologies, methodologies, and methods are all parts of the philosophical aspect of an academic study and need to be defined for each research since this is a way to make scientists aware of the own biases and the angle of their interest within the topic of their research (Moses and Knutsen 2012). Basically, ontology is about “reality,” epistemology about the relationship between that reality and the researcher, while methodology is about the techniques used by the researcher to discover that reality (Sobh and Perry 2006). However, before discussing these aspects, a brief review of the etymological roots relevant to project planning is presented.

3.1 Etymology

The etymology of the word project is originated in the Latin “*projectum*” from “*projicere*” that translates into “*throw something forwards*” where the first part of the word “pro” signifies something that precedes the action of the next part of the word in time “*jacere,*” “*to throw*”. Hence, the word project meant originally, “*Something that comes before anything else is done*” and its initial use was to refer to a plan of something, not the act of completing that plan. The use of the word project changed during the 1950s when project management as a discipline evolved and started to implement managing techniques (source: Wikipedia).

The etymology dictionary, explain that the word management derives from the words “*manage*” plus “*ment*” describing a governing body. The term “*project management*” appears for the first time in 1953 as a term used by the US defense-aerospace to describe a collaborative development of complete weapon systems that required the participation of several different departments (Morris, Pinto, and Söderlund 2013). An important management function is to plan the execution of a project. The word plan originates from the Latin “*planum*” which means level or flat surface, and it implies “*scheme of action, design,*” a technical term in perspective drawings. Planning is then a combination of the word “*plan*” and the suffix “*ing*” reflecting the act or process of making a plan (https://www.etymonline.com/).

From a philosophy of science perspective, planning as a process is rather interesting to analyze thanks to its complexity and significant influence on the success or failure of a project. Project planning is an important management tool and until recently was, in fact, identified as the project management itself (Morris, Pinto, and Söderlund 2013). The definition offered by Humphreys (1991) describes project planning through its most important activities and explains in a way that misconception. He states that planning is a process of "*making decisions now with the objective of influencing the future"* (Humphreys 1991, p.467) and its specific attributes are:

- Setting objective
- Collecting information
- Determining realistic alternatives
- Indicating the best alternatives
- Communicating the plan
- Implementing the plan
- Making in-process adjustments of the plan (re-planning) to meet the variations
- Review the results at the end of the project

Based on the definition above, project planning is a complex process that involves communication between people from different disciplines, technical and analytical skills, as well as the capacity to adapt to constant changes. Project planning is much more than an activity designed specifically to create a plan that tries to forecast exactly what would happen, who will perform the task, and when. The objective of project planning is to increase understanding of the project scope of work, highlight potential problems and enable organizations to prioritize the most important issues, rather than defining exactly what will happen (De Reyck 2010). How would one identify which scientific categorization fits this description, is presented later in this dissertation. For now, ontological, epistemological, and methodological assumptions on project planning itself and to this research are presented.

3.2 Ontology

According to Moses and Knutsen (2012), ontology is concerned whether reality is of an objective nature, or it is a result of our perceptions and interpretations. Its fundamental question is "*What is the world really made of"*? Through the ontological perspective, scientists analyze the nature of social entities. To understand this better, it is useful to investigate the two extreme ontological positions: positivism and constructionism. Positivism states that social phenomena and their existence are independent of the researcher's views. It suggests that we can gain access to that phenomenon by thinking, observing, and recording our experiences carefully. The second ontological position is constructionism, which states that each of us sees things in our own ways and what we comprehend is determined by a complex mix of assumptions, social as well as background influences. In other words, our own perceptions and experiences influence the way we understand the world (Moses and Knutsen 2012). Every researcher takes a philosophical position that reflects one of two approaches or their variations (e.g., realism, pragmatism).

Ontologically, from the perspective of creating project plans, it is possible to categorize project planning within the constructionism approach, where the plan constructed through the planning process is compared with what has actually been achieved. Most of the differences between these two stages are results of human construct: misjudging own capabilities, lack of experience in estimating time and resources, lack of information, unclear or missing communication, etc. However, as a tool supporting the decision making and strategy formulation, project planning is built on three general basic assumptions: 1) the assumption of order; 2) the assumption of rational choice; and 3) the assumption of intentional capability (Kurtz and Snowden 2003).

Applied to the project planning process, the assumption of order argues that there are fundamental, identifiable, and empirically verifiable connections between cause and effect in human interactions and planning. Consequently, it is possible to define prescriptive and predictive models and design solutions that allow project organizations to achieve their goals. Thus, this idea implies that by understanding the causal links in the past performance allows us to identify "best practices" for future behavior (Kurtz and Snowden 2003). However, the definition of a project presented above argues that each project is unique which means that the assumption of "best practice" must be limited to some general aspects such as meeting's structures, project organizations, and planning communication.

The assumption of rational choice argues that project participants will make "rational" decisions when faced with the choice between one or more alternatives. These "rational" decisions would be based on "*minimizing pain or maximizing pleasure and in consequence people's behavior can be managed through manipulation of pain/pleasure outcomes and through related education to make those consequences evident*" (Kurtz and Snowden 2003, p.1). Both project management and project planning theories are built on the rational choice assumption where project participants make decisions based on the project's best interest. However, as will be shown, this assumption proves to be limited because projects in general deal with many internal and external entities who would try to maximize their own benefits even at the expense of the project as a whole.

The assumption on intentional capability argues that the "*acquisition of a capability indicates the intention to use that capability",* and then actions from project participants are the result of deliberate behavior. Thus, we accept that we do things by accident, but we consider that the others do things deliberately (Kurtz and Snowden 2003). In project planning, this assumption applies especially to the relationships and dependencies between activities or disciplines.

Based on the discussion above, project planning as a tool supporting the decision making and strategy formulation seems to fit better within the critical realism ontology. This ontology agrees with the fact that our knowledge of reality is a product of social context and cannot be understood independently of the social actors involved in the inquiry process, yet it disagrees with the view that reality is a product of an inquiry process (Saunders, Lewis, and Thornhill 2019). This view argues for "*necessity and contingency rather than regularity, an open system rather than closed systems, on the ways in which causal processes could produce quite different results in different contexts*" (Moses and Knutsen 2012, p.13). That is because project participants tend to interpret the planning process from their own perspectives and interests within the project. In other words, there are very few objective participants in a project, and that requires more effort into creating a plan that considers all of their requirements. Thus, achieving a consensus on the plan and its consequences becomes a difficult task in many ETO projects.

The presented ontological perspective on this research (about project planning), must match the ontology of the planning process as discussed. That is because the research must be performed in the same context as the planning since projects are dealing with humans and how they work. In other words, it cannot be expected that this research would follow the positivist doctrine, understanding it from afar with statistical data as input. Indeed, due to its complexities, it cannot be expected that a researcher understands project planning without being a part of the process. This is discussed in section 3.4 and further argued as well as illustrated in Chapters 2 and 5. Therefore, research about project planning at the level of detail done here can only be achieved through active participation. This is discussed in section 3.5 as well as in Chapter 4, but before that, the epistemology of this research is discussed next.

3.3 Epistemology

While the ontology is concerned with the nature of existence and what we think science is, the epistemology studies the nature of knowledge and what it means to know (Gray 2009). Epistemology is essential from the philosophical perspective of scientific research due to reasons like: 1) it establishes what kind of knowledge is appropriate for the planned research; 2) it helps clarify issues of research design; 3) it helps the researcher to recognize which design will work for the research and which will not (Gray 2009). Epistemology is concerned with what can or should be regarded as acceptable knowledge in a field of research and whether or not the social world should be analyzed using the same values, techniques and ethos as the natural science (Bryman and Bell 2011). There are several philosophical perspectives within epistemology, including Positivism, Interpretivism, Critical Inquiry, Phenomenology, and more. In this research are mentioned only the ones that are significant from the project planning perspective.

Epistemologically, project planning can be analyzed through an interpretivist perspective, which states that the world is interpreted through the classification and representations of the mind. Interpretivism is preoccupied with the idea that "*natural reality and social reality are different"* and hence require different types of approaches (Gray 2009, p. 23). Indeed, project planning is challenged by the fact that a planner must handle simultaneously (Ferreira, Sykes, and Batey 2009) factors like:

- Knowledge from the natural science – for example to plan activities for one discipline while planning for the whole project
- Knowledge rooted in social science – for example, to understand the social implications of a new reporting program
- Provide information on what needs to be done, when it should be done and why to do it

Gray (2009) argues that there are five interpretivist approaches: Symbolic Interactionism, Phenomenology, Realism, Hermeneutics, and Naturalistic Inquiry. Project planning in complex environments like ETO is a challenging activity both from the practitioner and from scientific perspectives due to so many underlying factors and their inherent complexities. Based on this, the naturalistic inquiry seems a proper approach to study project planning. This paradigm argues that there are multiple constructed realities that can only be studied from a holistic perspective. The outcome of an inquiry into all these multiple realities is more questions than it answers making forecast and control of the results "*largely futile expectation*" although some understanding can be accomplished (Gray 2009).

The naturalistic inquiry does not attempt to generalize the outcome, but to develop an ideographic concept that describes particular cases that can only be understood within their own context and environment. There is no pre-determined research design for this type of research, as this will be determined throughout the study. However, some of the methods selected usually by the researchers within this field have a close association with a human component: interviewing, action research, and document analysis (Gray 2009).

Studying the planning process for design and engineering activities and a way to integrate them within a project plan at the case company proved to be a challenging task in this research. Many complex factors must be taken into consideration due to their influence on all the other branches and levels within the company. For example, establishing activity codes for engineering activities have to be accepted by the financial department, clocking system, IT department, and other internal entities. This means that developing a project planning tool at the case company might not result in a generalizable concept that can be implemented outside this specific case except some shared ideas (meeting structure, common concepts used to improve the process, etc.).

The interesting and directly relevant implications of this paradigm for this research is that since knowledge is holistic – comprising of both direct-, indirect- and tacit knowledge (Polyani 2009) - project planning cannot be performed in simple, formal information exchanging/ transactional ways. True dialogue, as defined by Bohm (2003), is required, and this means that the communicative aspect of project planning is much more critical than most realize including the literature, as demonstrated in Chapter 2.

3.4 Project planning as a decision-making tool

Most of the literature that assesses project planning theory describes it through its software view that is the scheduling part of the planning process, and that is usually misleading. Project planning is a complex process that stretches across different departments, different companies, and even different countries/-cultures. Integrating all these entities through the planning process is often dependent on the people involved. Here seems to apply the concept of utilitarianism, which argues that we should do that which is proved to be the utmost happiness for a given population (Jakobsen 2014, Taylor 1980). This idea can be understood as all project participants should do what is best for the project and not for the best of every single entity. However, the reality is that each project participant is often interested in achieving the best results for own entity, and that leads to a conflict of interest in many projects.

In managing and controlling projects, planning is an important factor that can contribute to both success and failure of meeting the established objectives. Although most of the practitioners and academics agree that planning is undeniably essential to assure project success, the project planning in many organizations within different industries “leaves a lot to be desired “(De Reyck 2010). The US Government Accountability Office presents a statistic of 413 projects that failed to achieve their goals, and 79% of these failures were due to poor planning, 15% were poorly performed and 6% both (Powner 2008). Within project management literature, Kerzner (2013b), identifies numerous root causes for project failure and among these several are planning related: Poor overall planning, lack of re-planning on a regular basis, plans are based on insufficient data, no systematization of the planning process, and planning is performed by a planning group. These statistics have in common one important idea: that project management practice needs to improve the project planning approach by taking into consideration specific complexities and the fact that every project deals with people and their biases. Or, as Shenhar and Dvir (2007) argue, there is a need among project participants for a new framework and new semantic to communicate with each other about projects.

Grierson (2009) argues that the western world is dominated by a mechanistic view that treats the universe as a mechanical system composed of related but distinct elements. Through this perspective, the observer focuses on control and efficiency, and the organization is designed as a collection of precisely interconnected parts linked together by clearly defined lines of command and communication. This mechanistic view argues that in an organization, all the thinking is done by the managers and designers while all the doing is left to the workers (Jakobsen 2015). Another view is that created by Taylor, who applied scientific methods to study and analyze how workers performed each task and then formulated the normative principle that supposed to result in optimal efficiency (Normann 2006). This type of thinking is representative on the project management literature describing a planning process where most of the decisions are taken at a management level and communicated down the system to the workers (Ballard 2000).

The lean construction environment criticizes the project management approach for lacking focus on the communication, commitment, and involvement of workers within the planning process which usually results in rigid and unreal plans (Koskela and Howell 2001). LCI community acknowledges the importance of taking into consideration the human aspect within the project planning process, and thus, they developed LPS. This tool helps project planning to accomplish some important aspects of planning like: proactively eliminating activity constraints; better communication among project participants; commitment to the plan by involving project participants in the planning process (Ballard and Howell 2003). In addition, from a practitioner's perspective, planning is about the communication and information process that brings people together and creates a sense of responsibility and involvement. The lean construction approach to project planning supports the critical realism ontology and the interpretivist epistemology applied through this research. The results of implementing such an approach to project planning confirm better control over the project development, as shown in e.g., (Emblemsvåg 2014b, Kalsaas 2013).

3.5 Methodology

The third important aspect of the philosophy of science is the methodology to be applied to the research. The methodology is defined as the study of which means are suitable to produce reliable knowledge. Its core purpose is to investigate concepts, theories, and basic principles of reasoning on a domain (Moses and Knutsen 2012). Examples of methodologies: Action research, Ethnography, Case study, Grounded theory, and Survey research. Within the methodology selected for a research, scientists use methods for gathering and analyzing the data. A method is defined as a technique or procedure of a discipline and can be: Sampling, Observation, Interview, Statistical analysis, etc. The methods applied in this research are explained in Chapter 4.

Any methodology applied to a research has to match the chosen ontology. Critical realism is an ontology that allows naturalists and constructivists to work together on common ground. Each of these ontologies accepts case study as a research method, however with different perspectives (e.g., experiment versus historical view). At the same time, both of them are skeptical about employing action research. That is because naturalists strive to formulate general laws neutrally so that they can predict the behavior, while constructivists are not so eager at experimenting with new ideas. Hence, critical realism seemed a proper ontology when using action research methods, which, as an ideology, is grounded in a democratic tradition that promotes the importance of context. As a methodology, action research is a method that prescribes different ways of collecting and interpreting the data. From this perspective, every action researcher aims to achieve two objectives: to accumulate data in a scientific and systematic way, and to develop practical solutions to problems experienced by people and companies (Moses and Knutsen 2012).

Studying the way planning is understood and applied calls for investigation of the underlying factors that create the situation where all agree that planning is an important process, but very few companies use time and resources on actually planning their projects. There are many intuitive models recommended by the project management literature as solutions that would lead to a “perfect plan”, however, none of them consider the complexities and realities in today’s projects as discussed in Chapter 2. Understanding these complexities and the way they affect teams planning their projects, as described in detail in Chapter 5, an insider view provided by an action research perspective seemed the best approach as demonstrated in Chapter 4.

For any action researcher, the ethical dimensions become particularly important as explained next.

3.6 Research Ethics

Research ethics refers to the role of the researcher in a research project. As an action researcher, it is imperative to be honest in reporting collected data and results, communicating scientific outcomes, and avoid deceiving colleagues, case companies or other interest organizations (Jakobsen 2014). Consequently, there is a fine line between researching and influencing, as well as growing ownership to the results and the biases such ownership can lead to. Although interviews of multiple sources over longer time-periods reduce this risk, there is no guarantee that the research is not suffering from some bias. Furthermore, my role in this project demands careful interpretation of the data to be published or presented publicly. Hence, the main case company approved, before publishing, any article or report containing their brand. All the other case companies are anonymized. Following the agreements with the case companies, extra care in structuring, analyzing and anonymizing the collected data was applied.

Research ethics for an action researcher can be more demanding - compared with other research methods - due to easier access to sensitive data. Since people were performing their daily tasks when I was collecting data for this research, I had to handle individuals anonymously. Moreover, since each project team applied own tactics to organize and lead project- and planning meetings, describing each of them would be impossible without readers recognizing people and projects. Consequently, the observed types of meetings, both in Vard and other case companies, are summarized in Section 5.10 as a more general description that prevents identifying specific cases. This is discussed in Chapter 6.

3.7 Closing remarks on philosophy of planning

The planning process is undeniably an important management tool that enables and supports project teams in achieving the intended project objectives. The discussion above illustrates the importance of recognizing the fact that project planning is dependent on its participants and the way they understand their tasks within a project. As shown in Chapter 2, most of the traditional project management literature as presented by PMBOK® (2013a) focuses on project planning from a mechanistic perspective while Lean Construction argues for critical realism that emphasizes the need to acknowledge the influence of the social- and communicative aspects of the planning process. Furthermore, the critical realism position is far more appropriate for the planning of design- and engineering activities due to the inherent complexities of these activities, as discussed in Chapter 2.

In this dissertation, it is argued for analyzing project planning from a critical realism ontology that gives a better understanding of the fundamentals of the project planning as a concept. An effective project-planning tool must be based on good coordination of project participants, commitment, efficient communication, while being easily adaptable to changes and variations within the plan. Otherwise, it will not manage to cope with the inherent complexities of design- and engineering activities, as discussed in Chapter 2, nor the market realities of many ETO companies, as illustrated in Chapter 5.

The implications of the aforementioned findings for the choice of research design are presented next.

Chapter 4

Research Design

4 Research design

In this chapter, a description of the research design containing research context, research methods, data collection process, and methods of analysis are presented. The research process can be divided into three distinctive phases: 1) Exploratory phase where the scope of the research and the research questions were defined; 2) Descriptive phase where relevant underlying affiliations and contextual factors were identified, and 3) Synthesis phase that proposes solutions for the identified problems. Before presenting the methods used for conducting this research, a short description of my background is provided since this is relevant to the action research method applied to this dissertation.

4.1 Background and experience

The research domain objectives were chosen due to my interest and experience in logistic and planning. After graduating with a Master in Supply Chain Management at Molde University College, I worked for several years as a researcher in logistics at Møreforsking Molde AS, an affiliation related to the same college. Then I started as a project planner at one of the shipyards within Vard Group, where I was involved in project planning activities while the shipyard was implementing LPP. During this period, the shipyard leaders were preoccupied to develop better planning procedures for the design- and engineering activities, which (at that time) were not included within the total project planning due to the complexity of doing it well. After starting the PhD research project, I remained employed at Vard in a part-time position until the research project was finished. There, I became a member of the improvement team established first at the shipyard level and later at a group level. The mandate of this team was to find solutions that would improve the planning process of design- and engineering activities since there was an increasing problem caused by delayed drawings. All members of the team were well acquainted with my new role as a researcher, and they were willing to discuss the methods and the outcomes of the data collection process. However, as the research progressed, the number of people we worked within our improvement process grew to the hundreds, so it became impractical to explain the details of my research role to all of them. So, we decided to inform about such issues only when relevant for the outcome of the research project or asked by employees in Vard.

During these years, I have been involved in several improvement projects - all of them connected to project planning and project management. When the period of the PhD project was concluded, I returned to Møreforsking Molde AS and here I have got involved mostly in research projects concerning the ETO environment.

Examples of projects I was involved in during the research years:

- Mapping project management challenges in shipbuilding projects
- Introducing lean tools at some of the yards and other companies within the group
- Standardization of the planning process for four of the shipyards located in Norway
- Developing a procedure/manual for project execution strategy within the group
- Implementing LPP at three other ETO companies
- Mapping and analyzing planning processes at two hull yards
- Other activities connected to project planning and management at several other Norwegian ETO companies

Through these projects, I managed to understand the project planning process from different perspectives like operational, economic, social and technical. My roles in these projects were ranging from: consultant, project planner, member of the improvement team and researcher.

Before explaining the methods used in performing this research, a brief explanation on the context of the research is essential.

4.2 Research context

According to Easterby-Smith, Thorpe, and Jackson (2012), good research ideas are rarely derived directly from literature. There are several contextual factors that shape the what, why and how of a research study, among them the researcher's background and experience, academic as well as corporate stakeholders, trends in the field of study and so on. Often, the literature-based endorsement and validation only take place *post hoc* (Easterby-Smith, Thorpe, and Jackson 2012). This research has been no exception, and therefore, some essential contextual factors within which this study was developed are presented in previous chapters and discuss in detail in Chapter 5. As argued in Chapter 3, the particularities of this context makes it best suited to critical realism, and the next question is how. Before answering this question, the units of observation and unit of analysis are introduced.

4.3 Units of observation and unit of analysis

During the research years, I had the possibility to collect data from several companies, but only two of them are described in the case description chapter. Nevertheless, the main units of observation in this research contain the following cases:

- Four Vard outfitting yards located in Norway
- Two Vard hull yards located in Romania
- One 3D modeling Vard subsidiary located in Romania
- Two projects at the basic design subsidiary

Additional units were:

- One design and engineering company located in Norway (Company X)
- Cases from research projects at Møreforsking Molde AS.

All units of observation were ETO companies connected directly to the shipbuilding industry in Norway. Having the opportunity to study more than one company helped me to gain more experience and understanding of the planning challenges within the ETO environment.

The unit of analysis is focused on the planning of design- and engineering activities within the observed projects and companies. The emphasis on the data collection process was on how each of the observed team plans and organizes their project planning meetings. That means the data collected refer to the "meetings" and not to the individuals in the meeting.

There are several types of methods used for research in OM, and the ones used in this dissertation are presented next.

4.4 Methods

The term method denotes the technique used for collecting the empirical data rather than the way we interpret these data. Many researchers argue for a mixture of methods specifically when developing valuable theory from observation of practice. Among the methods used within OM studies are: survey, case study, action research, experiments, etc. However, it is important that a researcher chooses the most suitable method(s) for investigating the research questions (Croom 2009).

The whole PhD project was from the beginning planned as an Action Research (AR) approach, and that resulted in my involvement in several improvement projects at Vard. Now, at the end of this research project, AR is still viewed as the best research method when studying the planning of ETO projects due to the inherent complexities of design and engineering activities in such projects.

However, since the PhD duration was prolonged, I decided to apply the case study method to the projects where AR was no longer an option due to lack of inside perspective, which is mandated by AR. Thus, the answers to RQ3 and RQ4 as well as the argumentation to their hypothesis are provided mainly through the AR approach in Vard, but further validated by the other cases. Not all the proposed research questions could be answered through these two approaches, so a literature review had to be performed in order to provide answers to RQ2 and to partially support the proposed solutions to RQ1, RQ3 and RQ4. So, the three methods used during this research - AR, case study, and literature review - are presented next.

4.4.1 Action Research

This is the main method used during this research due to its epistemological alignment with the realities of project planning in the ETO environment, as explained in Chapter 3. Through AR, the researcher becomes an active participant in the management and resolution of the organizational problems together with the rest of the project team (Croom 2009). AR addresses the subject of research in action where the aim is to both take action and create knowledge or theory about that action contrasting the traditional positivist science that aims at creating knowledge only. Knowledge created through AR is particular, contextual, and out of praxis because data collected through AR is contextually embedded and interpreted (Coughlan and Coghlan 2002). There is a need for more research based on critical realism as a way to link theory and practice in a better way. This view makes AR a method that can enhance the relationship between academics and practitioners Greenwood and Levin (2000).

AR is a wide concept. As a generic term, AR covers many forms of action-oriented research and indicates a vast diversity in theory and practice among action researchers. AR provides a wide choice of methods to be approached when answering research questions (Reason and Bradbury 2008). Westbrook (1995) argues that AR is a type of research that can contribute to overcoming some of the deficiencies identified within the traditional research topics and methods: it has broad relevance for practitioners, it can contribute to theory development, and it can be applied to unstructured and integrative issues. Moreover, "*the grounded, iterative, interventionist nature of AR ensure closeness to the full range of variables in settings where those variables may not emerge all at once*" (Westbrook 1995, p.18). Based on a comprehensive review of publications on AR applied within OM, Coughlan and Coghlan (2002) identified four broad AR characteristics:

1) Research **in** action, rather than research **about** action. This is to underline the idea that AR uses a scientific approach to study social or organizational issues together with company's employees experiencing such issues directly. AR is performed through a cyclical four-step process: planning, taking action, evaluate the action, and propose further action. A conscious and deliberate enactment of the AR circle is the basis for

the validation of the research. The evolution of these steps throughout this research is described in more detail in Chapter 6

2) AR is participative. The members of the team participate actively in the steps presented above as opposed to using case companies as objects of the study.
3) AR is concurrent with action. The aim is to make that action more effective while concurrently building up a body of scientific knowledge
4) AR is both a sequence of events as well as an approach to problem-solving. As a sequence of events, AR implies iterative cycles of gathering data, analyzing that data, planning action, implementing the proposed solution, evaluating it and proposing further action that leads to gathering new data, and so on. As an approach to problem-solving, AR applies the scientific method of fact-finding and experimentation to practical problems requiring action solutions and involving close collaboration and cooperation among the team members. The outcomes of an AR approach are not only the solutions to the immediate problems because in addition to the intended learning outcomes, there are also unintended learning outcomes for both the organization and for the researchers.

AR is an evolving process because it evolves through the unfolding of a series of events as the selected problem is confronted and attempts to solutions are developed by the member of the organization together with the researcher. Performing the cycle of planning, taking action, and evaluating can be anticipated, but cannot be designed or planned in detail in advance. AR is based on the philosophy that the stated scope of the project leads to planning the first action, which is then evaluated. Consequently, the second action cannot be planned until the evaluation of the first action has taken place (Coughlan and Coghlan 2002). This means that implicit to AR lies a sequential approach. However, due to the duration of shipbuilding projects, i.e., 18 to 30 months, this becomes an impractical constraint. So, the approach had to be adjusted to the realities of ETO projects with a relatively long duration. This was achieved through a staggered approach whereby many projects were researched but not in the same phase, allowing us to take the learning from one project into the next project before the projects were fully completed, as discussed in more detail in Chapter 6.

This introduces some epistemological uncertainty that had to be dealt with. Ideally, we should have had the same project specifications, same people, same shipyard, the same type of vessel, but by using a staggered approach, we end up involving different project specifications, different people, different shipyards, and different vessels. This epistemological uncertainty is handled through the introduction of three archetypical meeting approaches, see Chapter 6. I also added a fourth archetype, which describes the ideal case as derived from the literature and practice. This also allows discussions between what is best ideally versus what is achievable in a relatively short period of time. This has implications for future work, as discussed in Chapter 7. By identifying the four archetypes, I achieved some repetitiveness, which is important for the hypotheses testing, but I also eliminated the need for having too accurate information, which many people could have found intrusive in their daily work. Throughout the research years, I interacted with several hundred people, and if I were to explain my research and my research approach to all these people that would have been highly impractical.

There are two types of roles an action researcher can assume during the research period: 1) the expert model where a company asks for expert diagnosis and prescriptive directions; 2) the process consultant model in which the researcher works in a facilitative manner to help the customers inquire into their own issues to develop and implement solutions (Coughlan and Coghlan 2002). As Project Planner, I was involved in improving project outcomes by focusing on planning processes in both production and in design- and engineering activities. I was also part of a team whose scope was to improve and standardize the planning process for design- and engineering activities as well as to develop a project execution strategy that focused on procedures to be followed by the project team. Standardizing and improving the planning process was an iterative procedure, and the team was often challenged by the inherent complexities within such ETO projects. While proposing a solution to one of the problems, the team had to consider many different interdependencies among departments, scheduling-software with other software used within the company, as well as existing reporting requirements. For example, reporting the number of hours used by each team had to be done by the supervisors in a software that had some specific limits when it comes to using a combination of numbers and letters. Hence, our team had to test the proposed solution in several departments, find out how numbers are transferred between that software, the planning software and financial software before developing a new solution that considered all the constraints from the interconnected software. This kind of iterative solution development is a continuous process since new challenges occur from project to project (e.g., customers demanding new types or forms of reports, producing units of a vessel on a different hull yard than the usual one, etc.).

Coughlan and Coghlan (2002) recommend action researchers to use a six steeps process when implementing AR. These steps have also been followed during the research period.

1) Collect the data. The data is collected through several different formal and informal approaches like observations, interviews, and meetings. Observations of the dynamics of the groups, communication patterns, leadership behavior norms, elements of culture, problem-solving and decision making, use of power, interactions with other groups, all

these provide the basis for inquiry into the underlying assumptions and their effects on the work and life of these groups.

2) Data feedback. The action researcher takes the collected data and feeds it to the company system with the scope of making it available for analysis.
3) Data analysis. Company representatives, together with the action researcher, analyze the data. This is based on the assumption that the organization knows what will work and ultimately implement and follow the actions that resulted from the research process.
4) Action planning. Based on the analysis from the previous step, further action is planned. For that, several key questions are recommended: what needs to change? Where in the organization? What types of changes are required? How is a commitment to be built? How is resistance to be managed?
5) Implementation. The company implements the planned actions, which implies making the desired changes and following the agreed plans.
6) Evaluation. This step involves reflecting on the outcome of the proposed actions, both intended and unintended. Evaluation is the key to the learning process because, without it, actions can go on and, regardless of success or failure, errors are proliferated and ineffectiveness and frustration increased.

The evolution of these AR steps is described in Chapter 6, when presenting the findings for the proposed research questions.

The period as an action researcher lasted from 2012 until 2015, when the PhD research project ended. During this period, I was actively participating in project management and project planning meetings at several of the Vard shipyards and at Vard Basic Design while also delivering conference articles and essays as part of the PhD work. In 2014 and 2015, the low oil prices affected the number of new orders and, one of the results was a reduced number of project planning meetings. At the end of the PhD grant, the research approach was extended from AR to case studies. These were ETO companies to which I had access through the research projects organized at Møreforsking Molde AS.

4.4.2 Case study

A relevant definition of case study as a research method is given by Leonard-Barton (1990, p.249), who states that "*A case study is a history of a past or current phenomenon, drawn from multiple sources of evidence. It can include data from direct observations and systematic interviewing as well as from public and private archives. In fact, any fact relevant to the stream* *of events describing the phenomenon is a potential datum in a case study, since context is important*". This definition covers many of the characteristics of case study as a unit of analysis. In a research based on case studies, the researcher can use different cases from the same company to study diverse topics or research the same topic in a different context in the same company (Voss, Tsikriktsis, and Frolich 2002). It is also possible to study the same topic in several different firms. Case studies are a popular type of research, and one of the reasons for this lays in the variety of methods and methodologies that can be applied when constructing case analysis (Croom 2009, Yin 2014).

According to Yin (2014), a case study research should include five elements: 1) Research question(s); 2) Hypothesis or proposition; 3) Unit of analysis; 4) A logic that links the data to the proposed hypothesis; and 5) Criteria for interpreting the findings. All these elements can be found throughout this research. Research questions and hypotheses are defined in Chapter 1 and explained in Chapter 6. The unit of analysis was discussed in Section 4.3, while the logic of argumentation is presented in Section 4.5. The criteria for interpreting the collected data are discussed throughout Chapter 6.

As states earlier, there are three research methods applied in this research. Hence, a brief description of the literature review as a method used for finding answers to RQ2 follows.

4.4.3 Literature review

A semi-structured literature review was conducted during the early years of this research, and the results were presented at the Annual Conference of the International Group for Lean Construction in Oslo, 2014, see (Kjersem and Emblemsvåg 2014). The scope of this literature review was three folded: 1) develop a better understanding of the project planning approaches used by ETO companies, 2) identify state-of-art research on this subject, and 3) identify the need for such research. According to (Karlsson 2009), the purpose of a literature review is: 1) to contribute to updating the research about the existing research gaps, 2) serves to justify the research topic and the methodology applied, and 3) supports the development of skills in the evaluation of the existing knowledge.

Relevant references were collected from databases like Google Scholar, ABI Inform ProQuest, Science Direct, as well as several specific journals such as Journal of Project Management, Journal of Construction Engineering, Journal of Production Planning and Control, Journal of Ship Design and Production, and Journal of Maritime Research. Additional literature, including book chapters, reports, and conference papers was found through the references in the articles. In line with the scope of this research, papers with topics like "project planning," "shipbuilding," "concurrent engineering" or "EPC," "ETO," "design engineering planning" were selected and examined. Papers that were not addressing planning issues were excluded while the remaining papers were categorized according to their relevance for a specific ETO context: shipbuilding, design- and engineering, and construction industry.

The selected papers were carefully analyzed in order to capture concepts, methods, and approaches used for planning ETO projects. The basic assumption was that such projects are difficult to be planned and controlled due to their ETO context. Among the conclusions presented in the literature review paper were these (Kjersem and Emblemsvåg 2014):

- Planning, scheduling and controlling iterative design- and engineering activities in a CE environment with a network-organized project is a scarce subject within project management and lean construction literature
- Both project management and lean construction literature provide a few studies on 3D modeling and its effect on the planning process. While project management literature assumes that measuring such activities can be done in the same way as before (if it was measured before), lean construction literature acknowledges the need for improving LPS for a better adaptation to technology changes
- Preliminary findings of this paper argue that there is a need for a better way of planning, scheduling, and controlling design- and engineering activities. However, finding new solutions must take into consideration the challenges brought by the iterative nature of design- and engineering activities, CE and the way projects are organized, as well as the implementation of 3D modeling tools

Nevertheless, reviewing literature was a continuous process during the whole research period, but as the research progressed, the main role of the literature was to confirm the gaps and eventual validate the findings.

Since the main research problem is inspired by a real-life phenomenon, the logic used for analyzing the topic was abduction, as explained next.

4.5 Logic of argumentation

An essential part of any study is a description of how the researcher builds the logic of the argumentation during the research process. The most common sets of logic are deduction, induction, and abduction. Through a deductive approach, the researcher starts from a general rule and affirms that this rule explains a single case. In other words, the researcher develops propositions from the current theory and test them in the real world. An inductive approach starts with empirical data from several single cases and assumes that a connection that has been observed in all the cases is also generally valid (Alvesson and Sköldberg 2009). The third approach is the abductive logic of argumentation, which is a mixture between the previous methods.

Abduction relies more on refining existing theories than on developing new ones. Through this approach, the researcher successively refines the original frameworks by considering the unanticipated empirical findings and theoretical insights during the process (Dubois and Gadde 2002). Hence, abductive reasoning starts with researchers who observe the real-life phenomenon and initiate a creative, iterative process of systematic combining or theory matching in an attempt to find a possible matching framework or to extend the theory. The difference between the abduction and the other two reasoning methods is that abduction includes the understanding of the empirical data in a theoretical context that needs to be adjusted and refined (Alvesson and Sköldberg 2009). For this research, abduction was an implicit approach since the problem within the industry was already identified, but the theoretical context seemed to lack a proper overview or solution to that.

Within AR, abduction is particularly useful reasoning during the development of the initial solution design (Holmström, Ketokivi, and Hameri 2009), but is also used during other stages as it facilitates a better linking of the research with the context and the knowledge base. This was supported through the literature review, as argued above.

As stated earlier, this research project started with the observations that planning design- and engineering activities was not a successful process, and the team tried to understand why. Both the studied literature and the observed projects agreed that the complexity of these activities required a change in the way the planning meetings should be structured.

The data collection was a complex activity throughout over six years of this study, and in the following, I present a summary of this process.

4.6 Data Collection

In 2014, an economic downturn started within the oil- and gas industry and that affected, among other areas, the investments in new offshore-specialized vessels. There were almost no new contracts for the Norwegian shipyards, and that affected the data collection process as I was studying the planning of the design- and engineering activities and these are performed mostly at the beginning of a new project. Towards the end of 2016, the situation was starting to improve, but the PhD grant ended in 2015. Nevertheless, the data collection continued regularly, until 2016, parallel with the other research projects conducted at Møreforsking Molde.

Data in an AR can be collected through qualitative and quantitative approaches as well as through direct observation, minutes of meetings, documents related to the research subject, questionnaires, interviews, written descriptions of meetings or interviews, and recording of meetings (Bryman and Bell 2011). A variant of direct observation is participant observation when the researcher makes observational reporting while he/she is part of the group being observed. I used all these methods during the research process by being either part of the project team or an observer for other projects. The data collection process started in early 2011 when I started to work within Vard Group and ended late 2016. Because of the epistemological uncertainty introduced in the research due to the relatively long duration of shipbuilding projects, the data was put into the context of the archetypes mentioned earlier in Section 4.4.1. This is also the style used for presenting the research findings.

Among the types of activities I was involved in during the research period are: mapping the design- and detail engineering planning process, lessons learned from the previous project, developing standard planning processes used in standardizing the planning activity within the group, and implementing LPP at other ETO companies. Figure 4-1 is part of the data collection process and illustrates a map of the planning process for design- and engineering activities at Vard. This map was created by a technical coordinator, together with two project planners then presented and discussed together with the improvement team consisting of several other technical coordinators and two project managers. This map was an important element in the decision to take a closer look at the planning meetings, their content, and execution.

Note: The names of each phase and activity are not readable in the figure presented here. However, the figure visualizes the complexities of the detail engineering process within the studied shipbuilding projects. The symbols used in this map follows the recommendations made by Visio as shown on the legend placed on the right side of the figure.

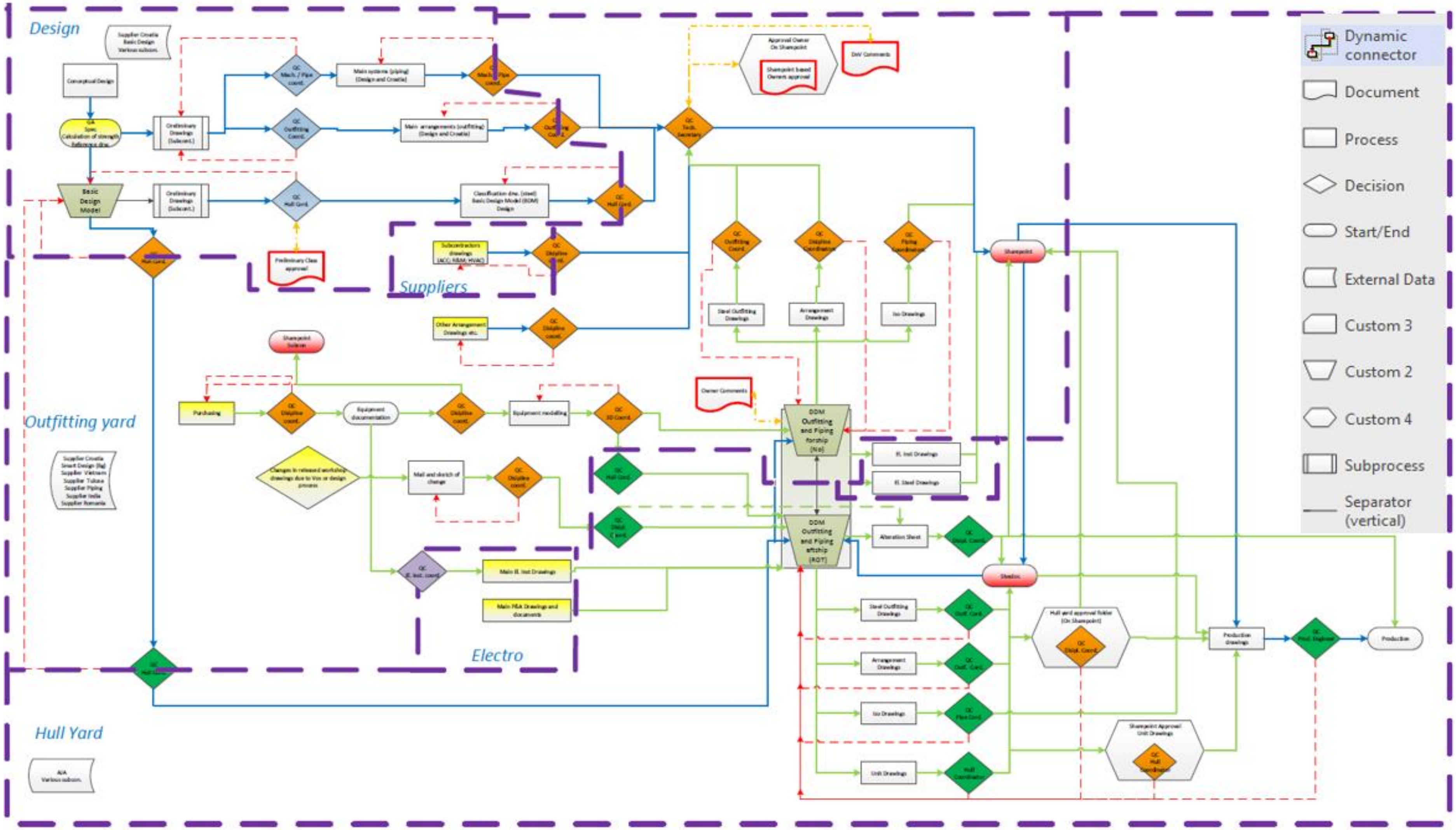

Figure 4-1: Planning design- and engineering activities (Vard documents)

This map evolved throughout the project and it continued to be developed due to continuous improvements applied by the shipyard to its working processes. However, this was one of my first steps in the AR process for this dissertation.

At the beginning of the data collection process, we made a comparison between results from similar vessels with the same design delivered from three different yards. The numbers analyzed were: 1) the total number of hours used per project; 2) hours used for design; 3) hours used on detail engineering; 4) hours used by the production department, 5) delivery precision and 6) administrative expenses. The cost of materials was similar since the ship-owner ordered similar vessels. The analysis showed significant differences between the outcome of the projects despite the same customer and similar vessels. The shipyard where the team was using a proper planning process delivered their vessel on time and within the budget, while the other two delivered late and with significant budget overruns. This comparison was used as a motivational case in the standardization of the project execution strategy and the planning process.

Throughout the research period, I participated in about 388 different meetings – all connected to various project planning issues. About 320 meetings were within Vard Group, while the rest of them were in other ETO companies (shipbuilders or suppliers to the industry). I have also participated in projects that were testing the use of LPP in three other companies, all of them dealing with challenges in planning the design- and engineering activities. Notes taken from these meetings are kept in computer files and in form of more than 1500 handwritten pages. These notes are kept in a chronological way and follow a structure containing:

- Place of the meeting
- Date and time of the meeting
- Participants (number of participants and in small meetings their names)
- Topic (e.g. detail engineering meeting, production meeting, project meeting)
- Resolutions agreed during the meeting
- Own observations

My own observations are written as comments to aspects like: discipline of the meeting (people arriving on time and prepared), leadership style, involvement of the participants, clarity of the agreed issues, focus on the next period activities, records of reasons for non-completion as well as progress measuring issues. Table 4-1 summarizes the number of different meetings as well as interviews and other activities from where I collected the data for this research.

Table 4-1: Summary of data collection

Type of meetings	2011	2012	2013	2014	2015	2016
Production planning meetings	62	59	6	1	1	0
Detail engineering planning meetings	0	17	33	15	16	0
Design planning meetings	0	2	5	13	26	9
Planners meetings	2	2	2	7	6	1
Hull yard meetings	1	10	23	2	1	3
3D modeling meetings	0	0	1	1	3	0
Project execution strategy meetings	0	6	8	16	28	0
Total planning meetings per year	**65**	**96**	**78**	**55**	**81**	**13**
Total planning meetings 2011-2016	**388**					
Informal interviews	7	9	0	3	2	5
Formal interviews	0	0	0	14	3	0
Other meetings and workshops	0	0	0	15	12	16
Total per year	**7**	**9**	**0**	**32**	**17**	**21**
Total 2011-206	**86**					

Due to my role as a project planner, I had the opportunity to discuss planning issues with other planners, engineers, technical coordinators, production coordinators, purchasers, project managers, and other senior managers. In most of these discussions, a recurrent topic was the way different project teams organized planning meetings since each team applied different methods and tools to organize and structure them.

Later, as a researcher at Møreforsking Molde, I had the opportunity to interview other ETO companies within the maritime environment on issues regarding their planning challenges. One of the first questions asked in these projects was: "*do you plan your design- and engineering activities*"? In many cases, the answer was no, and then we would discuss the reasons for this lack of focus on planning. When the answer was yes, I would then ask them to describe the process they use when planning these activities. Often, the description was centered on the software used to create the project plan that soon was outdated, and people did not have the time to update it. The software remained a tool where people could register the number of hours used per each activity. When we discussed the topic of organizing and structuring planning meetings for design- and engineering activities, there were only a few teams that would be familiar with such an approach.

During the research I have also participated in several workshops, conferences, and seminars where project planning was the main topic. One of the workshops organized as a deliverable in another research project was called "the cost of not meeting" where engineers from several ETO companies met to discuss the role of organizing planning meetings. It turned out that only a few of them were preoccupied to organize such meetings, however, all of them emphasized the importance of organizing technical meetings where they could discuss issues regarding features of the final product.

Between 2011 and 2016, I have also conducted both formal and informal interviews with:

- Five senior managers
- Fifteen technical coordinators
- Twenty-two engineers from different discipline and companies
- Ten PM from different companies
- Three purchasers
- Twenty-one planners.

Fourteen formal interviews with engineers at a hull yard were organized within the Next Ship project as part of the mapping process. The research team interviewed engineers working with design, detail engineering and with production drawings as well as some of the leaders from several technical disciplines (structure, piping, electro, etc.). The main topic was planning of own activities, and the way plans are communicated between departments. The research team recorded, transcribed, and later summarized these interviews in a confidential report. The informal interviews were organized with two, sometimes three participants, and the topic was connected to planning issues. Many of these meetings took one hour and were most of the time planned in advance. Yet, in some cases, the meetings were organized *ad-hoc* as that seemed the best solution at the time.

As a project planner, I had access to archived documents, minutes of meetings (MOM), statistics, different memos, and informative documents. Research projects at MFM, indirect observations collected from press materials and workshop participation helped med in understanding how other similar companies deal with the same problem. The process of analyzing the collected data is presented next.

4.7 Data analysis

According to (Karlsson 2009), there are four criteria for evaluation of a research: construct validity, internal validity, external validity, and reliability. Construct validity concerns whether the operational measures used to measure the construct actually measures what they are intended to measure. Given that a study actually measures what it is supposed to measure, the internal validity concerns whether or not the established relationships are explained by the factors included and not by other factors.

External validity means that the results are valid in similar settings outside the studied objects. For example, can the findings in one company be generalized to another company in the same industry? Can findings from companies in one industry be generalized to companies in other industries? If so, how and what are the caveats?

Reliability concerns the extent to which others can repeat the research and achieve similar results. For many researchers, reliability has become the most important criterion for good research. Other criteria for good research quality are: systematic, rigorous, repeatable, and ability to follow. However, the ultimate objective of good research is to be credible and trustworthy (Karlsson 2009). The introduction of the archetypes in this research increases the reliability by increasing the repetitiveness of the types of meetings. This comes to some extent, at the cost of accuracy, but relevance and reliability are more important at this stage. To make this research more accurate implies more time as discussed more in Section 7.5.

Due to a relatively long period of the research project, a large amount of data was collected, and the content shows a clear development from a simpler planning process to a more complex one. This development offers a good historical perspective that explains the decisions taken by the case companies concerning the improvement of their project planning processes. Analyzing the accumulated material, a pattern of project meetings became visible. Correlated with the results of the observed projects, the hypothesis of well-structured planning meetings contributing to better project outcomes occurred. Based on the lean idea of continuous improvement, the fourth type of planning meeting is proposed.

As specified through the data collection section, my role in many of the studied projects was quite active observing, taking notes and discussing them with the improvement team. When appropriate, we discussed these observations and eventual solutions with project managers, technical coordinators, engineers or other planners. During the data analysis, I started to identify the patterns of the attended meetings by following the elements presented in Table 4-2. Identifying these elements was an iterative process since the changes and evolution from the first meetings to the last ones were quite substantial.

Table 4-2: Sample of data structuring and analysis

Date of the meeting	Time frame	Type of meeting	Participants	Topics	Communication	RCA	Prerequisites	Reporting	Observations
10.10.16	10:00 – 12:30	Planning	KKR, XXX	Planning	Open Good skype connections	No	No	Yes	People were prepared
15.10.16	09:00 - 10:00	Planning and technical	XXX KKR	Technical issues	Use a lot of time in connecting Trust issues	No	No	No	Blaming culture

These results had to be validated both internally and externally. The internal validity is accomplished by confirming with the case companies that the scope of this research was achieved. Projects, where engineers applied structured planning meetings delivered better results is also a confirmation of the internal validity. External validity is accomplished by comparing the findings with the existing literature. Several references have been used to support the findings presented in this research. The literature on lean construction identified similar challenges within that specific industry, and they work with several types of solutions. Yet, many of these solutions treat only one or two of the challenges identified when planning design- and engineering activities in ETO projects.

The reliability of the collected data and their interpretation is achieved by a large amount of data repeating the same issues and the fact that many other companies have signalized similar problems, as shown in Chapter 5.

Even though I was employed as a Project Planner, and I have been relatively closely involved in improving planning processes, I tried to maintain some objectivity during the data collection to avoid being biased. My background as a researcher both before and after the Project Planner job was also a support in trying to stay unbiased. However, parts of the argumentation used in this dissertation are influenced by my subjective interpretation of the data and the context of the research. As a practitioner, I might be biased in interpreting the theories behind project planning and being aware of that, I have tried always to find research that helped balance my ideas.

4.8 Linking research questions, methods and outcomes

The type of research questions and methods applied to this research was influenced by the challenges identified within the ETO project planning practices as well as by the availability of previous research on the subject. According to Edmondson and McManus (2007), when literature on a subject is scarce, exploratory research based on qualitative data is a common approach, while explanatory research based on quantitative data is more common when the maturity of the research on the subject increases. The same authors argue that there is a connection between the type of data and the maturity of a theory, as presented in Figure 4-2.

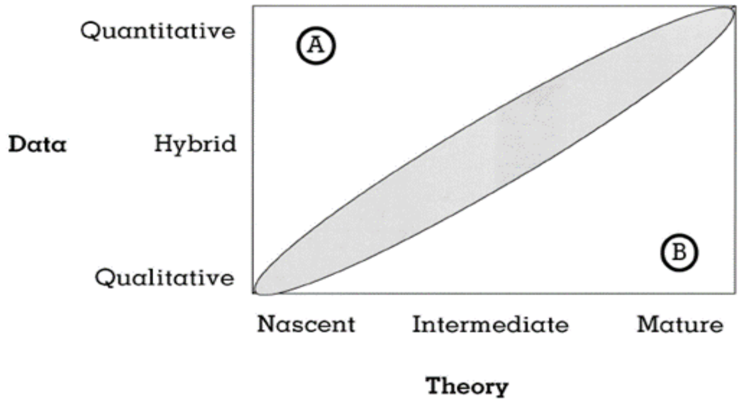

Figure 4-2: Methodological fit (Edmondson and McManus 2007)

However, this connection is not intended as a rigid rule, but as guidelines that help to clarify how the choice of methods can improve or reduce the ability to address certain research questions (Edmondson and McManus 2007).

This research fulfills the methodological fit of the overall criteria to ensure the quality of the research. Indeed, project planning has been developed mainly for production activities where planning was performed by planners using different software systems, and using these in ETO proved to be challenging, especially for design- and engineering activities. Thus, it seems logical to assume that project planning in the ETO context is a “nascent theory” that lacks an adequate theoretical foundation.

This research was organized around one main research question and three sub-questions as described in Chapter 1. Table 4-3 presents methods and outcomes for each of the research questions and is inspired from (Mello 2015).

Table 4-3: Research questions, methods and outcome

Research Questions (RQ)	Methods	Outcome
RQ1: *How can we improve the project planning process in ETO projects?*	AR Literature review Multiple case studies	Proposal on approaches that can improve the planning process in ETO
RQ2: *What are the main challenges of design and engineering planning, in general, and how can these be handled?*	Literature review AR	Identified the challenges that affect the project planning process in ETO projects
RQ3: *What planning meeting structure produces better outcome?*	AR Multiple case studies	Categorization of planning meetings to allow testing via comparison
RQ3: *Apart from meeting structure, what other elements are important to ensure the best possible communication and interaction between project participants to the benefit of the project outcome?*	AR Multiple case studies	Elements that can improve project planning meetings identified via comparison

As stated above, due to unexpected events in the shipbuilding market, the research went through several adjustments to the circumstances, but the outcome is still valid.

4.9 Research process

Organizing the research as a monography gives the researcher the possibility to follow a line of thoughts throughout the research and create a good sequence of the whole process. Karlsson (2009), state that a researcher has to explore before s/he gains the ability to describe the knowledge, identify the components before establishing connections among them, and understand the relations among the components before predicting their effects.

One of the major challenges during this research was to handle the increasing organizational complexity of shipbuilding projects as Vard implemented new approaches to managing their projects. Another challenge in most of the studied ETO companies was the high staff turnover as many of the employees either changed their positions within the company or left the company while improvement activities were started. In some cases, the employees that changed their position within the company got involved in new types of processes and their connection with the previous position diminished. A different type of staff turnover was among project managers and engineers working on a project only for a short period and then moving on to another project at another location. It implied that new people coming in the project did not have the same training and background, so many of the already started improvements had to be reiterated. That takes time, and it added complexity to my research. Several of the companies dealing with such challenges started to ask for training programs that would ensure a continuity of their improvement process when the staff turnover is high.

Mello (2015), who studied coordination in shipbuilding projects, identified a list of challenges that affect research projects in ETO environments. Table 4-4 depicts these challenges and they are valid for most of the researchers who study this industry. These reflections confirm again the inherent complexity of the shipbuilding context.

Table 4-4: Reflections on the research process adapted from (Mello 2015)

Characteristics	**Challenges**
Low availability of previous research	*It was more difficult to establish a solid theoretical basis*
Customer-specific projects	*It posed difficulties to replicate and cross validate results*
Deep product structure	*It required more time to comprehend the product and its main components*
High interdependence between activities	*It was more difficult to understand how the some of the other organizations operate*
Low level of formalization of activities	*It increased the challenges to streamline the process workflow*
Project data/documentation/ records distributed in various departments	*It increased the number of people involved and demands a higher number of interviews to contextualize how problems occur*
Human-based system (project situation)	*The perceptions about the problems varied from person to person and from organization to organization*
Staff turnover	*It increased the effort to obtain and validate data*

The challenges provided in Table 4-4 have also influenced my research project. That is because each vessel is a complex project with many variables and uncertainties. To understand the challenges engineers deal with when planning their activities was a daunting task that required a considerable amount of time since each team uses own approaches. Nevertheless, when embarking on AR, the researcher should be interested in learning and adapting to the realities within the specific industry, not just blindly follow a research protocol. The challenges presented in Table 4-4 became even more demanding due to the turn of the industry. But, with more time than planned, I believe that I managed to land this challenge well in this research.

4.10 Discussion of the chosen methods

All research methods have their strengths and weaknesses. Hence, combining several methods was a way to minimize potential biases during the data collection process. The AR was useful and allowed me to understand the context of the research and its challenges in a more detailed way compared with other research methods. AR was an opportunity for discussing planning issues with practitioners and other researchers, both providing valuable knowledge, new insights and helped examine the hypotheses. Some of the weaknesses in using AR approach are: 1) the generalization of the results can be limited, 2) it is time-consuming, and 3) a large amount of collected data can be difficult to structure and validate.

An AR approach was followed in this research, however, there are some case-specific elements that add complexity:

- Relatively long project duration of each project in the case companies prevent the sequential approach typically applied in AR see Section 4.4.1. This has been handled by using a staggered approach where I studied a portfolio of projects, see Chapter 5
- The topic at hand – project planning meetings – invites to relatively detailed analysis involving individuals. However, due to research ethics, this is not a sound research approach so I have chosen to not provide data at a lower level than the meeting
- A consequence of the two aforementioned elements is that the epistemological uncertainty in the research increases. To handle that, I have introduced three archetypes to allow effective categorization and some repetitiveness of the data. That facilitates the testing of hypotheses which is presented in Chapter 6

This research design is therefore based on AR, but adjusted to the identified challenges within the studied companies. I believe, however, that due to the large sample of meetings (388) these issues are taken care of to such an extent that they reduce the uncertainty to an acceptable level concerning the presented results.

Multiple case studies is a method that increased the potential for generalization of the results and facilitated the formulation of the factors affecting the project planning process in the ETO environment. This method was also useful in the analysis of the results since it made possible a comparison between several case companies. One of the weaknesses of this method is the amount of available data that is not the same for each of the studied companies and that each project is customer-specific, limiting the possibility of replication.

After presenting both the theoretical and methodological aspects of this research, it is time to introduce some of the cases studied during the PhD period.

Chapter 5

Case description

5 Case description

"A ship in a harbor is safe, but that's not what the ships are built for"

Dale Carnegie

The data collected for this research is mainly from the offshore specialized vessels market. However, due to the recent advances in the industry, relevant information from cruise projects was added toward the end of the research period. Vard Group AS was the main case company for the first three years of this research and is described next. There were several other ETO companies observed during the PhD period, but only one of them is briefly described (in an anonymized way) towards the end of this chapter. The scope of these descriptions is to present the context of the research and the observed project planning methods.

5.1 Vard Group AS

Vard Group AS (hereafter Vard[3]) is a Norwegian shipbuilding company owned by Fincantieri Oil & Gas S.p.A, (hereafter Fincantieri) a wholly-owned subsidiary of FINCANTIERI S.p.A., one of world's largest shipbuilding group. Vard headquarter is located in Ålesund, a town on the Norwegian west coast, a region renowned for its strong maritime cluster and its long shipbuilding traditions.

Vard is a typical ETO shipbuilding company that over the years has built a strong reputation within the maritime industry by delivering highly customized products like: platform supply vessels (PSV), anchor handling tug supply vessels (AHT), offshore subsea construction vessels (OSCV), offshore patrol vessels, fishing and aquaculture vessels, as well as other specialized vessels. In their quest to adapt to market challenges, Vard started in 2016 to also build small passenger vessels for arctic waters and other specific markets.

Vard designs and builds most of these vessels in close collaboration with its customers as most of them are interested in tailor-made solutions that reduce fuel consumption, increase safety and reliability, rationalize the deck area and optimizes the operational time. Producing those vessels can take 12 to 36 months from design to delivery depending on the vessels' size and complexity. Upon customer request, Vard also sells design to be built by other shipbuilders or builds design provided by other companies (e.g., UT design from Rolls-Royce Marine, Skipsteknisk, Marin Teknik, etc.).

[3] The name Vard derives from the Norwegian word "*varde*" that describes a small tower of stones, which, since Viking age, were used as navigation marks along the coast.

Most ship-owners have a set of requirements established in collaboration with their own customers or the contractors of the vessel. This typically results in highly customized vessels. Furthermore, due to technological development, most suppliers frequently offer newer and improved products, which means that, most of the time, fitting these new products on a vessel requires different engineering solutions from vessel to vessel. Hence, a large number of the components and equipment installed on the vessels are ETO as well.

Another relevant trend in the market is that ship-owners wish to fit as much equipment as possible on each vessel, turning it into a multi-purpose vessel (e.g., a PSV can be used for some small construction jobs) because it gives more revenue flexibility in today's demanding and volatile market. This is also one of the reasons that each ship-owner is interested in following each project from the design phase and in keeping some solutions open as long as possible or until a final scope is decided. This flexibility is a major competitive advantage offered by many Norwegian shipbuilders.

However, the competition among shipbuilders is tough, and the profit margins have diminished radically during the years with low oil prices. Likewise, the increasing complexity of the ships, new environmental rules and regulations, as well as new safety demands, are important factors that influence the results in a shipbuilding project. Vard, like many other similar companies, has increasingly been challenged by a demand for more cost-effective solutions, as their customers are also pushed to deliver lower prices for their services.

5.2 Organization of the group

Vard operates on a global market owning subsidiaries in Romania, Singapore, Croatia, India, Canada, Brazil, Vietnam, Italy, Chile, UK, Poland, Latvia, Estonia, USA and several locations in Norway. Nine of these subsidiaries are shipyards located on different parts of the world: Norway, Romania, Vietnam and Brazil. The other subsidiaries are specialized in developing power and automation systems, deck-handling equipment, accommodation solutions, as well as on providing design and engineering services to the global maritime industry. Vard employs roughly 9,000 people and follows an organizational structure where each subsidiary is a small profit center within the group. Figure 5-1 illustrates all profit centers (with own subsidiaries) and, for some of them, the shared percent (as per January 2017) owned by Vard in each of these profit centers. Until 2010, each shipyard or subsidiary maintained a certain autonomy regarding sale, project management, project organization as well as project planning and control, but that was changed when the company started its improvement strategy that implies more standardized management processes.

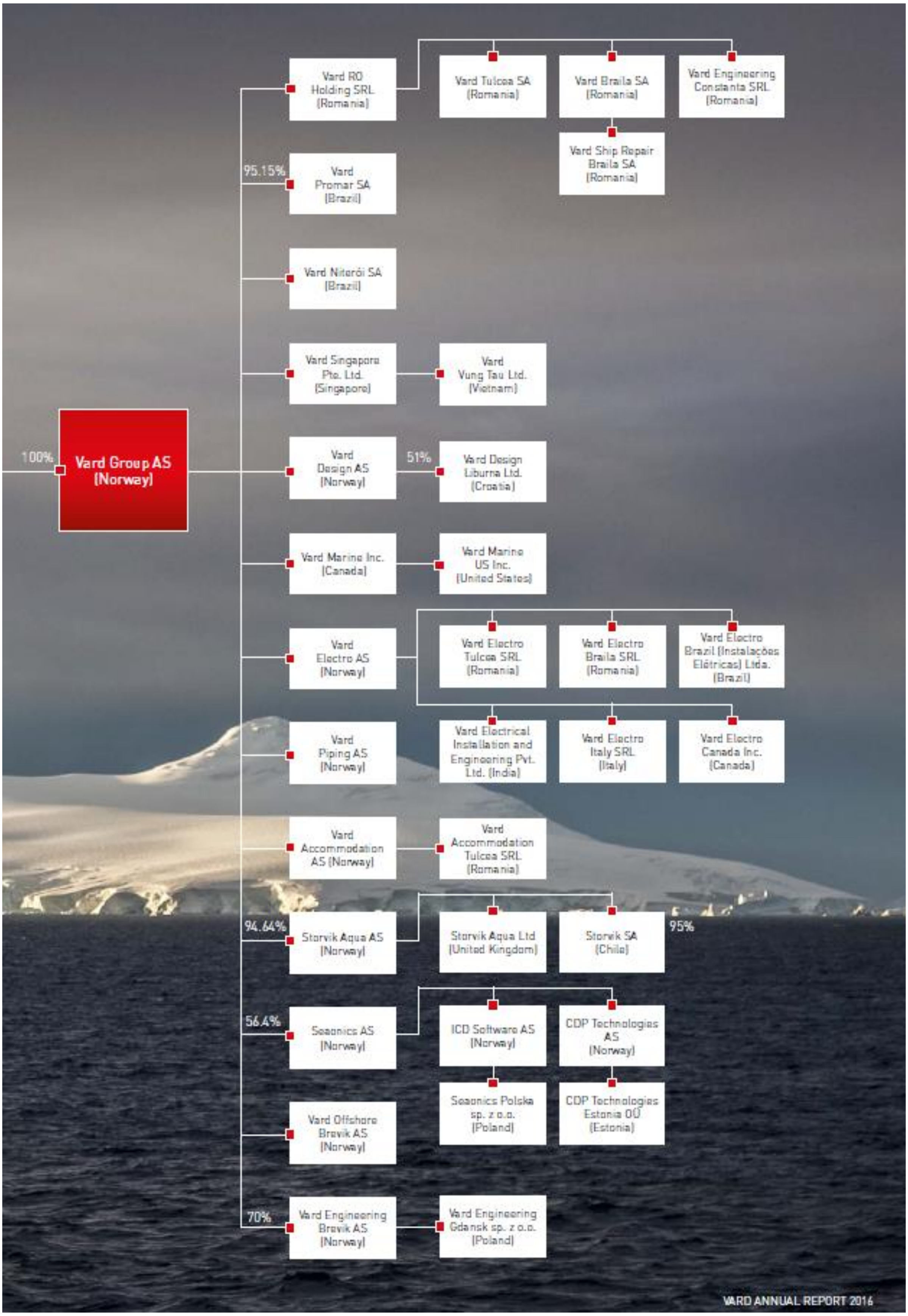

Figure 5-1 Shipyards and companies owned by Vard Group AS (Vard 2016)

Typically, Vard has made profits of 10-12 billion NOK revenue from an order book of roughly twice the size. In later years, though, due to the downturn in oil- and gas prices, the financials of Vard have been affected hard. However, to become more cost-effective, the group decided to develop and implement more standardized working methodologies setting in motion a wide-ranging continuous improvement process. They started with several technological investments (automation) at some of the shipyards and continued with improving methodologies for most of their working process. Among the results of this improving process was a standardized project execution strategy that included, among other issues, a planning approach for design- and engineering activities. These strategies are described next.

5.3 Project execution strategy (PES)

PES is about management tactics applied by Vard to manage, plan, control, and complete each shipbuilding project. Since not all project phases are completed at the shipyard responsible for delivering the vessel, PES is divided into phases executed by different internal or external suppliers. The main phases in a shipbuilding project are: concept design, negotiation, basic design, detail engineering, fabrication, outfitting, and commissioning & delivery. These phases are described in more detail later in this chapter. As part of the PES, each project team establishes at the beginning of the project which department or supplier will complete each of the project phases and under which terms.

Due to factors like location, labor cost, as well as other countries' rules and regulations, Vard applies two different PES for the vessels built at its shipyards. The strategy applied by Vietnam and Brazil shipyards is to build the whole vessel locally. That is because they have enough space and good logistics around the shipyards to ensure a good flow of the production capacity. This approach gives Project Manager (PM) the possibility of more detailed control of the operations and processes during the project execution. Figure 5-2 depicts the PES for these shipyards, but it is not subject of this research due to space and time limitations.

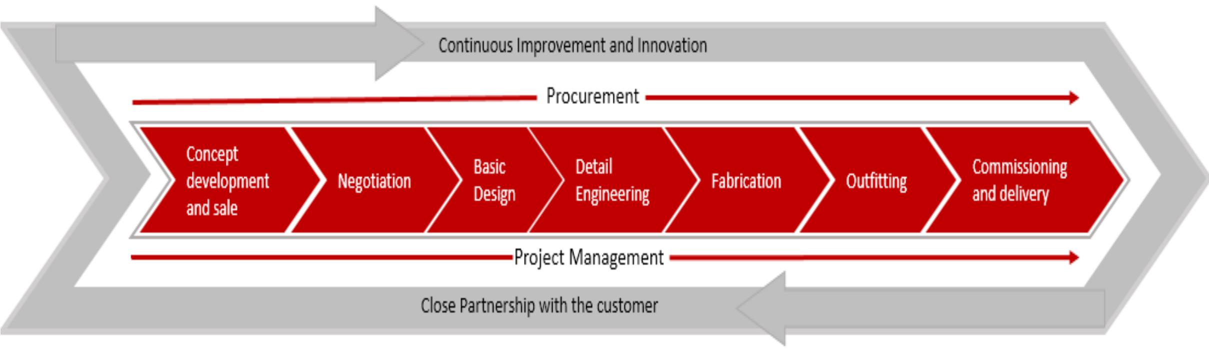

Figure 5-2: Project execution strategies at Vard, adapted from (Vard 2014)

The other type of PES is to build the hull at a Romanian shipyard and, after concluding a pre-outfitting phase, tow the hull to Norway for the rest of the outfitting, testing, commissioning and delivery phases. Figure 5-3 presents the project phases of this RoNo[4] strategy where the following factors have a significant influence on the project management process.

- Each project phase is allocated for execution to an entity that is in fact a profit center
- The hull is purchased from the hull yard through detailed contractual agreements
- The project work is interrupted by the towing phase which take from four to ten weeks
- The outfitting phase is completed at a Norwegian shipyard
- Project plans are divided in more phases (each entity creates own plans)

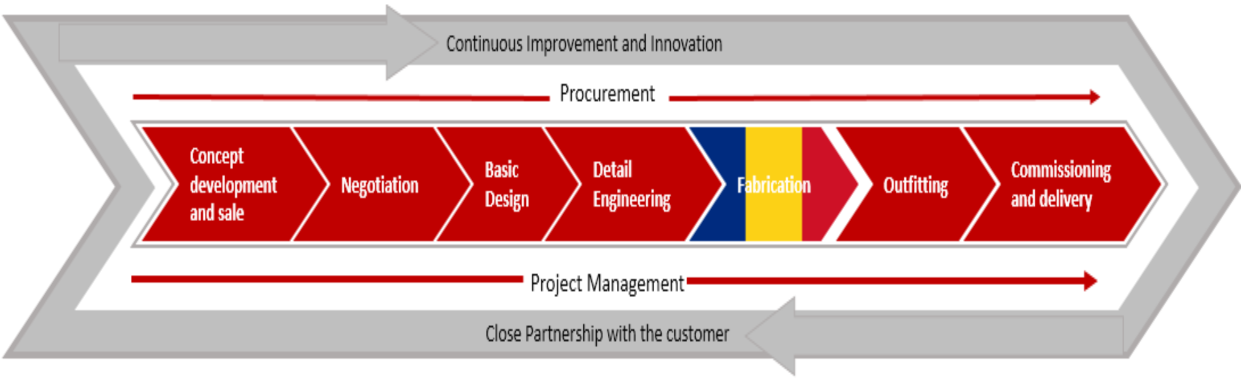

Figure 5-3: Project execution strategies at Vard adapted from (Vard 2014)

These two PES affect somewhat different the managing methods applied at these shipyards, but such aspects are not analyzed in this dissertation. The cases studied in this research are from the RoNo type of projects, and the data are collected from several Vard entities both in Norway and Romania. However, due to remarkable results in implementing LPP at Vard Vietnam, some references to this shipyard are used as examples. Since RoNo strategy is part of the context for this research, some of its most relevant aspects are presented next.

5.4 RoNo strategy

The shipbuilding process described in this chapter is, to a certain extent specific Vard, but at the same time, it can be generalized for many other Norwegian and European shipbuilders. The differences lay on the approaches each company chooses for executing each of these project phases as described in (Kjersem and Jünge 2016).

[4] Abbreviation from Romania – Norway

The concept development and sale phase is a common phase in every shipbuilding project. It can be triggered either by the customer or by the shipbuilding companies. Some customers may require vessels based on concepts already developed by shipbuilders or ship designers, while others require entirely new concepts based on their own requirements. Irrespectively of approach, the customer starts the negotiations by selecting the type of vessel to be produced. During the negotiation phase, the ship-owner, in close collaboration with the sales team, establish issues like vessels' purpose and main features. If the ship-owner has already contracted the vessel to a specific customer, this customer may have a central role in determining some of the attributes of the new vessel.

The negotiation between the ship-owner and the bidding shipbuilders is a phase that can take from several weeks to a year or even more and depends on the evolution of a specific market or customer requirements. During the negotiation phase, the participants define the specifications of the final product and create a document named "Building Specification" (hereafter Spec.). This document contains a description of the particularities and performances that each component, and system fitted on the vessel must achieve in order to be approved and accepted by the ship-owner. The Spec, together with a preliminary project plan, also established during the negotiation phase, are key documents at the contract-signing stage. The project plan displays the whole duration of the project and contains milestones as well as some of the most important work packages for each discipline (steel, piping, electro, etc.). This plan is what project team refers to as "sale plan" and is usually transformed in a project plan with new details once the contract is signed. It should be mentioned here that in some contracts, the EVM functionality of the project plan is a prerequisite for winning the contract.

Vard Basic Design (VBD) is in charge of the basic design phase, however, they participate also in the negotiation phase by delivering drawings and 3D models that help customers visualize features of the final product so that they make informed decisions. VBD starts the project before the contract yard[5] (the shipyard that is responsible for delivering the project) and has an important role in establishing the cost of the whole project. Hence, contract signing is a major milestone of a project since, by this time, main responsibilities are assigned, and the contract yard takes over the lead of the whole project.

In the RoNo strategy, PM must deal with projects divided into phases performed by many different profit centers located at several places (e.g., design in Norway, hull yard in Romania, 3D modeling team in Croatia or Vietnam, etc.). This strategy is also labeled as phase-based

[5] Contract yard and outfitting yard terms are used interchangeably in this dissertation due to the recent change in Vard's policy which establishes a clearer role for the outfitting yard by calling it contract yard.

project management (Ciobanu and Neupane 2008) and implies that each profit center assigns a PM and own project organization to manage and deliver their part within the whole project. Consequently, the main PM (located at the contract yard) must receive status updates on each phase from the project managers located at each participating organization. That means the level of communication usually stops at the project managers' level located at each of these profit centers. Throughout this research, the PM abbreviation defines the main project manager that has the responsibility to deliver the complete vessel.

During the basic design phase, VBD delivers class drawings and the corresponding 3D model to the contract yard and to the suppliers that need such information to start their own procurement and production processes (especially for items that are ETO or need long lead-time to be produced). Basic design phase has an important role throughout the PES. During this phase, the most important features of the vessel are decided and approved by the customer, the classification society (where applicable) and other relevant authorities. The procurement team, who must find the right equipment and acquire the technical documentation within the established timeframe, also makes an important contribution to an effective basic design phase. Hence, this is the phase where the major costs for the whole project are committed, so close cooperation is necessary to save costs.

To improve the collaboration between basic design and procurement, Vard decided to move several procurement activities at VBD who is now responsible for defining specific features for some of the main equipment in direct collaboration with the respective suppliers. This facilitates a closer and faster information exchange process between engineers involved in the project, equipment suppliers, and the contract yard. Procurement activities have a huge impact affecting not only the cost of a project, but also many decisions taken by design and detail engineering teams. Actions taken during this phase affect both the price of the project as well as the delivery schedule and set the frame for the next phase: detail engineering.

The contract yard is responsible for the completion of the detail engineering phase. The Technical Coordinator[6] (TC), located in the contract yard, is assigned a team of discipline coordinators (engineers specialized in e.g., steel, piping, electro, 3D, etc.) and each one of them coordinates in turn teams of engineers who produce 2D drawings and 3D modeling. Not all engineers are located at the contract yard. They can be located at subsidiaries in Norway, Croatia, Romania, Bulgaria, Vietnam, India, USA, and Canada depending on the workload both at the contract yard and at the companies delivering this kind of service. As soon as

[6] This role has several other names, depending on each company's internal vocabulary (e.g. lead engineer or technical leader, etc.)

drawings and 3D models are approved for production, another team of engineers (located at the hull yard) transforms these into production drawings containing all details needed for the production site. Transforming models and drawings into production drawings is a process that can take from two-three days to two weeks depending on the level of details required for each activity and on the internal approval process organized by the hull yard.

The hull production process depends on the delivery of the right drawings. This phase contains activities like hull production and pre-outfitting as well as some outfitting actions involving complex logistics and planning activities. Close collaboration with the contract yard is also a key factor in a successful hull production phase. The contract yard sends teams of engineers and discipline coordinators periodically to the hull yard to follow the fabrication process and stay informed on the evolution of the project. At the end of the hull production phase, a specialized team performs a thorough inspection of the vessel establishing the actions needed after the towing period. This information is used for planning the activities at the contract yard so that the discipline coordinators are ready with the necessary resources and materials when the vessel arrives there. The towing period is planned to take four weeks, however, it can take over ten weeks when the weather conditions are unfavorable.

The outfitting phase starts with an inspection of the vessels during which the Norwegian team asses the status of the hull after the towing period. Eventual transportation damages are evaluated, and actions for repairing these are introduced within the planned schedule. The contract yard completes the rest of the outfitting activities, and within three to five months, they start the commissioning phase which is another particularly important milestone of the shipbuilding process. This phase implies a dynamic planning procedure during which representatives from the customer, the contract yard, and other relevant authorities or equipment suppliers test each component and system on the vessel. The vessel can be delivered only after all tests are accepted and approved and all pending issues are resolved. Each vessel has a warranty period of one year.

This description of the RoNo type of PES is not meant to be exhaustive and lacks a detailed description of the inherent complexity in many of Vard's shipbuilding projects. Most of the relevant aspects are however, discussed throughout this chapter.

The elements within the described PES are developed following recommendations from traditional project management literature. As shown in Chapter 2, there are several ways of organizing projects: line, projects, matrix, and network organized projects (Gray and Larson 2006). At Vard, most of the projects have become a network of organizations that collaborate for delivering each ETO product. The way these network organized projects function at the case company is described next.

5.5 Project organizations at Vard

Technological development, together with the outsourcing of both project phases and work packages, resulted in an important change in the way shipbuilding projects are organized today. From simple structures where own employees were planning and controlling each detail of the entire project, a project organization is nowadays counting several participating organizations being in charge of project phases or work packages. Consequently, the project organization became a network of organizations participating in designing and delivering a customized vessel. Figure 5-4 provides a simplified visualization of a network-organized project.

Figure 5-4: Network organized projects

Each of the organizations (e.g., hull yard or accommodation) depicted here has their own project manager and a project team responsible for each specific project. However, since every company has a portfolio of other commitments, people can be involved in several projects at the same time. Thus, the information travels now through longer and more complex channels than in projects delivered just a few years ago, making communication more difficult. Hence, having to deal with such complex organizations, a new approach to project management is required, yet, there are no recommendations to such an approach within the studied literature, as shown in Chapter 2. In some of the most successful Vard projects, the project team invested a significant amount of time in the planning process and used structured planning meetings to achieve good communication and commitment to the project plan among the participating organizations. That was one of the starting points of this research.

This view on network-organized projects is what we see at the whole project level. Yet, this reality is not addressed within the traditional project management literature which describes only three types of project organizations (line-, project-, and matrix organizations) as shown in Section 2.2.3. Most shipyards have functional line departments like project management, technical/ engineering, procurement, safety and production. However, at a lower level (the level of each participating organization) companies are usually matrix organized where the line organization provides resources to each project. Each participating company creates own project organization that contains a technical part and a production part. Figure 5-5 depicts a project organization created at one of the shipyards within the group.

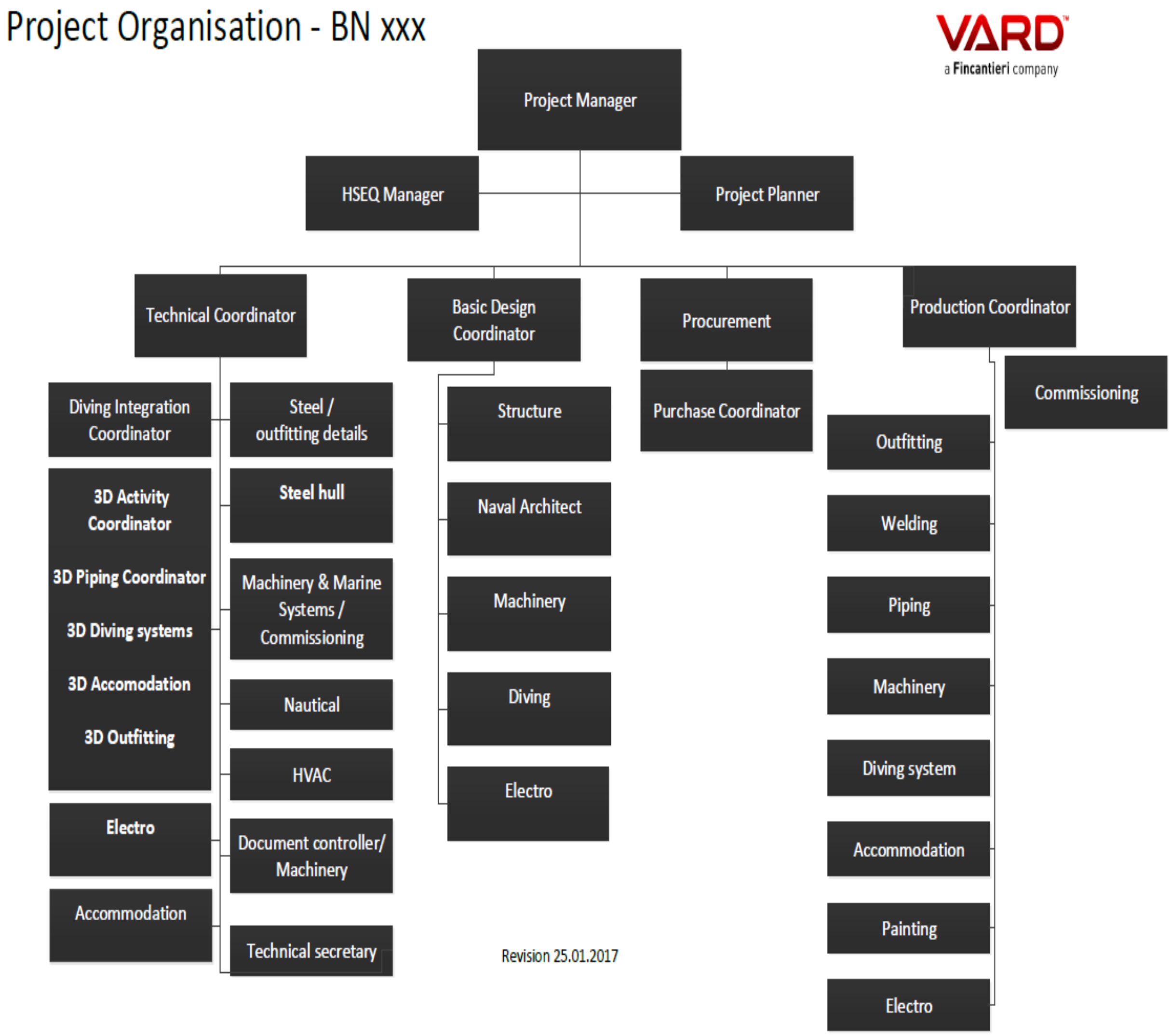

Figure 5-5: Project organization (Vard documents)

On the left side are the HSEQ manager, the TC and the allocated discipline coordinators (from the technical department), while on the right side are the project planner, production coordinator as well as the allocated discipline coordinators (from the production department). Procurement coordinators are represented in the middle of the organization, right under PM.

The structure of each project organizations differs from company to company because each one of them has own preferred approaches to project management. Most project organizations contain between five to thirty-five/forty employees allocated to a project. Figure 5-6 depicts a different type of project organization with different departments and project team leaders. The point of showing these different project organizations is to visualize the differences in defining and structuring such teams since this has a significant influence on the planning process.

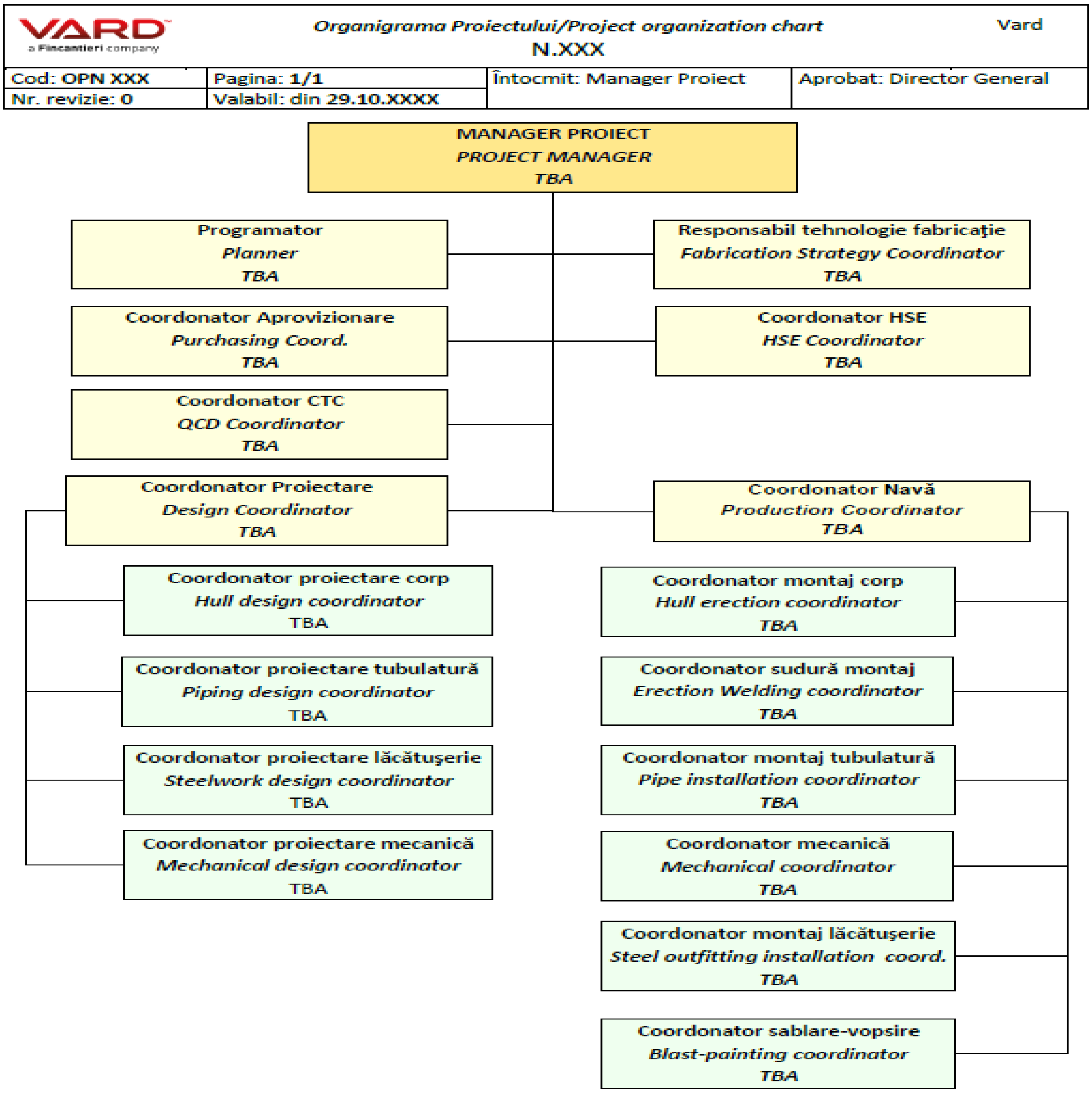

Figure 5-6: A different type of project organization (Vard documents)

There is no “best way” of organizing projects within ETO companies and many of them have adapted the recommendations from traditional project management to own needs. Typically, each of the participating organizations has its own approach to both the planning process and the systems applied to scheduling and reporting. So, getting a clear status of the whole project is a demanding task, especially because PM cannot verify the accuracy of the received data. As stated in Chapter 2, no software is able to deal with all these complexities, so there is a need to identify a better approach to improving the planning process. Hence, the focus on improving the planning process through organizing project planning meetings in a more structured way. The next section provides a description of the planning process first for the whole project, then for the design- and engineering activities.

5.6 Planning Process

Planning a new project starts during the negotiation phase when the parts must agree on major milestones of the project where the focus is on the delivery date. Another important issue discussed at this stage, are the milestones related to the payment plan, usually divided in percent of the total sum. The division of these percent differs from customer to customer, however, the milestones are the same. Achieving a milestone releases a certain amount of money to the yard, with the largest sum at the delivery phase. The milestones are:

- Contract signing
- Start steel cutting
- Keel laying
- Launching
- Delivery of the vessel

These dates have a significant role in the project execution and influence the decision process especially at the hull yard who plans own activities around these dates. The planning process must, therefore, consider these milestones when planning other parts of the project.

As the negotiation process between the ship-owner and the shipbuilder advances, the lead planer (located at VBD) creates the sale plan based on the information received from the sales team. This plan establishes deliveries of the main phases of the project and covers important milestones during the project execution from the contract award to the delivery of the vessel. As stated earlier, the sale plan is part of the contractual documentation between the ship-owner and Vard, establishing the ground for further planning of the project.

At contract signing, the PM, takes over the responsibility for the whole project. One of the first actions is to establish the PES where the four main project participants (basic design, contract yard, hull yard, and electro) start negotiating the milestones within each project phase. A kick-off meeting is organized two-three weeks after signing the contract. There, representatives from Basic Design, Contract Yard, Hull Yard, and other relevant project participants meet for discussing the master plan of the project. The scope of the meeting is to achieve a consensus on the important delivery dates and create the first baseline of the project. A baseline depicts the preliminary budget and delivery dates of a project and serves for reporting and analysis of the actual data compared with the planned ones, an important element when using EVM.

After the kick-off meeting, each participant develops further their own detailed plans and schedules within the agreed frames. At VBD, planning activities have already been started (they often start before the contract is signed) because each project contains issues that might take a long time to solve (e.g., ordering equipment that might take a long time to be fabricated, getting approvals from the customer or from the classification societies, etc.). VBD has own project manager responsible for the planning and delivery of the allocated work packages. The lead planner is responsible for creating several schedules like Portfolio Schedule, VBD Schedule, Procurement Schedule and Milestone Pool and updates these plans until most of VBD's deliveries are completed. Through a gradual process, some of these schedules are transferred to the project planner located at the contract yard. Based on the information from the VBD plan, the TC from the contract yard together with the project planner creates a preliminary schedule for the detail engineering activities and connect these with procurement activities and hull production schedule. The project planner delivers information to the planners located at the hull yard and other relevant participants in the project. Each of these entities uses the information to create their own plans and schedules while considering the total workload on own portfolio of projects. Planners from all relevant participating organizations report progress to the project planner weekly.

The lead planner facilitates making the first preliminary delivery schedule. When creating this schedule, the lead planner asks for information from the concept and basic design engineers, portfolio plan (contains all shipyards within the group), sale plan, procurement schedule, and other appropriate data. The lead planner also facilitates the procurement schedule that contains major components and equipment whose documentation is important for the VBD's scope of work in the project. When the class drawings are approved, the project planner takes over the project scheduling. However, due to time pressure, many of the detail engineering and procurement activities within the project have already been started while basic design was working on the class drawings. The project planner has already created a preliminary master plan where durations and budgets are adjusted from previous, similar vessels. This plan is sent to all relevant project participants for comments and revisions before the kick-off meeting. The agreement achieved at the end of this meeting serves as a preliminary baseline.

Figure 5-9 depicts some of the planners involved in a project as well as some of the schedules they create while completing their allocated work packages. In most cases, discipline coordinators from both design, detail engineering, production, and outfitting deliver the information each planner needs for creating the plans and schedules for every project phase. In addition, representatives from all relevant suppliers send information about their activities to PM or TC, who establish where this info fits in the project plan. Discipline coordinators are responsible for sending updated information to the project planner. In other words, discipline coordinators plan and report, while the planner schedules and analyzes the data collected from discipline coordinators and supervisors. This is a good exemplification of the division between planning and scheduling as defined by Mubarak (2010) and by Baldwin and Bordoli (2014) as explained in Chapter 2.

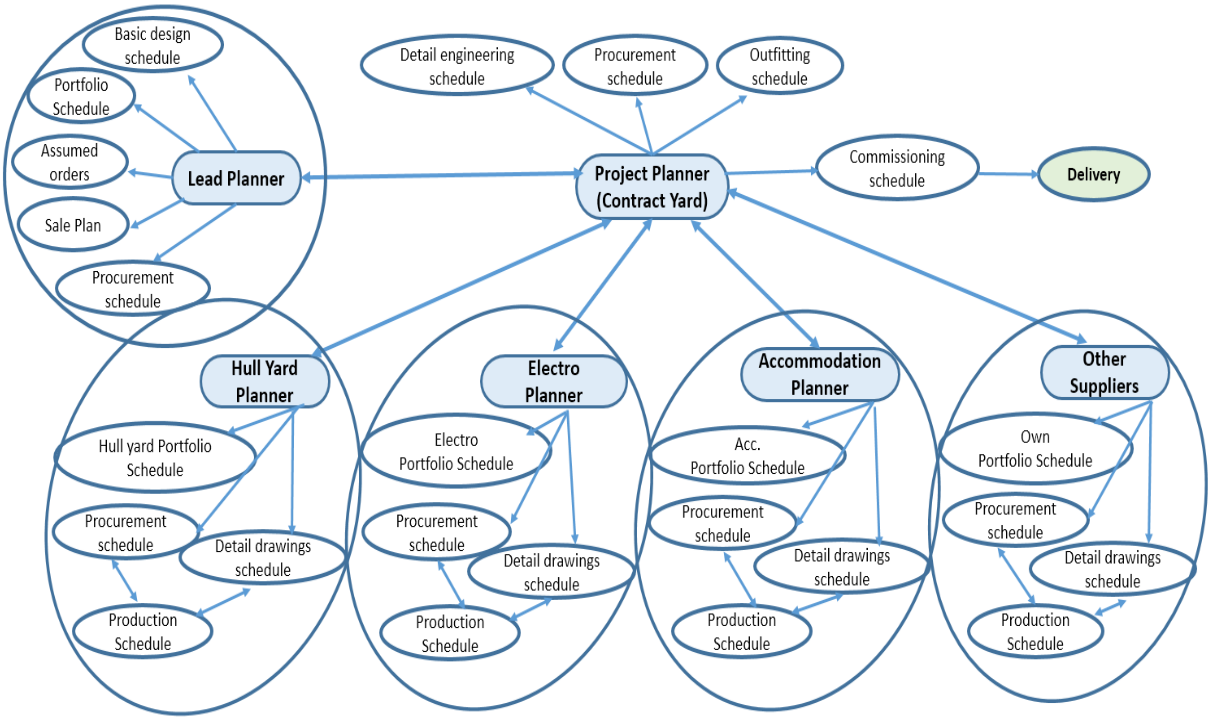

Figure 5-7: The main planners and their plans (adapted from Vard documents)

Most of the schedules created by the Vard planners are created in Primavera (P6) software. This software is complex, requires extensive training and together with high prices per license, mandates a limited access to using it. Therefore, only the project planners have access to create a schedule, update it and extract reports from the software. The project planner sends these reports to PM, discipline coordinators, and other relevant project participants as well as to the management team at the contract yard.

The connection between many different plans and schedules created by many different participating organizations is assumed by the traditional management literature to be completed at the software level. However, data sensitivity and the fact that each company uses own codes and vocabulary of terms, as well as other customized solutions, challenges the transfer of data between project participants even when they use the same software.

At the time when the project planner has completely taken over the planning responsibility, several detail engineering activities have already started. The TC has already started to organize weekly meetings with engineers, procurement, and hull yard representatives. By the time the hull yard delivers the hull, over 80% of the project drawings should have been completed. However, many of them need to be changed during the outfitting phase, especially when customers require that. The planning process continues at the contract yard for the final outfitting phase. Commissioning and testing are activities planned usually by a chief engineer together with a team allocated to this purpose.

Since the scope of this dissertation concerns planning for design- and engineering activities, the remainder of this section focuses on this topic.

5.7 Planning design- and engineering activities

The improvement team started with identifying the main work packages and activities included in the design- and engineering phases of a shipbuilding project. Figure 5-8 depicts these phases as well as some of the work packages (containing both drawings and 3D modeling activities) allocated to each phase. Identifying these phases helped Vard in defining clear responsibilities and better planning roles for the project team. The work packages depicted for basic design and detail engineering are transformed in several thousand activities divided on several plans (in Norway, Romania, Croatia, or other Vard subsidiaries).

Another scope of Figure 5-8 is to visualize the phases included in the term “design- and engineering activities” used throughout the research. Each phase is executed by a different team, an approach that challenges the planning process and the flow of information among project participants. Moreover, the number of the work packages varies from project to project, increasing the challenges to plan and schedule such activities. Along with the work packages, procurement activities, and information from suppliers get included on the schedules for concept, basic design, and detail engineering phases.

The lead planner facilitates the planning of activities for the concept design phase and basic design, while the project planner enables the detail engineering planning. The engineers and planners at the hull yard plan the delivery dates for production drawings in close collaboration with detail engineering. The verification phase, part of the commissioning and testing activities, is planned by the "Chief Engineer" and his/her team. Here, the team needs information from the inspectors (experts who approve or reject results from the testing activities), suppliers, and all the necessary personnel for completing this phase.

Concept Design	Basic Design	Detail Engineering	Production Engineering	Verification
• Hull weight estimate • Light ship estimate • Speed calculation • Bollard pull calculation • Tank capacities calculations • Deck area calculation • Preliminary freeboard calculations • Preliminary damage stability calculations • ERN number calculation • Operational mode defined • Makers list • Tank plan drawing	• General arrangement • Reference drawings • Local vibration analysis • Noise analysis • Lines plan • Fire integrity plan • Damage control manual • Field of vision drawings • Escape route plans • Pillars in superstructure • Preliminary stability manual • Main cable routing • HVAC arrangement • Welding table • Crossover • Traverse sections • Bilge keel	• 3D model • Hull markings • Hatch plan • Doors plan • Manhole plan • Bilge and suction plan • Grinding plan • Gutter bar arrangement • Fire and safety plan • Window plan • Site plan • Clean design plan • Tank plan • System drawings • Freeing plan • DP3 • Layout of the equipment • Side and doors plan • Main mast • Lifting eyes plan • Propeller shaft arrangement • Railing • Foundations subject to class approval • Deck arrangements • Insulation plan • Stairs and ladders • Accommodation plan	• Isometric pipes spool drawings • NDT plan • Panel line info • Assembly line work stations info • Lifting lugs and lifting procedures • Cutting plan • Working procedures	• Final damage stability calculations • Final stability manual • HAT plan • Inclining test procedure • Inclining test report • SAT plan • Seal trial • Tanks sounding tables
20 work packages	65 work packages	74 work packages	20 work packages	8 work packages

Figure 5-8: Work packages for engineering each phase (Vard documents)

Planning the design phase

Each of the five phases presented in Figure 5-8 results in schedules that have several hundred activities and are connected mostly at the milestone pool level. A milestone pool is a collection of about one hundred milestones from the most relevant disciplines. These milestones are connected with predecessors and successors in other schedules at different departments (e.g., a milestone from the milestone pool might have a predecessor in the procurement plan and a successor in the detail engineering plan).

At the beginning of basic design phase, the team of discipline coordinators at VBD estimates number of hours and the duration for each activity in own work package. The lead planner collects this information and creates the schedule for this phase of the project. A basic design plan contains activities that are dependent on information from the concept design phase and some procurement activities. The same basic design activities are predecessors for activities at the detail engineering phase and many of the procurement activities. The VBD team organizes weekly project meetings where the status of basic design- and some procurement activities is updated. When required, relevant suppliers are also invited to these meetings. The lead planner sends updated reports to all relevant project participants, and to the customer.

VBD creates a plan called DocReq (document requirements) at the beginning of the basic design phase, which is then updated throughout the project by the detail engineers. This plan contains the dates when documents from the suppliers, (like footprints or dimensions of the equipment to be mounted on the vessel), is needed for drawing or modeling activities. An updated DocReq is dependent on the information from suppliers as well as information from the engineers modeling nearby the location of the equipment. The process can iterate several times until the final solution is agreed upon by the customer and the project team.

The procurement department plans own activities by considering: 1) the dates when the equipment and materials are needed in production; 2) dates when basic design and detail engineering need technical information from suppliers. This information is included in the procurement plan so that suppliers would deliver technical information on time. However, matching these dates is challenging due to issues like iterations on the drawings and concurrency of phases and activities.

Planning detail engineering phase

As mentioned earlier, this phase is planned at the contract yard by the TC, discipline coordinators, several relevant suppliers, and the project planner. The technical part of the project organization is composed of several specialized engineers and a technical secretary. Each discipline coordinator estimates the duration and hours needed per activity in own work package. The project planner uses this information and creates the schedule for this phase of the project where some of the activities are dependent on activities from basic design and procurement, some, on the activities planned at the hull yard. The team of discipline coordinators together with representatives from the hull yard, and other relevant suppliers meet weekly to update the status on the project plan. These meetings have a duration of about one hour to ninety minutes, and TC is responsible for leading it. The production coordinator is also attending these technical meetings in order to stay updated with the project status as well as to advice about engineering issues that might affect the production in a negative way.

Planning production drawings at the hull yard

At the hull yard, the production planner, together with estimators, discipline coordinators from the engineering department and production, create a project schedule for their phase of the project. Engineers at the technical department create 3D models and drawings for some parts of the vessel. They also extract drawings out of the 3D model to create production drawings (in 2D), print them on paper, inspect and approve them before sending those drawings to the production unit. This process can take up to two weeks. The milestones for the production phase are usually created during the negotiation phase and updated during the basic design phase. The engineering project team at the hull yard update their schedules on a weekly basis in own project meetings and report the status to the production planner[7] every second week. Also the production team updates the status of their activities every second week. Based on these updates, the production planner sends bimonthly reports to the project planner.

Planning at internal suppliers

Electro, Piping, and Accommodation (Vard subsidiaries) use similar scheduling and planning methods. When they are part of a project, they report weekly to the TC (during the design and detail engineering phases) or to the production coordinator (during outfitting phases). However, since most activities are interdependent, all the entities involved in the project are dependent on a dynamic communication and good information flow.

In addition to the organizations presented above, customers and classification societies also have an influence on the planning process since their delayed approval or rejection of the proposed drawings affect the rest of the activities that are dependent on these approvals.

[7] The title production planner is a way to clarify roles within a project. A project planner is responsible for planning the whole project while production planner plans the hull and pre-outfitting activities

Concluding aspects of planning design- and engineering activities

After identifying and analyzing most of the organizations creating plans that must be connected with the main project plan, it became clear that project teams needed more than just a planning software to plan and control such a challenging environment. They needed an arena where planning issues could be discussed and dealt with in a dynamic and structured manner. Therefore, the improvement team started to observe the way engineers organize and lead project planning meetings, especially for design- and engineering activities. In many projects, engineers would show some interest in organizing project planning meetings, however, little effort was made to structure these meetings around planning issues only. Quite often, these teams would start discussing technical issues, or reporting the number of hours used per activity, forgetting to address relevant planning aspects. Other teams would put considerable effort into organizing and leading their project planning meetings, and they managed to define and structure better approaches to deal with the inherent challenges of planning design- and engineering activities.

The scope of the sections presented above is to illustrate the complexities in planning shipbuilding projects in general. Since all of the observed projects were built through an ETO approach, the ETO characteristics within shipbuilding follow. This description serves two purposes: 1) connects the case description with the studied literature, and 2) emphasizes the inherent complexities in planning ETO projects.

5.8 ETO characteristics in Vard projects

As described in Chapter 2, ETO projects are characterized by a dynamic, uncertain, and complex environment (Bertrand and Munstlag 1993). These characteristics are typical within the Norwegian shipbuilding industry, and Vard is no exception. The sales fluctuate as these are dependent on the situation of the market. Consequently, projects are difficult to forecast, and that creates high fluctuations of resources and type of specialized workers needed for each project. For example, the recent low oil prices resulted in a decision to reduce the number of employees, yet when the cruise projects started to arrive, a higher number of people were needed. Then, it became difficult to hire specialized workers due to high demand on several other Norwegian and European shipbuilding companies.

Uncertainty in Vard projects is related to the specifications required by each customer who is in search of unique products that can give them a good advantage on a specific market. It is also related to the mix and volume of vessels to be produced.

Each shipyard may have to work with several types of projects: new vessels at different building stages, repairing, guarantee issues, etc. The engineers and people at the production department need to work on more than one project at a time, and that adds complexity to planning and controlling each project. Another issue that adds to the complexity factor is the customization element. Most of the vessels built at Vard contain a large number of equipment and components that need to be customized according to the customer requirements, which implies that many suppliers start producing the equipment or the component only after they receive a confirmed purchasing order. There are also different types of customization to deal with: while on offshore vessels customizations is focused on technical issues, on cruise vessels, the customization is focus on accommodation and visual impressions (unusual architectural solutions or features). Such change of focus had a significant effect on the way these projects are planned and controlled.

5.8.1 Iterations

Since each project is performed in close collaboration with the customer, modification and changes can appear anytime throughout the project duration. Finding solutions that fit both customer requirements, classification societies, and the design of the vessel result quite often in iterations that are difficult to plan and control. Vard projects deal with several types of iterations: 1) Iterations during the design- and detail engineering phases that need to consider customer requirements, information from suppliers, and constraints from the classification societies. 2) Iterations that appear before the production is started and are mostly performed in the 3D model. 3) Iterations that are required after the production of that drawing has started. Reasons for these iterations can be: customers changing feature of the vessels; classification societies not accepting proposed solutions; suppliers not being able to deliver information or products as required; and design/detail engineering errors.

Vard defines two specific groups of iterations: change orders (CO) and variation orders (VO). Most of the COs are caused by: 1) several engineering iterations during the process of finding the right solution; 2) errors in design or production; 3) customer requirements that were unclear; 4) suppliers changing features of their products. Therefore, not all CO have a positive effect on the project. Meanwhile, VOs are mostly positive iterations within a project because they are changes on the Spec. VOs originate in the customer’s request to change features that were already agreed upon at the contract signing stage. Hence, VO are evaluated, negotiated, and approved by the customer together with the project team. The price of a VO includes extra design hours, management hours, and price of materials as well as estimation on extra building time. For example, a VO on a delivery ready vessel led to almost one year of extra work.

5.8.2 Outsourcing

Due to increased specialization as well as high fluctuations in demand, Vard outsources many of the phases and work packages in a project. There are several types of outsourcing: internal, external, and mixed. Internal outsourcing implies that subsidiaries like Electro or Accommodation are invited to bid for executing these specific work packages. External outsourcing implies that companies outside the Vard Group bid for executing specific work packages in a project. Mixed outsourcing implies that Vard hires specialized engineers or production workers from external companies, on a temporary basis.

The decision on choosing the right suppliers is usually based on price and lead-time of the respective delivery, especially for key components. Since over 75% of the total costs of a project is spent on materials, equipment and services, acquiring them at a convenient price and proper quality is a major issue in shipbuilding projects. However, when customers impose some preferred suppliers (due to special deals or other background factors) it implies that teams have less power in negotiating both price and features of components or services.

When selecting suppliers, the project team takes into consideration the production strategy applied by these suppliers, especially for the ones using an ETO approach. That is because these products might have a long lead-time that can affect the total delivery of the project and require more information exchange between the several project participants (supplier's team, customer, design, detail engineering, and hull yard). In cases when suppliers use production strategies like ATO or MTO, the information flow is less demanding. Nevertheless, approvals from the customer, the classification society and other relevant authorities may result in lengthy and complex processes that affect the project plan.

5.8.3 Concurrent Engineering Procurement and Construction (CEPC)

The concurrency used in Vard projects is a consequence of the necessity to deliver each vessel within a short lead-time. Therefore, many of the activities in a shipbuilding project are executed concurrently, which results in project participants dependent on the right information at the right time. Concurrency among project phases and activities happens at every level of a project. During the negotiation phase, engineers start creating a product according to customers' preliminary requirements. Here, some of the procurement activities for the critical component are also started. At the contract-signing phase, many basic design drawings are approved and ready for the next phase. During the basic design, many procurement- and some detail engineering activities start almost simultaneously. Documents from the suppliers of material and components are needed to complete basic design drawings and 3D models. It also implies that suppliers start producing their deliverables following requirements from the basic design team. While engineering activities are performed, as soon as a drawing is completed and approved it is sent to the team creating production drawings. In the meantime, the materials necessary to start these activities are already (most of it at least) arrived at the yard. At later stages, e.g., outfitting, some of the testing activities start before the vessel is ready for commissioning. However, even though Vard uses some elements of CEPC, they have no working processes dedicated to improving it.

Vard shipyards are used to deal with a certain level of concurrency in their projects as they, throughout the years, have been building relatively complex vessels using simple drawings. Some of these drawings were completed after production was finished. Still, the level of CEPC is not clearly defined and structured in any of the observed projects challenging the sequence of activities and the way these can be planned or scheduled. This is particularly difficult for design, detail engineering, and procurement activities that in addition, are iterative and require several loops before they are approved for the next step.

The term CEPC is not discussed with the CE literature, where most of it refers to the concurrency between engineering and production phases. However, at least in shipbuilding projects, there is a need to acknowledge that the third element, which is procurement, has an important role in achieving a proper concurrency. Delayed or incorrect materials/components have a huge impact on the project outcome.

5.8.4 Design for Manufacturability (DfM)

As a measure to reduce the production costs, Vard decided to approach some elements of the Design for Manufacturability (DfM) tactic in some of the recent projects. Through this tactic, Vard aimed to increase the collaboration among the project participants, reducing the production costs, and achieving a better concurrency of phases and activities. The DfM method tested at the design- and detail engineering levels takes into consideration the existing technologies, the layout, and the production facilities at the hull yard. DfM has an important impact on design- and engineering for activities like dividing the hull into blocks, defining new engineering solutions, or establishing the sequence of each unit in a block, etc. By doing this, Vard identified areas for improvement and thus, invested in technology that facilitates production and increases its pace. Owning the hull yard is a factor that facilitates an easier DfM implementation than for other shipbuilders who must buy production capacity in other shipyards and follow different organizing rules. The design team began to work on implementing some DfM aspects in 2016, however, it was only the beginning phase.

Implementing DfM elements had a significant impact on the planning process for design-, detail engineering-, and procurement activities since these had to be rearranged into other units or follow a different sequence. Moreover, these issues might change from project to project as technological development and investment in new equipment result in more advanced building capabilities and methodologies.

An important aspect to be considered in order to achieve a better concurrency and proper DfM is the involvement of suppliers of components, equipment, and materials. Vard has a large network of suppliers, and, throughout the years, the group developed a close relationship with the strategic ones. Moreover, to improve communication and collaboration with its suppliers, Vard centralized key parts of the procurement process. This gave Vard the possibility to identify and to develop better common working processes.

5.8.5 Modeling software

Even though most of the shipyards use 3D modeling for their projects, there is still need for 2D drawings, mainly because not all suppliers can deliver 3D models of their products. Usually, after being approved by the customer and classification societies, the 2D drawings are sent to specialized engineers who transfer them into the 3D model of the project.

3D modeling offers new possibilities to see how the final product will look and behave like, and due to technological advances, the level of details in a model has increased considerably. Thus, the number of activities on the drawings list and the number of engineers involved in each project has also increased significantly. Only a few years ago, a project organization for the detail engineering phase would contain up to seven discipline coordinators while today their number goes up to twenty and that is just at the contract yard. However, a general trend is that most of the organizations involved in a project have now an increased number of engineers delivering both 2D drawings and 3D models. The increased level of detail in the models led to engineers specialized in specific operations for specific parts of the vessels (e.g., a specific steel structure, or a specific part of the accommodation, etc.).

Likewise, due to rapid software development, every organization would choose the most convenient 3D modeling supplier for their type of work. That is a challenge when different software applications do not accept a direct transfer from other similar software, especially in projects dealing with a large network of project participants. Besides, transferring information from one software to another creates some challenges for the project team; not only a longer information flow, but also a more time consuming work. Hence, planning all 2D and 3D activities has become a challenge both for the discipline coordinators, for the planner and for the project, as it requires more resources to monitor and coordinate all details on each project plan.

Even though the ETO characteristics presented in this section are the ones identified in Vard own project execution strategies, these can be generalized to several other Norwegian shipbuilding companies who deliver one-of-a-kind, highly customized vessels. Section 5.10 describes another Norwegian ETO company where these characteristics are quite similar.

As a way to deal with the ETO challenges while focusing on continuous improvement of their results, Vard started to upgrade the planning process by developing the LPP method. Its theoretical fundament was presented in Section 2.6, so its practical use is described next.

5.9 Lean Project Planning (LPP)

Like many other new working methods, implementing LPP needed support from leaders and project teams. Thus, one of the first steps was to visualize how planning of each project influences both the present and the future business of a company as illustrated in Figure 5-11.

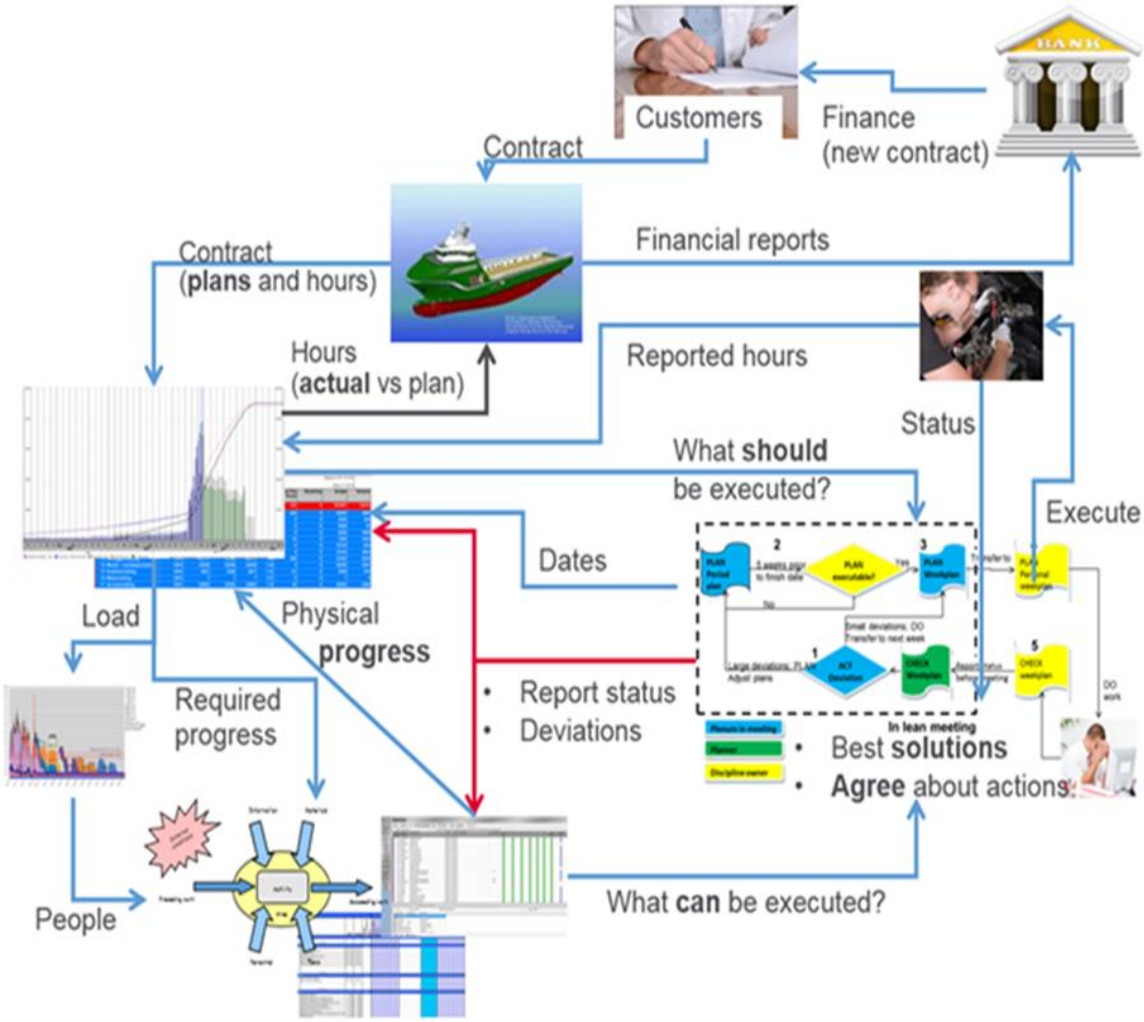

Figure 5-9: Planning and its role in the business process (Emblemsvåg 2012)

PMBOK® and other traditional project management literature indicate that planning and scheduling are activities that have an important role in the outcome of the project without connecting them to future assignments. This is an important aspect of shipbuilding industry because these companies need to provide good references (projects completed within the agreed frames) in order to gain new contracts. Figure 5-11 shows how a good planning process contributes to achieve trust from the financing parts (banks or other institutions) to get support for future contracts[8]. The figure is part of the training material developed for the LPP implementation.

During the negotiation phase, a bank interested to finance the whole project gets involved, and in many cases the project cannot be started before the agreement between the bank, customer and shipyard is signed. Soon after the contract is signed, the planning process must start so that the first reports can begin to take form. All project participants must report the status of their activities through a PDCA circle during which people agree on the best solutions and actions to be taken further. This process is depicted in the lower-right corner of Figure 5-11 and explained in more details in Section 5.9.1. Based on the data collected from all participants, status reports are sent to the project team depicted as a green vessel. The team sends monthly reports to the bank financing the project. When things go well, the bank agrees to finance the next contract. Such connections emphasize the need to deliver within the agreed frames as this can affect the future of the whole company.

Having established the strategical importance of planning, LPP brings to attention two essential elements that help even more to see the differences between scheduling and planning, where the latter is the process that enables communication and commitment among a large number of project participants. LPP distinguishes the planning system from the planning process, both being key parts of the project planning as a whole. This is a seldom approach in project management- and to a certain extent, in the LC literature. Table 5-1 shows several features that help to explain such distinction.

[8] Shipbuilding companies are dependent on credit from banks during the building period as the customers typically pay 80% or even 90% of the total price at the delivery of the vessel.

Table 5-1: Planning process vs. planning system (Fagerli and Kjersem 2015)

Planning process	Planning system

• PM is responsible for the planning process
• Defined as all actions performed to collect the information required for the schedule
• Forms the project organization
• Facilitate periodical planning meetings
• Establishes the sequence of activities
• Facilitate the estimation process
• Facilitate the reporting process
• Allocate resources
	• The schedule is created by the Project Planner in collaboration with discipline coordinators and suppliers
	• Schedule is a list of interdependent activities that need to be executed to achieve the scope of the project
	• Contains:
	  • Dependencies between activities
	  • CPM and Gant charts
	  • Different reporting layouts
	• Clocking system and other reporting software

Table 5-1 was created as part of the standardization process to give people a better understanding of their roles within a project.

Figure 5-12 depicts the planning process as well as the planning and reporting system as applied in LPP. Here, the planning process part is based on LPS®, EVM elements, and lean ideas while the system part contains mostly software that are used for planning and for following the economic evolution of a project (Emblemsvåg 2014b).

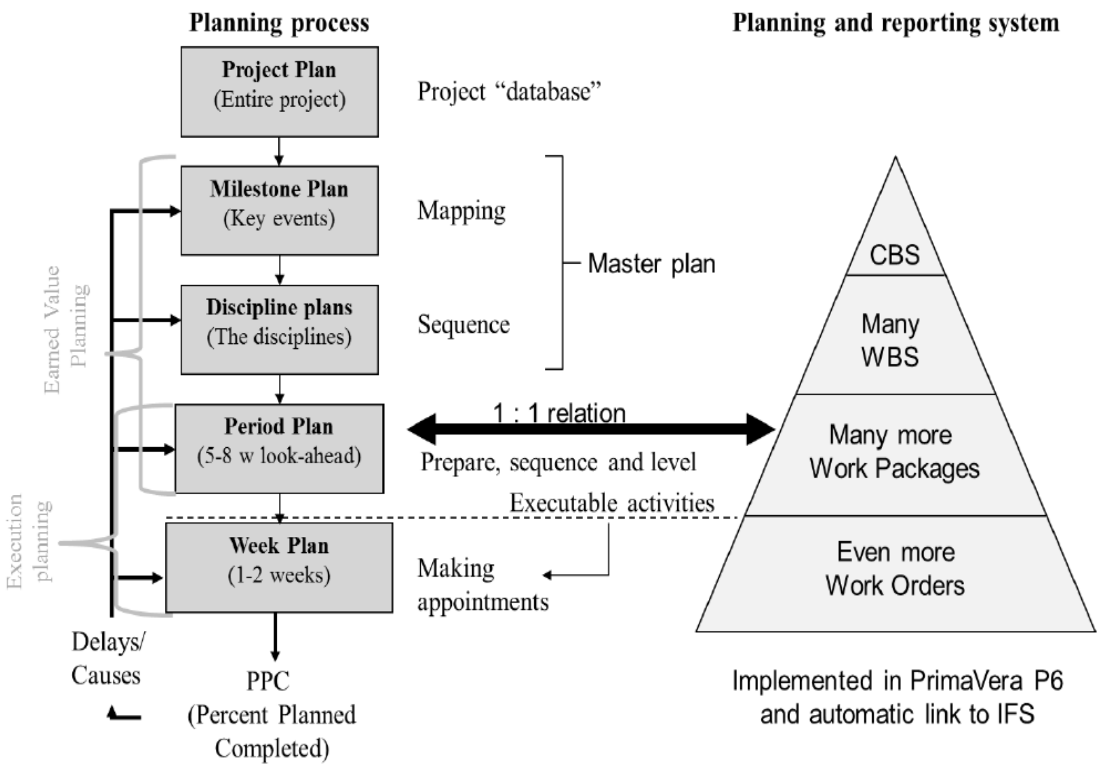

Figure 5-10: Lean Project Planning Overview (Emblemsvåg 2014b)

During a project, different planners fulfill the different planning levels shown in Figure 5-12. The initial idea was that the contract yard is responsible for the project plan, and all the participating organizations are integrated into this plan from the milestone level to the period plan level. However, the level of details, the increasing number of activities, work orders, and tasks on each project phase challenged the integration process. Consequently, this type of project planning was mostly used by the production department at the outfitting yard.

The project plan is for the entire project, and it is created by the project planner who uses information from previous similar projects and adjust it to the new project's peculiarities. The milestone plan serves as a starting point for the discipline plans developed by planners at the basic design, the contract yard, and the hull yard. This plan contains work packages for each major discipline (steel, piping, accommodation, electro, painting, and machine). Milestone- and discipline plans together form a master plan that serves as input for the rest of the organizations participating in the project. The period plan contains activities at a more detailed level than the discipline plan, and the aim is to prepare the activities to be completed as planned. It is developed in collaboration between discipline coordinators, their teams, and the planner. Looking ahead five to eight weeks, discipline coordinators can identify constraints that might affect the completion of each activity (Emblemsvåg 2014b) as discussed in Chapter 2.

The master plan, together with the period plan, form the basis for EVM. The decision to not involve week plans in calculating EVM is based on the following facts: 1) the week plan varies more than the period plan; 2) resource loading all the detailed activities is a waste of time; 3) it contains activities that are not related to planning – as such, it is better viewed as a work more than a plan. By looking ahead five to eight weeks, each discipline coordinator has the possibility to reduce variability by eliminating constraints before they can affect other activities or the project. Team supervisors create week plans that are quite detailed, helping them to relate to the project plan. A week plan has several functions (Emblemsvåg 2014b):

1) A tool that help communication and coordination. During planning meetings, these activities are reported and discussed in plenum, and all the other disciplines are informed and can take necessary actions.
2) It is a form for commitment to the project plan. Supervisors are informed on the project status and they can discuss during the planning meeting how to approach eventual delays or problems.
3) This plan is reviewed during the subsequent planning meeting, which is essential for the completion of the PDCA cycle (not only plan and do, but also check and act).

LPP emphasizes the need to identify the root-cause for problems in preparing and executing activities at period- and week plan levels in a classic lean way. Causes for non-completion are discussed during the lean planning meetings and measures taken to avoid reoccurrence.

The period- and the week plans are categorized as execution plans because it is here that the activities are followed during the execution of the project. The completion of activities within the week plan is reported through PPC. At the period plan level, LPP uses the EVM methodology (e.g., SPI, and CPI) to keep an overall track of the project. Typically, low PPC over time leads to low CPI, which means that PPC is in fact a genuine Key Performance Index (KPI) while CPI is a Key Result Index (Emblemsvåg 2014b). LPP implemented a project status reporting method where supervisors from each discipline had to report his/her teams' results weekly. Their reports to the project planner contain four main issues:

1) An estimate of the physical percent complete of each activity
2) Number of hours used per activity during that week (from the clocking software)
3) An estimate on the number of remaining hours for each activity
4) An estimated date for finishing the activity

Based on this information, the project planner creates status reports on each discipline as well as on the project as whole. The period plan reports include among other issues budgeted hours and CPI, estimated budget at completion if the project continue in the same style, remaining hours, etc. Figure 5-13 depicts the main template of these reports.

Activity ID	Operatior Activity Name / process	Performanc % Complete	At Completion	Earned Value	Actual	CPI	Actual This Period	Remaining	Budget	Variance	Variance Change
Total		100%	78644	75888	78644	0.96	1061	0	75888	-2756	-115
10 Administrasjon		0%	0	0	0	0.00	0	0	0	0	0
No SFI - Hovedgruppe		0%	0	0	0	0.00	0	0	0	0	0
12133	GEN Planner	100%	0	0	0	0.00	0	0	0	0	0

Figure 5-11: Status report as developed by LPP (Vard documents)

One of the main rules imposed by the LPP approach when reporting the status of each activity is to let people estimate own remaining hours for the time needed to complete the activity while estimating the number of people needed for the next week. Then, at the end of the reporting process, discipline coordinators and supervisors could see in the planning software how many hours they would work next week and how is that corresponding with the number of people needed for the same week. That helped them prepare the necessary resources for the coming period. In projects where people let the planning software calculate automatically the remaining hours or percent of activity to be completed, the resulting data are misleading as productivity varies both by individuals and by teams.

The period- and week plans contain a traffic light system that visualizes the status on each activity. Its main role is to direct attention towards those constraints that can affect completion as planned of any project activity. Figure 5-14 depicts this system.

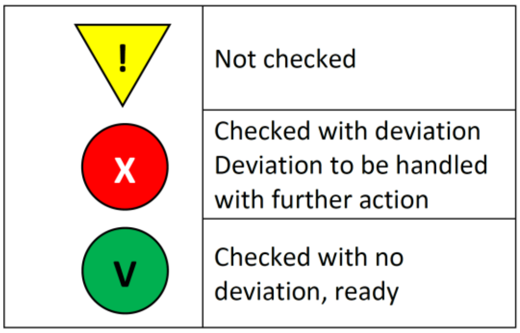

Figure 5-12: Traffic light system in LPP

A green mark on a constraint shows that the discipline coordinator has checked that constraint and the activity is ready to be executed. A yellow light on a constraint shows that the discipline coordinator has noted that there are some issues to be solved in order to complete the activity as planned. If the issues are not solved one week before starting the activity, a red mark is put on it as this shows that, there some constraints that need immediate action if that activity should be completed as planned. The red light is also used for visualizing the number of delayed weeks per activity. This traffic lights system was intended as a tool to help people direct their attention towards eliminating any constraint before it affected the activity or the project. But, in some of the cases, people used this system mostly to report the status after the activity was started. Yellow was for them a short delay, red was a big delay.

Most of the LPP elements presented above were included in weekly meetings organized both at period plan- and week plan levels. Meetings organized between production coordinator, discipline coordinators and the planner at the period plan level were following a simple structure: they would analyze eventual constraints on work packages planned for execution within the next five to eight weeks. The team used about one hour each week for updating the period plan and allocating tasks to be solved by designated project participants. While period plan meetings were less regulated, week plan meetings had to be organized in a more structured way due to their crucial role in facilitating dynamic communication and information.

5.9.1 LPP meetings – week plan level

An essential element when implementing LPP was to focus on organizing project planning meetings since many projects lacked a more structured approach to this process. Planning meetings at the week plan level followed the steps presented in Figure 5-13.

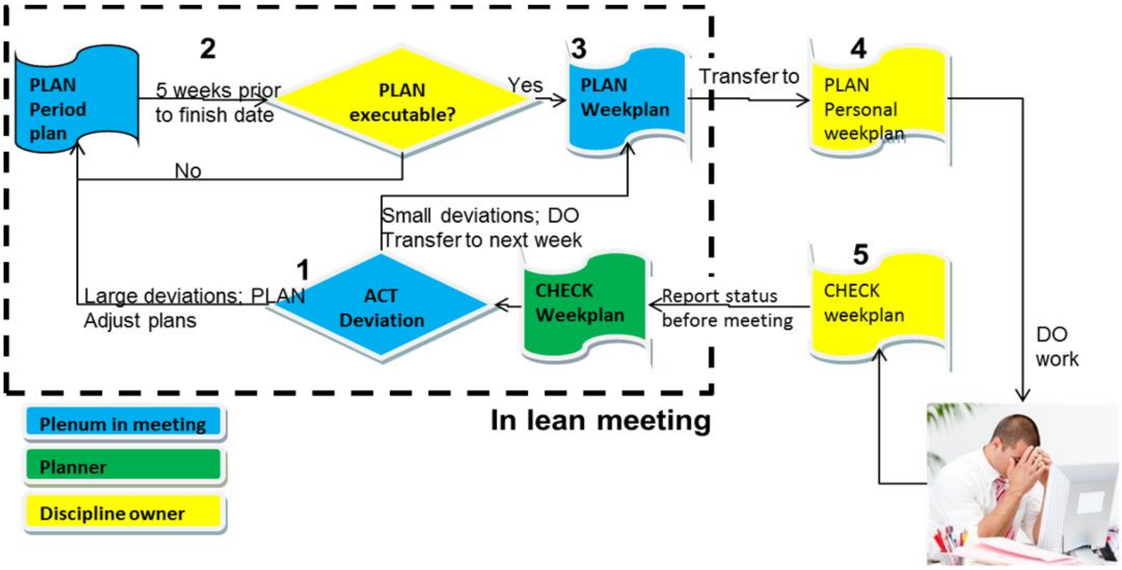

Figure 5-13: The LPP planning meetings (Vard documents)

Meetings at the period plan and the weekly plan levels are both part of the planning process as a whole since one without each other would not function well. The PDCA line of thoughts forms the fundament of conducting these meetings. The period plan meeting was usually organized several hours before the weekly meeting so that the production team would be updated on the status of activities to be executed two to five weeks in advance. The week plan meetings as proposed by LPP, started with analyzing the deviations that were reported by discipline coordinators, suppliers and other relevant participants to the project planner just before the meeting. The week plan was displayed through a projector and each deviation was discussed in plenum formed by all discipline coordinators from the production department, several of the relevant suppliers, a project purchaser, technical coordinator and the project planner. When a deviation was affecting other important activities and could not be recovered within the next week, that activity would be moved to the period plan. If the deviation was manageable, it was re-planned for the next week. Reasons for non-completion were discussed in plenum and activities that were dependent on the delayed ones were re-planned accordingly. The project planner updated the plan during the meeting and send it to all participants after the meeting.

In the beginning of LPP implementation, there were no proposed standard structure for these meetings, but a preliminary frame was introduced by the team that developed the LPP. While LPP was implemented in each new project, production coordinators developed “personalized” meeting structures and that was at time confusing for people participating in several different projects. Therefore, a request for a more standardized approach to week plan meetings was made by the people participating in these meetings. The main argument was the need for a routine that could help people use less time on the preparations for each meeting. Hence, all discipline coordinators from that production department created together one standard structure that would be used during their planning meetings. Each week plan meeting would follow the following steps: 1) Safety issues on the vessel; 2) General information about next week's challenges; 3) Discuss the PPC and deviations from last week's planned activities and take actions; 4) Discuss the next week's planned activities; 5) Discuss the manning for next week; 6) Eventual issues that each project participant wants to discuss during the meeting, and 7) A short discussion on eventual constraints in the period plan. At the end of the meeting, people were reminded to analyze the period plan at least once a week and try to avoid delays by eliminating constraints before the planned start date. Before creating this standard structure for weekly planning meeting, these were dependent on each coordinator's ability and preferences to lead such a process.

Based on the ideas proposed by the production team, as well as recommendations from lean and LPS literature, we started to observe and analyze how engineers organize and lead their planning meetings, as LPP implementation seemed to be challenged by other ETO characteristics.

5.9.2. LPP for design- and engineering activities

The implementation of LPP was a success at the production department and most of the people using it were satisfied with the improvements. However, implementing the same approach for the design- and engineering activities proved to be more challenging. LPP was though, tested on planning design- and engineering activities on some projects both at Vard and at other ETO companies with noteworthy results. One of the yards that implemented and developed LPP further is Vietnam. There, they implemented LPP from design to delivery and they reported improved project results. Among success factors in implementing LPP in Vietnam can be mentioned:

- A smaller project organization where most members were located at the same place
- An adequate training program for each project team
- A young organization (the shipyard was started in 2007 and many of the employees were newly graduates)
- The leadership at the yard gave substantial support in implementing LPP and drove the process further after the initial training from the Norwegian team
- Employees were involved in further improvement of LPP and so they develop a sense of ownership and commitment

The organization in Vietnam focused on improving the communication with the basic design team located in Norway by organizing a clear feedback process on the most important project issues. Since most of the procurement and detail engineering activities were executed in Vietnam, the project team had the possibility to stay focused on their weekly decisions while preparing for next week's activities. Due to their close involvement in implementing LPP, they also identified two more constraints that affected the completion of their design- and detail engineering activities. Figure 5-15 visualizes these constraints showing a more detailed approach (compared with the ones presented in Chapter 2) that can be considered when planning design- and engineering activities.

The first different constraint adapted by Vard Vietnam is Owner/DNV approval. It is used for showing the constraints posed by customer and classification societies since they have a huge impact on the evolution of the project through their approval processes. The second constraint is VO (Variation Order) used for visualizing the changes required by the customer after an activity was declared as completed. The results provided by Vietnam shipyard in managing their projects show that LPP can be implemented for design- and engineering activities, however, their challenges differ from the challenges in the RoNo type of strategy.

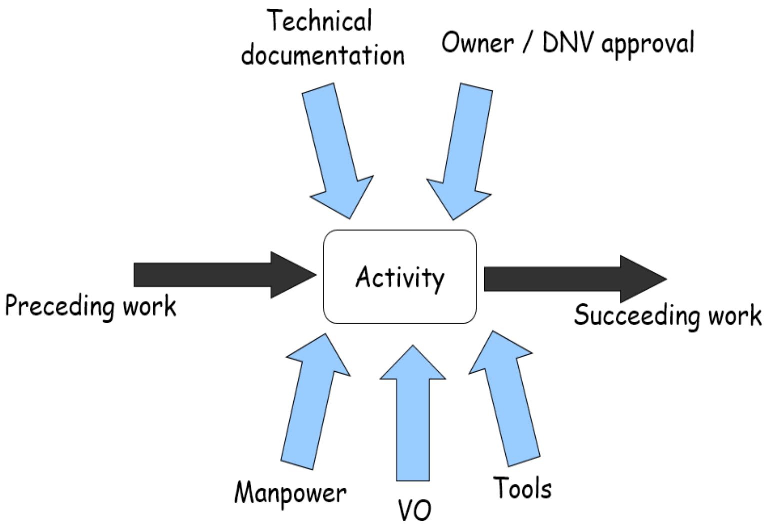

Figure 5-14: Activity constraints for design and engineering (Vard documents)

LPP was also tested in one specialized design- and engineering company within Vard. The company is part of the RoNo strategy and delivers mostly 3D modeling services through a team of specialized engineers employed by the company. An introduction to LPP and one week of training with a project team was the start of the implementation process. The team and the company's leadership were interested in improving their planning process as they encounter many challenges in delivering their 3D models as planned. The project team started to use LPP after they identified specific constraints and a proper project meeting structure. On their side of the project, things seem to work in a suitable way, however, receiving the right information at the right time proved to be a challenge. This organization was dependent on information from the Norwegian design- and detail engineering department who were dependent on information from the customer, own discipline coordinators, classification society and from suppliers. Hence, this long and intricate information flow created delays at the case organization, but LPP helped them to identify some causes of those delays and report them to the contract yard so a better communication plan was issued. However, due to lack of follow up on the implementation process, the company stopped using LPP, even though they acknowledged its usefulness.

These two cases presented here show that implementing LPP for design- and engineering activities can work when the context support the efforts. Since other experiments performed in several different companies failed to achieve the expected results, the improvement team started to analyze the causes for such results. The findings are discussed in Chapter 6.

During the research period, it became clear that the results improved considerably even though LPP was only partially implemented. This could only be ascribed to how people interacted, e.g., how the project planning meetings were executed, and this observation led to focusing on the project planning meetings as the unit of analysis.

However, one question became unavoidable: was this typical for Vard? Do other companies have managed to find better planning approaches? Starting to work as a researcher, allowed me to find answers to these questions by working with other ETO companies interested to improve the outcome of their projects through better project planning and control. One of these companies is presented next.

5.10 Second case company – Company X

This ETO company supplies design- and engineers packages for several types of vessels, e.g., offshore, cruise, fishing, special vessels, and alike. The PES applied by this company implies to serve as supplier of concept design, basic design, and detail engineering to shipyards. In some projects, they are responsible for the whole project management while in other projects, they are only supplying design and engineering services. Among the challenges with this type of PES are aspects like (Kjersem, Jünge, and Emblemsvåg 2017):

- Little flexibility in updating the project plan mostly due to lack of trust in sharing some of the project information
- Difficult to obtain a project plan where the PM can have an overview of the whole project

- Re-planning delayed activities is challenging and usually quite expensive
- Lack of feedback from the production phase especially regarding how new engineering solutions fit to the building process
- Different software among project participants both in 3D modeling and in planning

The company started to implement LPP during autumn 2015, and I was involved in this process from the beginning. Company X does not own any shipyards, so they have to find available production capacity at one or more shipyards before they can embark on a new project. However, none of the local shipyards produce complete hulls locally. They are dependent on hull yards located outside Norway, which implies several more constraints when planning such projects. This research involved the following units:

- Concept- and basic design in Norway, detail engineering in Pollen and Croatia
- Hull construction divided between Norway, Pollen and Lithuania
- Production drawings in Croatia and Norway, outfitting and commissioning in Norway

In the projects part of this research, Company X was in charge of planning design- and detail engineering activities, while the Norwegian shipyard was in charge of planning and completing the whole production process. In this project, LPP was implemented only at Company X, but the shipyard and several other project participants were invited to participate in the weekly planning meetings organized by the design department.

The design- and engineering activities were performed by a small team of own engineers producing 2D drawings that were sent to a partially owned subsidiary in Croatia for 3D modeling. The same Croatian company was responsible for delivering the production drawings to the shipyard, who, after verifying them sent them to the Polish yard (an independent company) where several blocks and units were produced and partially assembled. The Norwegian shipyard received a partly assembled hull, finished it and completed the outfitting process. The commissioning phase was also performed by the Norwegian shipyard. In addition to these project participants, several suppliers were involved during the project. The flow of information in this project was complex and at times, challenging due to a lack of trust and good communication among participants. The LPP implementation started with a training session that was provided to the team that would lead the projects studied in this research.

PM and his team of discipline coordinators (the company uses slightly different names for these positions, but their roles as similar to the ones described in Vard case) seemed interested in using this tool. Here, too, an improvement team was established where a company leader, the project manager, one team leader, and I were focusing on facilitating the LPP implementation. During the project execution, I was involved in about 20 planning meetings and three design review meetings. My role in these meetings was to support the implementation of LPP and to identify possibilities for improvement. After each meeting, together with the project manager, we organized a short feedback session where we discussed issues that needed more attention for next meetings. Among these issues were:

- Structure of the meeting. The PM tried to define a certain frame to follow during each meeting, but, due to unprepared participants, they ended up discussing procurement or technical issues
- The traffic lights system was applied only after an activity supposed to be started. Again, unprepared participants led to firefighting and little focus on the planning part where constraints should be eliminated on beforehand
- Reporting and preparation for each meeting. The PM used to send remainders to discipline coordinators so that they would report before coming to the meeting. This was usually done by one or two coordinators, the rest of them would report while attending in the planning meeting
- Lack of a correct and updated status of the project. The PM often emphasized that he needed a more clear status of the project and he tried to involve all relevant project participants in developing a good reporting process
- All discipline coordinators complained that they have too much to do and they do not have time to update their plans or to report the status on their activities
- Several equipment and components suppliers were delayed creating a chain of delays for detail engineering-, procurement- and production- activities
- Lack of resources at Company X led to a high workload on the team and little control over the status of the project

During such discussions, we proposed actions that could be implemented in the next meeting, however, none of them worked due to high pressure on the project team and several changes within the team (e.g., people left the team or the company, or were in maternal/paternal leave).

While being part of this project, I have also interviewed two project managers (the first one left the company during the project) four discipline coordinators and one system administrator that functioned as a planner at the beginning of the project. These interviews revealed lack of focus on planning and lack of support from the company’s management team in ensuring the resources needed by the project.

Due to delays in the negotiation phase, the start of the project was moved towards the end of June 2015, and that collided with the summer vacation in Norway. Consequently, the project started towards the end of August, several months later start than initially planned. This shortened the real project duration and forced Company X to apply even more concurrency to their activities, which implies a closer relationship with the customer, the shipyard, and all relevant suppliers. Company X invited all these actors to the weekly planning meetings, but most of them preferred to participate only occasionally. The interest was though, much higher for 3D model review meetings that were held two-three times per month. During these meetings, very few planning aspects were discussed, as the focus was on issues about design, 3D modeling, and engineering. The Norwegian shipyard was interested in these meetings aiming to advise design solutions that took into consideration the existing production facilities. Yet, stressed by the short delivery time, only a few issues on DfM were discussed.

The iterations of design- and engineering activities remained a planning challenge in this project also. During the 3D model review, many changes were discussed, and approval of each drawing was done by the customer, by the classification society, or by the Norwegian shipyard and discipline coordinators from Company X. Suppliers of 3D modeling and the shipyard were receiving information rather late, and that affected the results of the project.

The project organization responsible for this project consisted of one PM and five discipline coordinators. All were involved in parallel projects running within the company, and all were overloaded with project work. Each coordinator had a team of engineers producing mostly 2D drawings and, after an internal approval, sent those to the Croatian team for 3D modeling. The discipline coordinators were responsible for planning their own activities within the project plan.

The project plan was created and updated in a planning software developed in-house by Company X. The software was quite comprehensive, and most of the project participants were learning how to use it at that time. The software was adapted to the LPP requirements, however with some small changes. The reporting part of the software was supposed to be integrated with the financial system so that data would be easily collected. This issue was ongoing throughout the whole project duration.

Initially, most of the projects managed by Company X had an unstructured planning approach where the PM had the attribute to plan and control the project while dealing with the customer and the rest of the geographically distributed project organization. The company did not employ any planners. However, several interviews and discussions with project managers revealed that they lack the time and the energy needed to invest in planning each project. Hence, most of the projects were planned at a high level (close to a period plan) without enough involvement from the discipline coordinators or other relevant project participants.

The company started to implement LPP, and in the beginning, while the leaders of the company participated in planning meetings, everybody in the project team tried to keep up and follow the project. Nevertheless, a high workload and less focus from the leaders resulted in gradually less interest in using the concept in a proper way. One of the first things that started to be ignored was the analysis of the root cause of the problems. The status on each activity was updated only superficially (e.g., showing a green light when an activity was completed or a yellow one when the activity was delayed without specifying how long that delay was). Planning meetings were held once a week, however, with fewer and fewer people that were less and less prepared to discuss planning issues. Plans were updated during the meeting, and measures to deal with deviations were not discussed due to non-attending discipline coordinators. Planning meetings became a place for discussing technical issues among three to five participants (including hull yard and subcontractors of 3D modeling). The PM complained several times on missing planning updates, however, lack of resources within the company was a general problem for most of the projects. The project was delayed several months, resulting in high cost overruns for Company X.

5.11 Overall observations from the studied cases

During the research period, I had the possibility to interact with several other ETO companies (located not only in Norway, but also in Romania, Germany, Croatia, Brazil, and Poland) and project planning and control was a ubiquitous subject of most of these gatherings. It became clear that most of these companies struggled to keep up a good overview of the real status of their projects, and the blame was usually placed on the delayed information from design, engineering and suppliers. However, the data collected throughout the years also shows that some engineers are willing to learn how to organize and lead project planning meetings for design- and engineering activities so that they deliver right information at the right time to the right people. The results of such projects showed an improved communication, trust, and commitment to the project plan. Those project planning meetings served as an inspiration for the observations and the proposed improvements throughout the research period. While participating in many meetings, we identified several elements affecting the planning of design- and engineering activities and discussed them with several project participants. These elements are summarized next.

Organization of each planning meeting. Not all companies were using structured project planning meetings. In many cases, they invited people to what they called “planning meetings” only to solve some of the technical issues in the 3D model. Moreover, these planning meetings were organized every second week, which in dynamic ETO projects was insufficient for understanding the real status of the project and did not provide enough feedback opportunities for improvements.

In many ETO companies, planning was organized and performed by the PM while s/he had to deal with other duties implied by such role. In these cases, planning became less imperative since other issues (e.g., meetings with the customer, identifying and negotiating with relevant suppliers, reporting to company management, working on a parallel project or traveling) were more demanding, required management attendance and hence crowd planning out.

There were cases where the project team organized proper planning meetings for design- and engineering activities and where the technical coordinator took, in fact, the responsibility for the planning process. S/he managed those activities by involving discipline coordinators and other relevant project participants. In these projects, planning meetings were organized at least once a week, and in some cases twice a week during peak periods. Those projects were usually delivered on time.

In all the studied projects, the first issue to analyze was the way planning meetings were organized. To start with, did the team organize any planning meetings? If yes, how, when and how often? If they used other names for these meetings, we also looked for their scope and for the planned outcome. Were these meetings in any ways connected to the project planning process? Did they use the planning process as a way to exchange information and communicate future actions?

The improvement team got involved in organizing project planning meetings in newer projects, but it did not work well when we could not attend all meetings in the same project. So we started to wonder how this situation could be avoided, and we decided to improve the existing training programs. Together with a team of engineers we put together presentations that would help other engineers understand how to create and organize planning meetings. However, something was still missing since not all meetings were conducted as recommended in these presentations. Hence, we looked at what other issues would improve the situation, and we identified the elements presented in RQ4 and its hypothesis.

The next step was to look at the content of the observed planning meetings.

Content of planning meetings. Companies that lack a good and stable organization of planning meetings discussed mostly technical issues mixed with some due dates for critical or delayed activities. In companies where planning meetings were organized often, project participants were more focused on discussing activities that needed to be completed in the near future, the need for resources in order to deliver as planned, re-work and iterations that might need extra attention. They also discussed the effects of variation orders and other iterations on the plan and how to deal with these issues properly.

In all the studied projects, we analyzed the content of each planning- or project meeting. What was the main topic of the meeting: technical or planning issues? Did the engineers use the time to discuss how to prepare activities for completion? If yes, how? Did they attempt to identify the root cause for delayed activities? How often was the planned agenda followed? Were people prepared for the meeting?

In some projects, engineers seemed to have difficulties in assessing when their activities could be completed and blame that on the lack of information from other disciplines or suppliers. Moreover, not all teams would see planning as an important issue in project meetings, arguing that solving technical problems was a good way to plan. The statement made by an engineer: "*I have everything in my head, and I do not need a plan to tell me when I should be ready,"* describes one of the challenges in implementing structured planning meetings.

To achieve a good communication process among the project participants, we had to look at who participated in these meetings. That is because we observed an interesting variation between projects where management teams were interested in inviting all relevant participants, while others would only invite a few internal representatives.

Participants in the planning meetings. Observing who participated in these planning meetings revealed that, in many cases, this was important for the ability of the project teams to organize and execute proper planning meetings. Involving all relevant departments as well as relevant suppliers, was a core issue when organizing and executing these planning meetings. Collaboration and open communication were important aspects of these project teams. In less organized planning meetings, suppliers were invited only occasionally and mostly when there was a kind of critical issue that involved their participation.

Inviting all relevant project participants to actively be involved in planning meetings was not an easy task either. One of the challenges encountered here was that not all suppliers were in fact interested in "*losing their time in such meetings…we have enough meetings."* Hence, we started to look at what kind of training programs would motivate project participants to actively attend planning meetings. The first step was to emphasize the fact that if all participants are prepared for the meeting, then meetings would be short and to the point.

Participation. Many engineers complained that they use a lot of time on meetings and besides, their activities cannot be planned due to so many factors (e.g., iterations, concurrency, too many activities, too many meetings) i.e., complexity in short. However, when project teams focused on organizing and executing planning meetings well, engineers had to participate and to involve themselves in discussions. To begin with, the reluctance to participate was obvious, but when project results started to improve, participating was no longer an issue.

In companies with little focus on planning meetings, the lack of discipline in participation was evident, and many engineers argued that they must deliver their drawings and they could not attend such meetings. They chose to participate only in those meetings discussing technical issues or in 3D modeling reviewing. The challenge here was to assist teams to understand that coming prepared for planning meetings was a prerequisite for short and effective meetings. A detailed presentation showing how to prepare for planning meetings was developed, however, not all teams applied it arguing that it takes too much of their time.

We also looked at how people understand planning. What do they mean when they talk about this subject? Do they understand the differences between planning and scheduling?

Planning. Throughout the observed meetings, we noticed that many engineers perceived scheduling as the main planning activity so they preferred to rely on a software that could plan the project. Likewise, reporting status on activities was perceived as planning of the future work, where engineers assumed that by informing the team that they did not finish the planned activities, the project can continue without significant changes in the plan. Hence, we started to discuss the implications of each term and decided to define, and explain them better. Planning was defined as an activity where project participants prepared their activities for completion in the near future, while scheduling would be defined as the activity of using software for creating a visual plan. The reporting part of the planning process was defined as the activity where project participants informed the team about what happened in the project and the current status on their activities. Consequently, we started to observe and analyze these three different elements in each project and planning meeting.

In companies where planning meetings were taken seriously, project teams would prepare for the next period activities using the prerequisite for sound activities as recommended by LPS and LPP. Some teams defined their own prerequisites, and others would use the standard ones presented in Chapter 2: external conditions, technical documentation, resources, and preceding work. In projects less focused on planning, people would just assume that the information and resources were available as planned. This was of course not the case, but applying such prerequisites was, according to these teams, too much work in such busy times.

Depending on the company's culture, engineers distinguished between "task" and "activity" associating only one of these terms with the planning process. Some companies even had a dedicated plan for what they called "tasks" as these supposed to demand less working time. Since a task was not as important as an activity, there were no prerequisites for completing them even when engineers used several hours to solve one task. In several companies, the technical coordinator or the PM would plan the “tasks” and allocate them to engineers in parallel with the already allocated activities. This type of allocation was often performed at the beginning of a week reducing engineers’ possibilities to identify constraints beforehand or to prepare in advance for executing the allocated activities. Engineers would accept the activity and tried to complete it within the allotted time even though the prerequisites were not satisfied due to delays from suppliers, change orders from the customer, or other internal issues.

In order to deal with some of the planning challenges, several training modules were developed by some of the case companies. There, engineers were taught, among other things, how to identify and deal with constraints for the planned activities. The relevant modules were also sent to suppliers so that they would learn how to report back eventual constraints in their activities. Nevertheless, due to varying interest in planning both at leadership and individual level, this procedure was implemented in only a few projects. The high turnover of people in each company required a new training round at the start of every new project, and at least one member of the team that can lead such training. In one of the studied projects, almost the entire team was changed due to several different reasons (e.g., the project manager left the company, employees advanced in other roles within the same company, paternal leave). The new team had no training in how to use the ideas implemented by the old team, so they continued the project by using the old way: no planning, just technical meetings. The new PM declined the offered training session claiming that they are too stressed to use time on training. The project was delayed by several months and with significant cost overruns for the involved organizations.

Another interesting aspect here is that when implementing LPS elements, it proved difficult to use the post-it based routine due to iterations on many design- and engineering activities, the concurrency among phases and activities and the sheer amount of information-content involved. Several teams of engineers tried this technique. However, it became difficult to follow it when there were so many unexpected dependencies and connection between activities. However, using the constraints analysis adapted to their activities seemed to work in some of the cases.

Each organization participating in a project created their own project plan based on agreed delivery dates. Some organizations had one internal plan as well as an “external” plan that was made available to collaborating partners for coordination and/or reporting. Not always, the person reporting was the same as the one who executed the jobs. Moreover, lack of communication led to low levels of trust that in turn, increased the level of detail in each plan as well as the number of legal aspects in each contract. The latter added unnecessary limitations to the collaboration among project participants.

Scheduling. The scheduling software was, most of the time connected to other software used within each organization. One example is the clocking software that needed to be connected to the planning software. In some cases, such connection required a third software as interface because the first two could not connect directly due to limitations imposed by the developers. The scheduling software was also connected to the software used by the finance team as the hours used within the project needed to be paid to each worker as well as reported in the cost accounting system. Alternatively, it was connected to the software used by the procurement department in order to register the availability of materials and components. In cases where software were different, a new interface had to be developed. Some planning software needed an interface that could connect them with other planning- or 3D modeling software used by other organizations within the project. All these connections influenced the way a scheduling software was implemented and used within each company as many of the interfaces could limit the full implementation of the software. Figure 5-16 exemplifies the connections between the scheduling software (used by the planning department) with other departments (using different software for their activities). The focus in this figure is on the number of departments and not on the software used by each of them. The arrows show the direction of the information between departments, and reflects the complexity of the information flow. This figure displays only the internal connections at one shipyard, without depicting how this information propagates within the rest of the organizations participating in each project.

The connections between the scheduling software and other departments in a company are important issues when implementing new planning procedures as some of the interfaces to connect these systems can impose limits on reporting and transfer of data. This aspect was observed in several companies and could cost substantial time and money to deal with. The result confirm that informal reporting becomes as important as the formal one.

Some of the companies producing 3D modeling software for the shipbuilding industry (e.g., AVEVA and Siemens) have developed Product Life Cycle Management (PLM) software where they integrate 3D modeling, planning, and scheduling in an effective way. However, such software applications are expensive to implement and maintain, so many ETO companies prefer to use only specific modules of a 3D modeling software and then use interfaces towards other types of software developed by smaller and often local developers.

Not all project teams were interested in using a complex scheduling software, but most of them agreed that each project would benefit from having a project planner who can deal with scheduling issues. Establishing one person that have the responsibility of providing updated plans to the project team, was always beneficial for the project. That brings us to the next issue: who should have the responsibility for the reporting process?

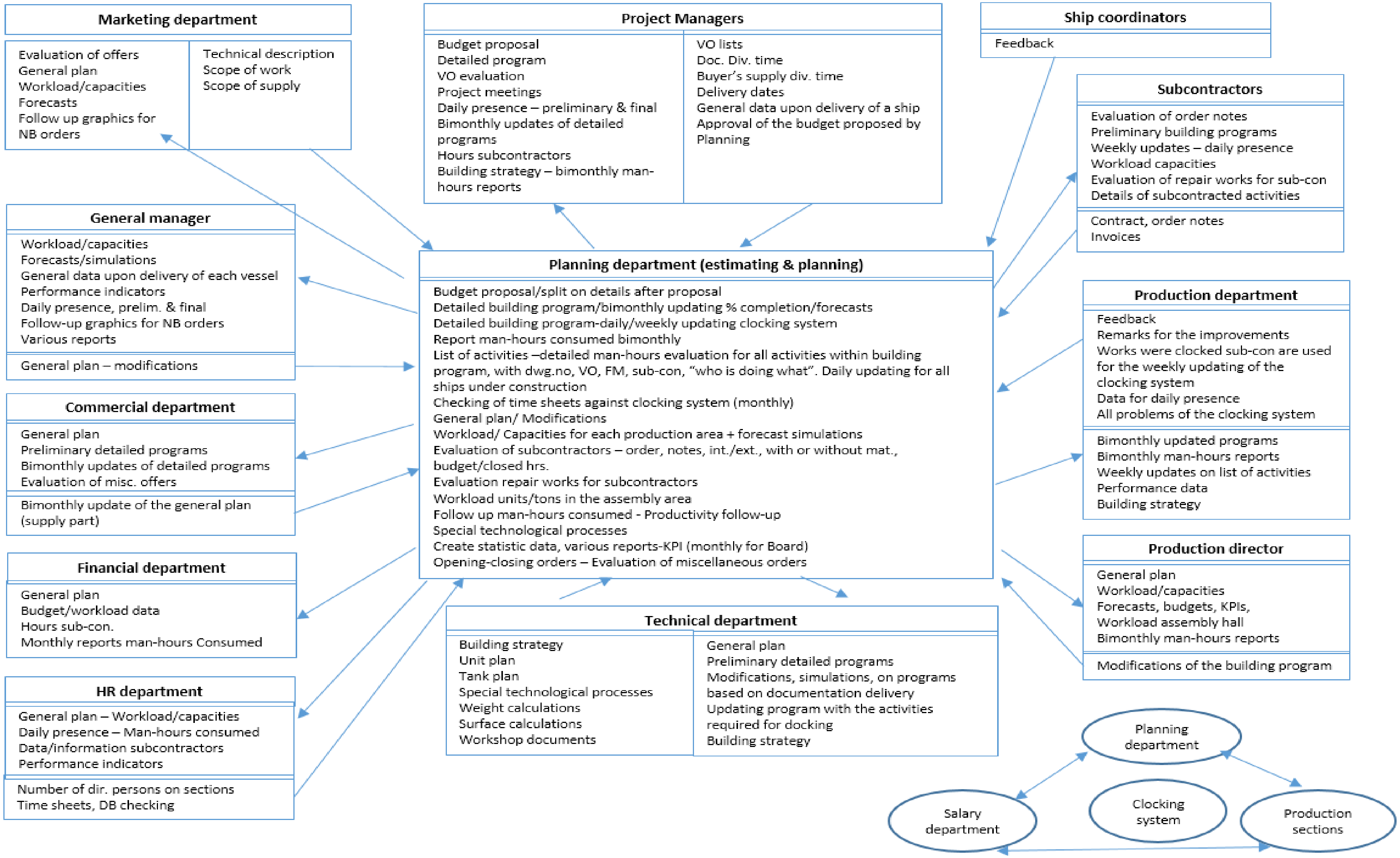

Figure 5-15: Planning department and its connections within the company

Reporting. In companies where planning was conducted in a proper way, reporting was also performed as a routine in the project. Engineers would report to the project planner several hours before the planning meeting so that delays and other relevant issues would be discussed during the planning meeting and an informed decision could be taken by the project team. There were only a few projects that used EVM as a reporting tool. That is because reporting physical progress and estimating remaining hours for design- and engineering activities can be difficult due to the major risk of iterations, or internal as well as external comments. Though, some statistics created as Excel documents were used to identify the status of the project (e.g., number of delivered drawings, number of hours used per drawing, number of engineers working in each project).

In some projects, the reporting was often performed automatically, using hours from the clocking software that were imported into the scheduling software. This type of reporting does not provide a real status of the project since there is no reference to the actual status of the activity and the actual remaining hours needed to complete it.

Another observed type of reporting was in projects where people would report the status of their activities during the meeting, taking too much time and making these meetings last more than two hours. That means participants used the meeting to other purposes than planning, which in turn resulted in less interest in such meetings.

Some project teams implemented a reporting procedure where engineers reported the status on their activities several hours before the planning meeting. Not all engineers agreed to use time on this activity claiming that either suppliers do not send information or they are too busy for such issues. Other engineers agreed to report the status of their activities through Apps connected to the scheduling software.

Yet, the kind of reporting that proved to work best is the one where issues affecting the evolution of the project were reported before the meeting then discussed and solved during the planning meeting. The training module for teaching the reporting procedure still needed some improvements at the time this dissertation was written.

In several of the observed cases, engineers would report that an activity follows a normal course almost to the delivery date when suddenly, the progress stops at about 99% and does not evolve anymore. The activity was not reported as completed; it remained a work-in-progress for several weeks or months. In other cases, engineers would change the agreed delivery date without considering the effects on the rest of the activities. When asked why, the reasons revolve around the lack of resources or suppliers who do not deliver the required information on time. Trying to discuss further such issue was challenging since not all teams were interested in applying a RCA to their problems.

Root Cause Analysis (RCA). Analyzing root cause for deviations was a scarce topic in the observed projects. That was because many engineers felt this was a way to place blame on people, and they tried to avoid such an approach. In other cases, they complain that it takes too much time, and it is out of their scope of work. Nevertheless, there were technical coordinators that created lessons learned reports showing RCA. They concluded that they need to improve their planning process in order to secure delivery as planned.

The attempts to implement RCA were unsuccessful in all of the observed projects. Many teams complained that it takes too much time and effort. Other teams would deny to put on paper reasons for non-completion, but they had to report some of those in an internal document. The scope of these reports was to assign responsibility to a project participant who should solve the issue, not to find the real cause of deviance from the plan.

Another aspect revealed during the observed meetings was the way technology was applied to improve the communication process. The idea was inspired by observing the amount of time teams used to connect to other project participants located at different places. Moreover, some teams were quite reluctant in using video conferences because they could not trust the system.

Communication technology. In some projects, the lack of trust in communication technology hindered project participants from attending meetings when outside shipyards. It seems a rather simple issue, however, most of today’s projects are dependent on good tools that facilitate information exchange and dynamic communication among project participants. At the beginning of the research period, Vard (as part of its improvement project) decided to invest in high-quality communication system based on web solutions that could connect several places simultaneously. This communication system allowed video conferences that contributed to increasing the trust among project participants.

Company X decided to use a different type of connection which was not well developed at the time. This system was also built for video conferences, but due to the high focus on internal security, it was impossible to access external entities. That was later interpreted as a lack of trust among project participants, leading to an increased focus on contractual agreements and limitations on the issues communicated during each project meeting.

Technology can enhance communication, however, project teams need to trust each other and the technology itself in order to make it work. In some projects, leadership at foreign locations would limit access to web based conferences as part of their security actions.

Beside the challenges presented above, a few additional observations are discussed next.

Additional observations

As many of the project activities are outsourced to external suppliers, many of them located at foreign lands, these would use different terms and vocabulary for their activities, creating misunderstandings within the team. Furthermore, in countries where the hierarchy is strong, middle-level managers or supervisors have no decision power and are bound by highly bureaucratic processes where nothing happens before the general manager approves it.

Another cultural aspect is that even in the same country, companies within the same group might encounter difficulties in implementing planning models that work well in a sister company. That is because each company has developed a competitive culture where their own tools are better than the ones used by other companies. Halse, Kjersem, and Emblemsvåg (2014) argue that knowledge and motivation are important factors for successful implementation of LPP and subsequently effective planning meetings. The article emphasizes the fact that successful knowledge transfer between different organizations is dependent on the absorptive capacity of each company. How to increase awareness on such issues is, however, subject to further research.

During the years of following the planning process, we noticed that the interest in actually planning design- and engineering activities vary from engineer to engineer. In cases where the technical coordinator worked closely with the project planner and kept updating plans in collaboration with all discipline coordinators, the results were better in terms of commitment and percent of activities completed as planned. That implies that the structure of each planning meeting was dependent on the person leading the meeting. Several companies recognized this aspect, and standardized meeting structures were attempted, but not all engineers abided to that. Besides, this standardization did not encapsulate how to secure good communication, and this aspect was mainly left up to the individual coordinators to figure out. For that reason, the lean meetings became a rich source of data on what constitutes good meeting practices and quality communication.

Another observation made throughout this research was the fact that implementing planning methods was often easier at the production department. However, the lack of planning at design- and engineering activities had a significant impact on the outcome of every production plans. That was also confirmed by LPP implementation both at Vard and other companies.

When analyzing the reasons for the variation in the way project teams adapted the proposed types of planning meetings, several other elements affecting the process were discovered:

- Lack of proper training in how to organize and conduct planning meetings. Some organizations were reluctant in sending people to courses or other forms for training due to the high staff turnover. Meanwhile, own training programs were shortened or delivered to only a few people resulting in a different understanding of the planning process. In some cases training was optional, and the result was low attendance.

- Involvement from the management level was one of the crucial aspects of a successful implementation of planning meetings. Yet, not all managers recognize the importance of structured planning meetings, and they are often interested only in the reports showing the status of the project and the cost of bringing the project back on track.
- Communication style was in some projects more of a one-way approach where project participants could not say no to the requirements coming from the leaders even when they knew that it would not work as planned. There were though projects where people were encouraged to discuss project problems so that the team would know how to deal with each specific situation.
- A culture of placing the blame was observed in several projects. Usually, the blame was on suppliers, or other disciplines, rarely on the ones discussing the problem. In other projects, the team was more focused on finding solutions to a problem regardless of who was responsible for it.
- Some engineers used a significant amount of time in learning more about planning, while others would claim that this is a planner’s role, and they did not need to learn such things. Some project managers and engineers were more interested in planning than the rest of the team. When having the power to decide in the project, many of them managed to implement some changes in the planning of their projects, but, in cases where neither the project manager nor the technical coordinator had an interest in planning, changes were often postponed or rejected.
- Applying lessons learned from one project to another seemed to be influenced by the short project duration that strained the employees who usually found own “best solution” with little regard to similar problems from the past. Likewise, high staff turnover resulted in difficulties in applying the lesson learned method.

In order to deal with these elements, we started to look at possible solutions, as described in Chapter 6. However, successful implementation of any solution is dependent on each organization’s desire to learn and develop at a faster pace than today’s style. Creating the right environment for learning and developing own people is necessary since many of these things are not common subjects during the education process for engineers. No shipbuilding companies can afford delays or cost overruns in the long run, and they must deliver their projects according to contractual agreements if they want to survive. Investing in proper training for project participants, where all aspects of the planning process are considered, is becoming a necessity, not just a choice.

5.12 Key points from the case description

The case description chapter proved to be, like the theoretical one, a long and complex description of how planning happens in practice and what are the factors affecting the whole process. This is a way to validate once again the inherent complexities in planning ETO projects in general, and their design- and engineering activities in particular. Some of these complexities are recognized by the literature presented throughout Chapter 2, like: CE, iterations, and outsourcing. The influence of elements like DfM, network organized projects, and 3D modeling on planning is largely ignored by the studied literature even though these are part of the daily practice.

As shown through the cases described in this chapter, most ETO companies are interested in developing better planning and control methods for their design- and engineering activities. That is because:

1. CE, Iterations, DfM are factors that affect the planning process as they need continuous updating, good communication, and commitment among project participants.
2. Traditional project management approach lacks tools that can deal with the challenges identified in the ETO shipbuilding projects.
3. Du to extensive outsourcing, the project team has become a network of different organizations collaborating in delivering a highly customized, one-of-a-kind product. Defining a project plan that include information from these organizations is dependent on good collaboration and trust among them.
4. The planning process is connected to several other processes within the company and must be considered when planning a project. To my knowledge, there is little research on the connectivity among planning processes and systems within ETO projects.
5. Most observed projects lack structured project planning meetings as an arena for communication, commitment, and dynamic information sharing.
6. Planning design- and engineering activities is a process that depends on the experience, interest, and efforts each coordinator puts into developing plans, running dedicated project planning meetings and creating the commitment needed from each discipline coordinator.

The items 5 and 6, are the main topics discussed in the next chapter as they relate directly to the hypotheses and the research questions. However, once these topics are explored and hypotheses hopefully accepted, the implications for the grander picture, as addressed by RQ1 and RQ2 and items 1 – 4 above, will be discussed.

Chapter 6

Findings and discussion

6 Findings and discussion

"No one can whistle a symphony. It takes an orchestra to play"

H.E. Loccock

In this chapter, the main findings and contributions are presented and discussed. These findings are based on observations made in all case companies and further verified by other research projects. Even though Vard was the main case company, additional research projects within other ETO companies contributed directly and indirectly to the findings presented in this chapter. The logic used in developing the proposed research questions (plus two hypotheses) and building their solutions is illustrated in the V-diagram (inspired by the systems engineering approach), Figure 6-1.

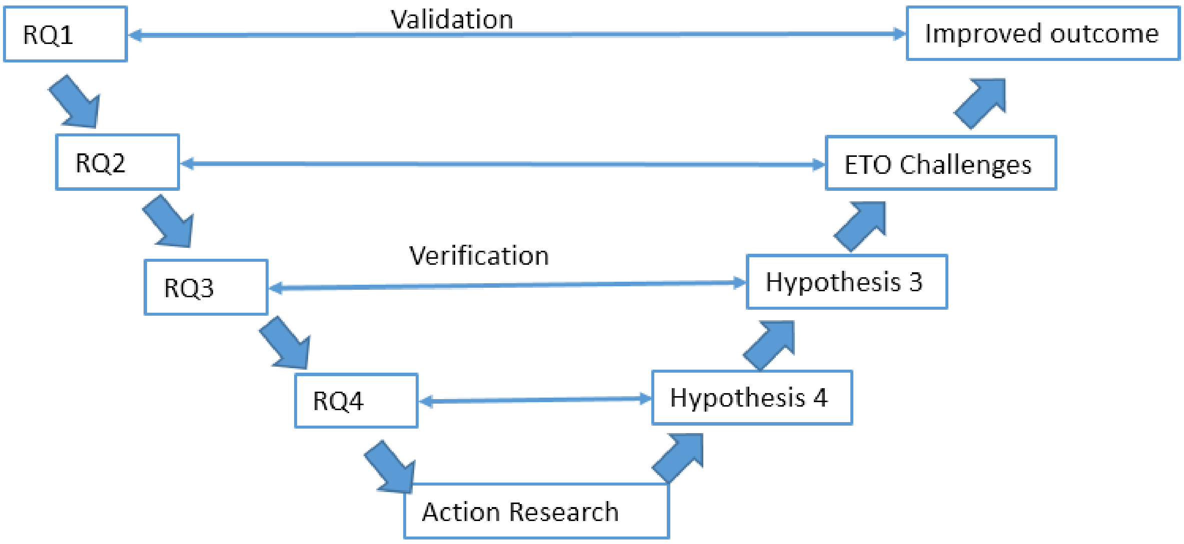

Figure 6-1: Logic of building the research

The research started with a high-level research question from which were developed three sub-questions. RQ1 refers to how to improve the planning process in ETO projects, however, since both practitioner and researchers agree that this is a challenging process, mapping the reasons for these challenges was one of the first steps in this research. The sheer complexity of planning ETO projects is also evident from Figure 4-1, where it is clear that managing all phases and activities of such an undertaking is a daunting task. Since production planning has received more attention, yet, projects were still delayed, a logical approach was to look at the planning of design- and engineering activities. The reason is that a closer look at the causes for delays in production, revealed that delayed, sometimes incorrect, and/or incomplete drawings/models were one of the main sources of problems. Thus, RQ2 was developed. To answer this question, a literature review method was applied, as well as testing the hypotheses associated with RQ3 and RQ4. Observing the way planning meetings were organized, the improvement team identified a lack of planning meetings in general, and structured planning meetings in particular, in most of the projects. Yet, teams organizing explicit planning meetings were able to have a better overview of their projects as well as to deliver on time. Thus, the hypothesis for RQ3 was formulated.

After participating in several projects, the team concluded that, in order to achieve well-structured meetings, we needed to identify what other elements should be considered without venturing into a completely different field of research, e.g., linguistics, as that would have made the research too large for the allotted timeframe and budget. Hence, we had to investigate what was relatively concrete and non-linguistic, and the result was the hypothesis to RQ4. The elements identified at RQ4 together with the proposed type of well-structured planning meeting were verified and validated by the improvement teams, other project managers and engineers, as well as by the lean and lean construction literature. The proposed solutions to the RQ1 are intended to provide a solution for an improved outcome of ETO projects by focusing on the way their design- and engineering activities are planned and controlled.

Throughout Chapter 2, were presented several theoretical stances. Table 6-1 aims to present how these theories are used to underline the findings in each of the proposed RQs.

Table 6-1: Summary of theories used in argumentation

Research Questions		**Applied theories and concepts**
RQ1	How can we improve the planning process in ETO projects?	OM and Project management ETO Iterations, CE, DfM Lean and LC LPSand LAP LPP and Communication
RQ2	What are the main challenges of planning design and engineering activities in ETO projects, and how can these be handled?	OM and Project management ETO Iterations, CE, DfM Lean and LC LPSand LAP LPP and Communication
RQ3	What planning meeting structure produces better outcome?	CE and DfM Lean and LC LPSand LAP LPP and Communication
RQ4	Apart from meeting structure, what other elements are important to ensure the best possible communication and interaction between project participants to the benefit of the project outcome?	Lean and LC LPSand LAP LPP and Communication

After providing the logic of building the research questions and their theoretical support, it is now time to present the findings. Since RQ1 is a high-level question, it seemed more logical to start with the findings for RQ2, RQ3, and RQ4. The proposed answer to RQ1 is provided toward the end of this chapter as it relies on the findings from the three sub research questions, as indicated in Figure 6-1. For now, RQ2 is answered as this sets the context for the acceptance/rejection of the hypotheses belonging to the third and fourth research questions.

6.1 Findings in RQ 2

RQ2: "What are the main challenges of planning design- and engineering activities in ETO projects, and how can these be handled?"

This question was triggered at the beginning of this research when the main case company started to implement the LPP approach in its projects. While the company managed to successfully implement it for the production activities, using the same approach for design- and engineering activities posed several other challenges. Hence, the idea of finding what these challenges are and how do they affect the planning of design- and engineering activities. To begin with, a literature review was performed, and its results were presented in Kjersem and Emblemsvåg (2014). Yet, the general lack of research literature in the ETO environment (Willner et al. 2014) led to only a few challenges to be discussed in our article, so the search had to be developed further. The results are presented in Chapter 2 of this dissertation. A summary of ETO challenges is presented in Table 6-2 where both findings from the literature and case studies are connected to how the planning process is influenced by these. The variety and complexity of these challenges indicated that focusing on scheduling activities alone, is not the best solution since not all of them can be modeled within the planning algorithms. Arguably, there is a need for an approach that brings LAP and communication elements as a supporting feature to the system-based type of planning used by most ETO companies.

Two conclusions can be derived from the studied literature: 1) it does not provide a comprehensive and systematic review of all the challenges in planning ETO projects, and 2) it provides no planning tools that would adequately address such challenges. That is also due to the complexities of ETO projects, as well as large varieties of ETO types of companies

The answer to RQ2 is divided into two parts: the first one categorizes the challenges within ETO projects and is presented next, while the second part proposing solutions based on findings from RQ3 and RQ4 is presented in Section 6.4 of this chapter.

Table 6-2: Summary of ETO challenges

ETO context	Relevant Elements	Consequences	Challenges for the planning process
Project based approach	Network organized projects	Several PO involved in each project	Long and complex information flow between the involved organizations. Information exchange at project managers level (Gray and Larson 2006).
	Traditional scheduling	Focus on system	A rigid plan that is difficult to update. Lack of focus on the planning process (Laufer and Tucker 1987, Shenhar and Dvir 2007)
Customer involvement	Flexibility/ Incomplete spec.	Customers want to keep solutions open late in the project	Activities must be often re-planned. Big fluctuation on resources allocation. Delayed decisions due to customer requirements (Bertrand and Munstlag 1993)
	One of a kind	Several customized elements	Often long lead time for such products (Jin and Thomson 2003). Suppliers achieve more power in the negotiating prices and delivery time
	Iterations	Several reviews per drawing	Planning and re-planning completion of drawings (Eckert and Clarkson 2003, Jarratt, Eckert, and Caldwell 2011, Wynn, Eckert, and Clarkson 2007)
Outsourcing	Phase-based projects	Silo thinking as every org. wants to maximize own results	Each organization creates own plans without considering plans from the rest of suppliers (case)
	Many specialized suppliers	Many adapted or customized components	Suppliers need more data and time to deliver highly customized component (Gosling et al. 2015, Willner et al. 2014)
	Geographically spread project organizations	Multicultural organizations, different planning strategies	Each organization uses own terms and approaches to planning. Language differences challenge communication among participants (Hoegl, Muethel, and Gemuenden 2012)
	Flexible workforce	Labor intensive, need for high-skilled workers	Shipyards count on hiring additional workforce during peak periods. Challenging at times of high order levels within the region (case)
Shorter lead-time	CE	Closer and shorter interdependencies among activities	Planning activities with interdependencies is dependent on dynamic information from all org. involved (Emblemsvåg 2012, Kristensen et al. 2003, Zidane, Bjørkeng, et al. 2015)
Lower project cost	DfM	Need for open and trustful communication among project participants	Suppliers should be involved in the planning process so that their capabilities are always considered (Gosling et al. 2015). Designers and engineers must consider production capabilities when modeling /drawing (Hamidi and Farahmand 2008)
	Labor shortage	Difficult to cover the peaks of resource need	High fluctuation on quality of workers. Resource allocation can be challenging. People work in several projects simultaneously (Gosling et al. 2015)
Technology	3D modelling	Involves more specialized engineering and more details in each drawing Different modeling software	Requires specialized functionalities (Sacks, Eastman, and Lee 2004). Higher number of activities to be planned, reported, and controlled. Difficult to measure progress on (Sacks and Barak 2005) due to interdependencies and iterations. Engineers use more time in transferring drawings between different software
	Planning software	Different planning software and methodologies Difficult to transfer data between	Transferring specific data between companies implies limitations within the software. Not all software developers accept connections with external software (Andrade, Montiero, and Gaspar 2015)

In addition to the challenges shown in Table 6-2, a specific approach within shipbuilding projects is the division between concept design, basic design, detail engineering, production engineering, and verification phases as shown in Figure 5-8. There are several factors that drive this division: 1) the classification societies and their role in the approval process, 2) shipyards using external design and/or detail engineering, which implies well-defined roles and responsibilities among different entities, and 3) the phase-based project management type of the work. Such a division implies that each team plans their own activities based on information from each other and information from customers and some of the relevant suppliers. Hence, collecting the information necessary on each working stage is accomplished through a much longer chain of relations among project participants.

Moreover, exchanging information in such a divided environment can be hindered by a lack of trust and longer communication channels among the project participants, which leads to the LAP aspects of the planning process. Understanding this aspect is essential since most engineers perceive planning as the activity of using a software to schedule a project. In one of the interviews, a leader stated: "*in many planning meetings, we discussed about the importance of reporting in a system, but not about discussing with each other*". The importance of planning meetings as an arena for social interaction needs to be better emphasized, especially for ETO projects that bring together a network of organizations which should learn to understand each other.

Most of the challenges identified within the ETO literature are indeed recognized by the shipbuilding industry as factors that hinder better planning and control of their projects, specifically of design- and engineering activities. As shown in Figure 1-1, the shipbuilding industry agree that over 76% of the nonconformities originate in methods/procedures used in management, planning, drawings, production, specifications, and system. Furthermore, Zidane, Johansen, et al. (2015) reveal that many project teams agreed that they need to improve their working methodologies and they often refer to management, planning, and purchasing as priorities of the improvement process.

As revealed in Chapter 5, most of the project teams were interested in improving their planning processes, yet, many of them relied heavily on a schedule that should not need big changes even though this was created at the beginning of a project. The planning process was not considered as important as the system part, as described in LPP, especially because engineers preferred to rely more on technology than on people. Or as Fawcett et al. (2007) state, technology is often viewed as the answer rather than as an enabler.

Analyzing the challenges presented in Chapter 2 and summarized in Table 6-2, it became clear that these are not easily solved entirely by using planning algorithms/software. ETO is a dynamic and complex environment influenced by new technological advances that constantly demand new solutions and approaches to solving engineering challenges. Therefore, managing and planning such projects should rely much more on a planning process that supports communication and a proper information flow. Based on the findings within the industry and LPS recommendations, it can be argued that increased focus on the process of planning ETO projects could provide a better solution. A place to start was the way the observed projects organized their planning meetings as part of the planning process.

One of the observations made during the collecting data period, and presented in Chapter 5, shows that most ETO projects lack an arena for discussing planning issues that concern their design- and engineering activities. Many of the observed project meetings were focused on discussing technical issues. Therefore, the solution proposed in this research is based on organizing dedicated planning meetings that combines elements from lean, LPS and LPP while considering the dynamic ETO context and the inherent complexities of design- and engineering activities. That is because lean practices are often “low-tech” but heavy on leadership and real interaction between people – an acknowledgment of the fact that systems cannot replace human interaction as also discussed by Macomber and Howell (2003). Or, as Flyvbjerg and Budzier (2015) put it, one needs to understand simplicity before struggling to model complexity.

To help understand how various approaches to the execution of the planning meetings result in different project performance, three archetypical planning meetings were identified. These categories emerged during the research years, and in the following, each of these categories is presented. By comparing them, it can be shown how the different proposed archetypes work and what will make them improve. This will enable testing of the hypotheses of RQ3, and RQ4, as presented in the next section.

6.2 Findings in RQ 3

This research question was proposed as a consequence of observing that not all projects were actually organizing planning meetings for their design- and engineering activities. Besides, most organizations assume that engineers or technical coordinators know how to plan, organize and lead project planning meetings, which is not always the case. RQ3 and its hypothesis are:

RQ 3: “What planning meeting structure produces better outcome?”

Hypothesis RQ3: “*Well-structured planning meetings for design- and engineering activities improve the project outcome*”

The traditional project management literature recommends organizing kick-off meetings at the beginning of each project, and these meetings are quite well described in terms of content, participants and issues to be discussed during such meetings, see for example (Kerzner 2013a). All observed projects followed this recommendation, and they all organized quite comprehensive kick-off meetings (some of them with more than 50 participants representing all disciplines and all relevant suppliers). In fact, on most milestone plans, one of the first activities was *arranging kick-off meeting* within a month after the contract signing. Participants in these meetings discussed issues regarding estimated costs and time for producing some of the most demanding parts of the project as well as issues about the organization of the project. The main scope of kick-off meetings was to achieve a common understanding of the aim of the project, and most projects seemed to manage that. A topic that was little or not discussed during these meetings was the topic of project planning meetings and how they would be arranged. However, most of the studied cases had to organize some kind of project meetings during the project execution.

Throughout the research period, I have participated in over 388 project planning meetings at different levels and in several different companies, as explained in Chapter 5. Having a background in lean shipbuilding and understanding the principles behind LPP while participating in those meetings allowed me to search for the elements that were actually missing from these meetings. Moreover, working directly as a project planner introduced me to the internal vocabulary and specific culture of the shipyards and their suppliers. All these opportunities led to a good understanding of the interdependencies and of the background information among plans and participating organizations, which is a key factor in determining the improvement possibilities. In addition, as part of the group working with the standardization of the planning process and with LPP implementation, we discussed often issues regarding organizing project planning meetings.

Based on the data collected, three archetypical planning meetings were identified. These archetypes describe how project teams address project planning in their meetings. However, inspired by LPS, LAP, and LPP, a fourth type of planning meeting is proposed as an improvement over the third type since there were several elements that could create even better outcomes. The identified archetypical planning meetings and their extent within the observed meetings are:

1. Business-as-usual planning meetings – About 115 out of 388 project meetings are be included in this category. This represents about 30% of the total meetings
2. Semi-structured planning meetings – About 234 out of 388 project meetings are be included in this category, representing about 60% of the total meetings

3. Structured planning meetings – Just 39 out of 388 project meetings fit to this category, which represents roughly 10% of the total meetings
4. Lean planning meeting – no examples. It is a prescriptive model since the aim was to develop a training procedure that would result in implementing this type of meeting

These archetypical planning meetings were identified by analyzing the elements of structured planning meetings and comparing them with the other types of meetings observed in other projects. Discovering what was working in those meetings and why, became a part of the data collection mostly because differences were quite visible, especially compared with meetings where planning was not an issue. Before presenting each archetype, a short description of the AR steps taken during the research process is in place.

6.2.1 AR steps

Since previous results in implementing LPP provided good results for the production activities, the improvement team started to analyze how the planning of design- and engineering activities could also be improved. An important reason was that LPP implementation revealed once again that delayed drawings were a major reason for problems in production. A closer look of the root causes was in place. The team decided to start with a mapping process (see Figure 4-1) where connections between participating organizations as well as the type of exchanged documents were revealed. During this mapping process, we participated in planning meetings organized by design- and engineering teams. The first observation was the obvious differences between approaches to each of these meetings. Consequently, we started to ascertain and categorize the elements that were making these differences visible.

To start with, we applied the rules for effective meetings as provided by Liker (2004), the LPS prerequisites (Bertelsen et al. 2007), as well as recommendations made by LPP (Emblemsvåg 2014b), to identify the elements that were contributing to planning meetings that seemed to work best. Since most of the team members had several years of experience within the shipbuilding industry, it was relatively easy to identify the projects providing good results in terms of delivery precision and budget.

The elements were identified gradually from one project to the next and we were constantly working on finding actions that would improve these elements. However, the dynamic shipbuilding environment led to challenges in applying the proposed improvements to the same project as the one that served as a starting point. Consequently, the evolution of implementation looks more like the one illustrated in Figure 6-2.

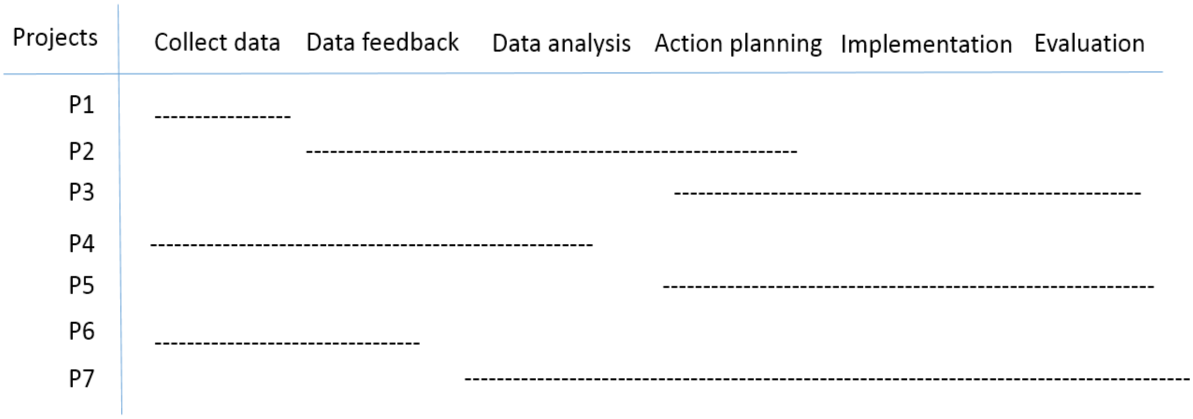

Figure 6-2: The evolution of the implementation process

This figure depicts several loops of the implementation process. We started with the first project (P1), which was in its second half of the execution stage. There, we identified some of the elements to be improved. The main reason for starting with this project was that part of the improvement team was also part of the project team.

We used several of the lessons learned in this project to define elements that could be implemented in the second project (P2). This project was also already started, but at an earlier stage. So, we tested some of the ideas on the planning meetings organized for this project. However, the setting evolved fast. Implementing changes from one meeting to the next proved challenging since some of the identified elements needed to be implemented from the beginning of the project in order to make sense throughout the project's evolution. A good example here is EVM that is dependent on a baseline established before the project starts if reporting should be used as a tool for avoiding big deviations from the plan. Moreover, teams using EVM needed a proper training program where everyone understood how to implement and use the tool. Therefore, the team had to adapt to each project's framework and status when proposing improving elements.

The data collection, data feedback, and data analysis processes were performed more often than the last three phases (action planning, implementation, and evaluation) of the AR process since we were actively participating in planning meetings and observing how they evolved. The action planning phase was most of the time well documented before we decided what should be implemented and where. After agreeing with the new project team on the starting date, we would develop and present a dedicated training program (e.g., how to use constraints analysis, or how to use RCA). Most of the time we were also participating during the implementation phase in order to collect data for the evaluation phase.

Nevertheless, the window for implementing changes was also relatively short since most of the relevant planning meetings for design- and engineering activities were organized before the hull would arrive at the Norwegian shipyard. In some projects, this period was just a few months. Therefore, most of the time, our team proposed an improvement based on one project's evaluation, and implemented in a newer project, sometimes at another shipyard and another type of vessel. However, since the improvement team remained almost the same throughout the whole process, our notes, propositions, documents, as well as presentations made as part of the training process followed a red thread based on continuous improvement.

Several members in the improvement team were acquainted with lean concepts and LPP implementation in production. We were also reporting and discussing the evolution of our work with the leaders at the shipyard and later with section leaders within the group. At Company X, we discussed each AR step with the project manager and with the company's management team. One of the biggest challenges in our implementation process was that not all teams were, in fact, willing to use the time to plan their projects. The result of such thinking is described in the first archetype of planning meetings.

The archetypes identified in this dissertation are a result of several years of working with improving planning meetings for design- and engineering activities. To introduce the proposed elements, a question for understating their roles in the planning meeting is attached to each one of them. As stated above, the elements are inspired from the lean literature, LPS and LPP. There might be several other elements that ensure a good planning meeting, yet, the ones presented in this research are the ones we operationalized based on the collected data:

1. Organization – how are these meetings organized?
2. Content – is the content of the meeting dedicated to planning issues only?
3. Participants – are all relevant people invited?
4. Participation – is participating mandatory?
5. Planning – is the team preparing for next periods activities?
6. Scheduling – how is the team re-scheduling activities during the meeting?
7. Reporting – do project participants report during the meeting?
8. Root-cause analysis – is RCA applied to the non-completed activities?
9. PPC and EVM – what kind of KPI's are used during the planning meeting?
10. Communication technology – how was it working?

The six recommended AR steps (Coughlan and Coghlan 2002) performed for each of the proposed elements are summarized in the following ten tables.

Table 6-3: Organization of the meeting

AR steps - Organization of the meeting	
Data gathering	This process targeted information about the organization of each meeting. Elements observed: how, and how often the meeting was organized
Data feedback	The improvement team shared the data within the team and discussed the findings in weekly meetings. In other companies, these issues were discussed with the project manager and the leader of the company
Data analysis	Structured the data by using the frequency of meetings. This resulted in a presentation of the results among the involved participants
Action planning	The importance of organizing planning meetings is emphasized and discussed with each project team. The management team introduced the rule that each project should organize planning meetings weekly
Implement	Implement weekly meeting in existing and new projects
Evaluate	Some project teams still reluctant to use time on planning meetings

Table 6-4: Content of the meeting

AR steps - Content of the meeting	
Data gathering	This process targeted information about the content of the meeting. Elements observed: topics discussed during each meeting
Data feedback	Data were shared within the improvement team. In other cases, data was discussed with the involved project managers and leaders of the company.
Data analysis	Data were structured based on the topics discussed during the meeting. Main categories of topics: technical, procurement, and planning
Action planning	Create a presentation about the observed trends and make this issue part of training material for the project teams
Implement	Organize training sessions for teams working in already started projects as well as in new projects. Follow up by participating in next meetings
Evaluate	Pressured by delays, some project teams were still discussing mostly 3D modeling issues. Other teams managed to increase the focus on planning topics

Table 6-5: Participants in planning meetings

AR steps - Participants	
Data gathering	This process targeted information about who was participating in a planning meeting. Elements observed: number of participants and their roles regarding to the project, as well which department they were representing
Data feedback	Data were discussed within the improvement team and project managers.
Data analysis	Data structured based on observed elements. The number of participants varied between projects, and there was no agreement on who should participate in each meeting or who should participate only in specific meetings.
Action planning	Identify how many of the participants are relevant in each meeting and create an explanatory material to be introduced in the PES. Use the project plan to decide representatives to be invited in specific meetings
Implement	Establishing the number of participants at each relevant stage of the project became a section within the project execution strategy
Evaluate	More relevant suppliers were invited to these meetings. This resulted in more updated information within the project team. However, some project teams remained reluctant to invite so many people since these meetings were a “waste of time”

Table 6-6: Participation in planning meetings

AR steps - Participation	
Data gathering	Data collection targeted information about the discipline of the meeting. Elements observed: if the meeting was mandatory and for whom, punctuality of the start, if people were well-prepared before the meeting, and how active they participated in the meeting
Data feedback	Data were discussed within the project team and with company leaders
Data analysis	Followed a structure based on the observed elements. How would project teams increase the preparedness of the participants and meeting discipline?
Action planning	Create a training material where the observed elements were introduced as a mandatory part of each meeting.
Implement	Several project managers and company leaders attended the meetings in order to emphasize the importance of these meetings. Several points about the discipline of project meetings were added to the PES document
Evaluate	It contributed to more discipline and more focus on active participation. However, the point of coming prepared for each meeting was more difficult to implement due to the high workload on most of the engineers

Table 6-7: Planning activities

<table>
<tr><th colspan="2">AR steps - Planning</th></tr>
<tr><td>Data gathering</td><td>This process target information about planning applied as a proactive tactic by each project team. Elements observed: level of details in the plan, active discussion on the next week's activities, use of constraints analysis and how delayed activities were re-planned in relation to next week's plan</td></tr>
<tr><td>Data feedback</td><td>Data were discussed within the team and with project planners at several companies</td></tr>
<tr><td>Data analysis</td><td>We structured the data, and the result showed different approaches to the level of detail in each plan. While some companies chose to maintain a plan with less than a few hundred activities, others would have several thousand activities. That required more detailed analysis on the most appropriate level of details on each plan. The conclusion was to start at the period plan level</td></tr>
<tr><td>Action planning</td><td>Develop and implement a training material about how to use constraint analysis for design- and engineering activities</td></tr>
<tr><td>Implement</td><td>The training material was presented for several project teams and then made available on the intranet. The period plan was adapted to include constraints analysis. These would be completed before the planning meeting so that during the meeting, only the problematic ones would be discussed. The two tables under illustrate different approaches to deploy constraints analysis.
<table>
<tr><th>SFI/ Doc nr.</th><th>Activity</th><th>Planned start (week)</th><th>Planned finish (week)</th><th>Comments</th><th>Responsible</th><th>Status</th><th>Previous activity</th><th>Information</th><th>Resources</th><th>External conditior</th></tr>
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<tr><td>xxx-263-315</td><td>Foundations for SB crane</td><td>24.03.2012</td><td>05.05.2012</td><td></td><td>KKJ</td><td>Com</td><td>0</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>xxx-209-201</td><td>Unit 20</td><td>24.03.2012</td><td>05.05.2012</td><td></td><td>KKJ</td><td>WIP</td><td>0</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>xxx-209-401</td><td>Unit 40</td><td>26.03.2012</td><td>07.05.2012</td><td></td><td>KKJ</td><td>NS</td><td>1</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>xxx-511-001</td><td>Accommodation arr. Main deck</td><td>27.03.2012</td><td>07.05.2012</td><td></td><td>KKJ</td><td>NS</td><td>1</td><td>0</td><td>0</td><td>0</td></tr>
</table>
<table>
<tr><th colspan="7">Project Yard</th><th colspan="6">Delivery and Status</th></tr>
<tr><th>Discipline</th><th>Group</th><th>SFI</th><th>Title</th><th>Preceding Work</th><th>Technical Input</th><th>Resources</th><th>Contractual Week</th><th>Contractual Delivery</th><th>Agreed Delivery</th><th>Preliminary Delivery</th><th>First Delivery</th><th>Remark</th></tr>
<tr><td>Electrical</td><td>216</td><td>890-001</td><td>Electrical installation Equipment list</td><td>⚠</td><td>⚠</td><td>⚠</td><td>2015 • 30</td><td>26.07.2015</td><td></td><td></td><td></td><td>To be delivered by HET (date?)</td></tr>
<tr><td>Electrical</td><td>216</td><td>425-010</td><td>Lay-Out of Internal communication on GA</td><td>⚠</td><td>⚠</td><td>⚠</td><td>2015 • 31</td><td>02.08.2015</td><td></td><td></td><td></td><td>To be delivered by HET (date?)</td></tr>
<tr><td>Electrical</td><td>215</td><td>891-023</td><td>SwitchBoard room arrangement, Lay-Out</td><td>⚠</td><td>⚠</td><td>✓</td><td>2015 • 35</td><td>30.08.2015</td><td>18.10.2015</td><td></td><td></td><td>will ensure that pumplist is updated and</td></tr>
<tr><td>Electrical</td><td>251</td><td>850-002</td><td>Electrical Load calculation</td><td>⚠</td><td>⚠</td><td>✓</td><td>2015 • 35</td><td>30.08.2015</td><td></td><td>30.08.2015</td><td>28.08.2015</td><td>Preliminary based on similar ship</td></tr>
</table></td></tr>
<tr><td>Evaluate</td><td>Some projects managed to partially implement constraints analysis, which resulted in improved accuracy of deliverables. However, high staff-turnover, led to less focus on the matter after a few years</td></tr>
</table>

Table 6-8: Scheduling

AR steps - Scheduling	
Data gathering	Data collection process targeted information about how the scheduling activity. Elements observed: how and who performed this activity.
Data feedback	Data were discussed within the team. We also discussed it with project planners and project managers
Data analysis	In many cases, each project had a project planner who was responsible for collecting data from project participants and then introducing them in the scheduling software. However, not all data was available on time, and not all plans showed dependencies between activities and phases
Action planning	Establish specific reporting days for all project participants so that the project planner would schedule/re-schedule as planned. An updated schedule would be sent to the project team. Develop plans containing dependencies between relevant activities and phases
Implement	Planners developed schedules containing dependencies between activities and phases in each project
Evaluate	In some companies, this approach worked well, and plans were updated as planned. However, some engineers would remain reluctant to plan their activities, and the result was a schedule that did not reflect the real status of the project

Table 6-9: Reporting

AR steps - Reporting	
Data gathering	This process collected information about how the reporting activity was performed. Elements observed: how often this activity was organized, who reported to whom, and what kind of data was reported
Data feedback	Data were discussed within the team, project managers and project planners
Data analysis	Data were structured based on the categories above. Several differences in terms of timing of the reporting were detected among companies: some companies were organizing reporting activities weekly, while others bi-weekly. The cases using the latter approach had little control over their activities, and there projects were suffering significant delays The second issue, concerning who reports to whom, revealed different approaches: 1) engineers were reporting progress and number of used hours directly to the project planner; 2) engineers were using the clocking system to register the number of hours used per activity. With the latter approach, the planner used the scheduling software to calculate the status of each activity as well as the number of remaining hours regardless of the real status of those activities. There were also differences in the way each company was measuring the progress of each activity. Some were using a generic type of status like work-in-progress, completed, sent for approval, and not completed. Other companies were using a predetermined scale connected to the number of used hours (e.g., 5 hours =10% completion of that activity). Only a few suppliers were reporting the status of their activities.
Action planning	Develop and implement training material where reporting was standardized to a weekly reporting that would have been concluded before the planning meeting so that the results could be evaluated during the meeting Develop procedures for who reports to whom. The proposed solution was that engineers would report to discipline coordinators who then sent the data to the planner. Develop a standard procedure for what data to be reported (e.g., physical progress, number of used hours, and an estimate of the remaining hours) Develop a procedure for suppliers' reporting without having to reveal sensitive information
Implement	Training sessions were held for several projects. Weekly reporting was implemented in many of the studied companies. Reporting to coordinators was implemented in most of the projects Procedure for suppliers' reporting was developed and implemented in several projects
Evaluate	Projects introducing weekly reporting improved significantly the control over the status of their project. However, not all companies agreed on weekly reporting arguing that it takes too much time. Engineers reporting to coordinators helped the latter to achieve a better overview over the status on their activities, and over the resource allocation. Suppliers' reporting was more complicated than expected since each of them use own performance measurement metrics. It took several more years to achieve an agreement, but that issues is no longer part of this research.

Table 6-10: Root-Cause Analysis

AR steps - RCA	
Data gathering	We collected information about if and how RCA were used during the project. Elements observed: how deviations from the plan were recorded, where and if the root-causes were discussed
Data feedback	The improvement team shared the data within the team and discussed them in our weekly meetings
Data analysis	Structure data based on categories of answers: not knowing what RCA is; reluctance to use RCA; misunderstanding the role of RCA (to place the blame)
Action planning	Make a presentation about RCA. Create an RCA column in the project plan
Implement	Coordinators and planners have the responsibility to identify RCA by using 5 whys technique
Evaluate	Workers were still reluctant to put RCA on paper and there was a need for even more training in how to use 5 whys. Discussions on who should be responsible for asking these questions

Table 6-11: PPC and EVM

AR steps - PPC and EVM	
Data gathering	We collected information about if and how PPC and EVM were used during the project. Elements observed: calculation of PPC and baseline for EVM
Data feedback	Data were discussed within the team and with company leaders
Data analysis	Data were structured based on the observed elements: using or not PPC or EVM techniques; other KPI's used for measuring the performance of the team
Action planning	Develop training material for implementing PPC and EVM. While PPC could be tried in already started projects, EVM could be implemented only in new projects due to its dependency on a baseline established at the beginning of the project
Implement	PPC and EVM were implemented partially in several projects. Training courses were provided to coordinators and project managers
Evaluate	PPC needed some improvements in order to fit design- and engineering activities because engineers could not define the real end of an activity due to iterations and change orders. A technique that could take these factors into consideration was still under development at the end of the research. EVM was partially implemented, but a high number of activities, as well as differences in the ways each company measure the progress of these activities, led to another iteration on the process (not part of this research).

Table 6-12: Communication technology

AR steps - Communication technology	
Data gathering	We collected information about how each project team used existing technology to connect with participants at external locations. Elements observed: time used to connect, type of connection (video or audio), possibility to share data live, availability of project data on Share Point
Data feedback	Data were discussed within the team. At a case comapny, project manager, and the management team were participating in these discussions.
Data analysis	We structured the date based on the observed elements. The analysis reveal lack of good technology to support the connection within the project team (e.g., slow network, imposed limitations on the number of participants, and difficult to share screen with external participants) The analysis revealed the need for a revision of the Share Point so that access to project data could be improved without jeopardizing the data security
Action planning	Find solutions to improve connectivity. Analyze the applied structures on intranet and on Share Point. Develop a procedure for what documents should be uploaded on Share Point, by whom and in which file
Implement	Implement better communication software that allowed the connection of several participants at the same time. Improve the Share Point solution by restructuring the type of data allowed to be accessed by external suppliers
Evaluate	The new solution improved the quality and speed of the connection. However, data security posed some challenges in implementing some of the existing solutions. This issue became a continuous work-in-progress by the end of this research.

The elements described above, are now identified and analyzed in each of the proposed planning meeting archetypes for design- and engineering activities.

6.2.2 Business-as-usual type of planning meetings

This type of meeting was identified in projects where neither project manager nor technical coordinator were interested in project planning. For them, the formal type of planning based on reports generated by the planning software was more than enough. The coordinator of such meetings was not interested in project planning *per se* and expected that the project planner delivered reports at the agreed intervals without further dialogues. S/he organized so-called planning meetings where most of the topics were referring to the technical solutions needed by the project. Even when these coordinators were introduced to better planning tools or participated in training programs, they did not see the necessity of improving the planning process. They believed that the formal planning system using automatic calculations (without human judgment) represented what was needed for project planning. One of the engineers summarizes this type of thinking: "*For me, planning is resource allocation, scheduling, load, and capacity planning. I do not see any differences between planning and scheduling*."

In some cases, the project manager might have been interested in organizing better planning sessions, however, when most project participants were against planning meetings and refused to prepare for such meetings, it became difficult to implement a planning culture that works. In fact, one department leader demanded a planning tool that will work *"without requiring any training or support from other departments.*"

In many of these meetings, department leaders were not involved in the planning process, they did not attend planning meetings, and they did not ask any questions about such meetings either. In one of the case companies considering to implement LPP, an evaluation report about challenges and procedures to improve in their planning process was written at the end of the testing period. The report was delivered to the leader of the company who commented its results by saying that he agrees with his team's reluctance to LPP ideas, so, they dismissed the record-keeping and discussing RCA. They could just continue to do the things the same way as before since LPP was stressful for them. One of the main reasons for this approach was that people were also complaining that planning took too much of their time, and they must focus on finishing the project.

Project teams using these types of meetings were on average more expensive (10-15% over the agreed project cost) than other similar projects where planning design- and engineering activities were better organized. These projects were also on average several months delayed. The numbers here are based on a comparison made between similar vessels produced by three different shipyards where one of them was using LPP for its production activities.

Using the elements proposed above, this type of meeting can be described as following.

Organization of business-as-usual type of planning meeting was, in fact, non-existing as the interest in project planning was minimum. People were invited to a project meeting where they discussed measures to deal with the most pressuring issues. In one of the case companies, people associated planning with "*shouting at each other while we are ready to leave the meeting room*". In cases where there was a proposed agenda, it was impossible to follow it within the allotted time for the meeting due to firefighting issues that could take a long time to agree upon. These project meetings were planned once a week or bi-weekly, however, without a predetermined structure. Traditional project management literature recommends organizing project meetings as often as necessary, but not too often. The term "project meetings" is also rather ambiguous, referring to meetings organized by each team when appropriate.

Content of the business-as-usual type of meetings was a mix between a few planning issues and many technical discussions. In most of these meetings, a 3D model or some drawings were presented on the projector screen and sometimes discussed by all participants, other times only by a few of them. Planning issues were seldom discussed, and project planners (where existing) were not always invited either.

Participants in such type of meeting were usually: the project manager or the technical coordinator (usually only one of them), a representative from design, some discipline coordinators from the detail-engineering department, and some representatives from the most relevant suppliers. Some of the participants were invited to all meetings, and others were invited based on the most pressuring issues to be discussed during the meeting.

Participation was not mandatory in the business-as-usual type of meeting, and people attended mostly because they needed to agree on technical issues and solutions to be adopted. In several cases, the technical coordinator and project manager were arriving late at the meetings, and soon, other participants started to imitate this attitude. One project manager made an interesting comment: "*my philosophy is that engineers know very well what they are supposed to deliver next week, so I do not need to hassle them about that*". Being prepared for these meetings was also a missing element in these meetings. In many cases, project participants had to bring their own computers to the meeting so that they would be able to find information when required. All participants were good at proposing technical solutions, however, most of them reluctant to discuss planning issues.

Planning, as a preparation for next week's activities, was non-existent in those meetings since planning was, in fact, not a subject approached by the participants. Some of the projects using this type of meeting used to have a plan with very few activities for the design- and engineering part of the project. Other projects had a very high level of detail in the design- and engineering plans, however, it was the planner's job to follow and update these activities based on the hours registered in the clocking software. In many of these cases, the existing project plan was not updated before the meeting. This attitude is well described by (Eckert and Clarkson 2010) who found that many engineers consider planning as a nuisance, and often they avoid discussing plans because it is difficult to do so. They cannot just simply check their activities and question their relationships with other plans.

Scheduling, as the activity of re-planning the delayed activities (concerning dependencies with the subsequent (successors) activities and the need for resources), was not discussed either. As stated above, engineers do not always see the consequences of delayed drawings/3D models, especially when parts of the project are produced at several foreign locations. In some projects, simple (re)scheduling activities were performed by the project manager or, where existing, by the project planner. A discipline coordinator in one of these meetings commented that "*I want a plan that does not need to be rescheduled all the time.*"

Reporting progress and status in the business-as-usual type of meeting was also very scant. However, while discussing technical solutions, some of the activities were reported as completed mostly as part of the solution, not part of the planning process. In most of these meetings, the idea of reporting was translated into how to deal with already delayed activities. The hours to be used by the engineers on main drawings were estimated at the beginning of the project and were based on data from previous projects. Then, during the project, the reporting was based on the hours clocked by engineers on main working packages while the planning software calculated the estimated number of hours left to completion. However, this type of calculation was showing neither how far each drawing was completed nor the number of hours needed to deliver the drawing. Consequently, by the end of the project, engineers and purchasers used a higher number of unplanned hours to deliver their part of the project.

Root-cause analysis was not a topic of such meetings. In most of the cases where companies would try to implement LPS (see for example (Fosse and Ballard 2016)) or LPP, this is one of the elements that is not easily accepted by the engineers. In one case company a manager stated: "*engineers have complained that identifying the root-cause is taking too much time, so I gave them the permission to stop doing that from now on.*" This is one of the main concepts behind avoiding repeating the same mistakes in future projects, however, the attitude in some of these meetings was "*we do not need the statistics from the root-cause analysis because we all know the reasons for delays*" as one engineer stated.

PPC and EVM were not among the KPI's identified during the business-as-usual type of meetings. In many of these projects, measuring the effectiveness on the production floor was done in a detailed manner, but measuring productivity for design- engineering activities was not a concern for these teams. Designers and engineers were reporting the number of hours used per drawing or model while the purchaser reported hours used on procurement activities per project.

Communication technology. In the business-as-usual type of meeting, the attitude towards sharing information was affected by a certain level of distrust among project participants, especially towards the hull yard and some of the suppliers. Most companies used a type of intranet solutions where information could be easy to access, however, each project participant had access to a limited amount of information as decided by the PM or by the technical coordinator. This is due to the reluctance to share information with people from other companies. Skype or video conferencing was often used for communicating with representatives from the hull yard and other suppliers. However, in many cases, due to technical problems, people had to be contacted by telephone. That limited their visual relationship to the issues discussed during the meetings. In one company, the share point was so well guarded that it was impossible to give access to external project participants, so the project manager had to send all kinds of project documents before and after the meeting.

To summarize the elements presented above, business-as-usual type of meeting is characterized by lack of structure and lack of focus. Therefore, it becomes more “time spent together” discussing what participants have on their minds at the moment than a regular meeting to manage the project via planning and follow-up. None of the lean recommendations for an effective meeting were identified in this type of meeting since the general attitude was an unwillingness to change. For teams using this approach, it was enough to use some adapted elements from traditional project management literature, without paying attention to the planning process.

The second archetype was a type of semi-structured planning meetings and is described next.

6.2.3 Semi-structured design & engineering planning meetings

This type of meeting was the most common type observed throughout the research. People leading this type of meeting were interested in planning and tried to organize planning meetings as a way to communicate within the group. However, these meetings were semi-structured and did not focus sufficiently on planning. Based on the observed data, teams using this type of planning meeting were using on average over 10% more hours for design- and engineering activities than similar projects delivered from projects using a better planning process. According to one company manager, “*this was too expensive for any project*”. He also stated that some of these costs could have been avoided with better planning. The projects using this method were delivered later than planned and with significant cost overruns often related to issues that could have been avoided if design- and engineering activities would have been performed on time and with the right quality.

Using the characteristics proposed at the beginning of this chapter, these meetings can be described as following.

Organization of the meetings in this semi-structured archetype is based on a general agenda that might also contain technical issues to be solved during the meeting. People were invited to these meetings by the technical coordinator and a general agenda was established most of the time in the beginning of the project. A request for the meeting (from Outlook) was sent to project participants for every week throughout the whole project period. Usually, the project manager had the responsibility to organize and lead these meetings, even though sometimes s/he delegated it to other people in the team.

Content of a semi-structured planning meeting was a mix between planning and technical discussions. There were discussions around the completion of planned activities and about measures for completing the delayed ones, however mostly through the technical part focused on finding solutions.

Participants at these meetings were: project manager or technical coordinator (sometimes both of them), several discipline coordinators from the technical department, the project planner, one representative from the production department, some hull yard representatives, as well as some of the most relevant suppliers. The project purchaser and the project planner were invited from time to time to participate in these planning meetings. However, in some cases, the project planner was not directly involved in these meetings, but s/he received information about the status of the discussed activities from the project manager.

Participation was mandatory in most of these meetings, however, people could find excuses for not participating, and the project managers usually accepted that. During the meeting, some of the participants used to work with solving some other project issues. The leader of the meeting was always the first one to arrive in the meeting room and start preparing for the meeting. Engineers were not always prepared for discussing planning issues, but they were well prepared for the technical part.

Planning. At the beginning of the project, the number of hours needed on the planned activities was established based on data from previous projects and, in some cases, comments from discipline coordinators. During the project execution, planning was focused mainly on re-planning of delayed activities, without analyzing the dependencies among those activities and the activities planned for the next period. There were no discussions about preparation for activities to be completed in the near future. However, in some of the projects, people were discussing the need for more resources to reduce the delays in the delivery of the drawings.

Scheduling was usually done by the planning software and was based on reports from the discipline coordinators. Re-scheduling delayed activities was performed in an unstructured way depending on the size and possible consequences of these activities. Decisions to re-schedule were taken by the project manager together with the technical coordinator and communicated to the employee or the planner responsible for updating the project schedule.

Reporting progress and status of project activities was mostly done during the meeting. That took some time, especially when people also started to discuss technical issues around some of the activities on the plan. The planning software estimated automatically the number of remaining hours per activity and the project manager or project planner created project reports based on these data. As a result, project participants were not always reporting the real number of hours used per activity, as the budget would have been exceeded. Instead, the hours were reported on other activities, which means that the budget for similar activities in the next project (many engineers use old projects to set the budget for a new project) would be most of the time wrong from the beginning.

To deal with such issues, LPP introduced the rule that discipline coordinators in collaboration with their team would estimate the budget from the beginning of the project and then adjust it according to the real evolution of the project. In this way, the total cost of the project would be closer to reality. Letting people estimate their work is also part of the LPS linguistic-action perspective (assessment) that leads to commitment and better control of the project cost (Macomber and Howell 2003).

Root-cause analysis was not an issue in these meetings. People argue that it takes too much time to analyze reasons for non-completion, so they just focused on finding a solution for dealing with those delayed activities.

PPC and EVM. The latter was used to a certain degree, and it was based on the calculations made weekly or bi-weekly by the planning software. However, its application differed from one project team to another. That is due to the metrics used to calculate the status of each activity: e.g., some measured the duration of an activity in hours, some in days. PPC was considered by these project participants as unfit for measuring status or progress on design- and engineering activities.

Communication technology. The teams using this type of planning meeting were usually sharing project information on the intranet or Share Point, where most of the project participants were given access by the project manager or by the technical coordinator. Skype, or other devices for communicating with people outside the room, were used often in this type of meetings since the level of trust was higher than in the business-as-usual tactic.

To summarize, the semi-structured archetype of meeting is characterized by a planning process that is partially implemented, and people using this approach acknowledge that planning is a necessary management tool. However, they do not make the effort needed to get more commitment from the project participants as the project team relies on very detailed contracts with all participating organizations. In some cases, the project teams were using tools recommended by the traditional project management literature (e.g., Microsoft Project software), but a high level of the detail on the plan required a large amount of work to update it (three days in some projects). Such detailed plans were a result of the comprehensive contracts with suppliers as well as an increasing level of details on the 3D drawings. A general observation here is that people treated planning as a technical process focusing on the reports provided by the planning software with little communication and commitment from the participants. Neither the social side of the planning process as recommended by (Ballard

2014), nor the open communication and trust recommended by (Emblemsvåg 2014a) were considered as important elements in these meetings.

The next identified archetype was structured planning meetings for design- and engineering activities as described next.

6.2.4 Structured design- and engineering planning meetings

During the research period, we encounter several projects using this meeting archetype. An interesting observation here was that both the project manager and the technical coordinator were keen on using planning as a communication- and decision-making tool. However, a proper planning process implies more work and involvement from the project managers as well as from the rest of the team.

Projects applying this archetype were delivered on time and the cost of design- and engineering activities was kept close to the estimated budget. There were also at least two projects delivered fourteen days earlier than planned. Analyzed through the proposed characteristics, this archetype can be described as following.

Organization of these meetings was defined from the beginning of the project and the agenda was committed to discussing only planning issues. Most projects using structured planning meetings had a planner allocated to each project, and their role was to provide support to the project team. The leader of these meetings was the technical coordinator with support from the project manager when necessary. The duration of these meetings was usually one hour or in special circumstances, ninety minutes depending on whether unforeseen project issues had to be discussed or not.

Content of these structured meetings was organized around planning issues, and only a few technical problems were discussed when necessary. One important point on the agenda was that each participant was invited to discuss issues regarding the planning of own teams' activities. Critical issues were dealt with around the table. All participants were aware of this point on the agenda, and they had to prepare for that before the meeting.

Participants at these meetings were: the project manager, the technical coordinator, the project planner, all discipline coordinators allocated to the project, one or two representatives from the production department, one or two representatives from the hull yard, and representatives from the most relevant suppliers. At least one representative from the design department and one project purchaser were always invited to these meetings. At the beginning of the project, the team established a day of the week, as well as the timing for these mandatory planning meetings where all relevant project participants were invited for the entire project duration. The technical coordinator would lead the meetings and evaluate the need for more or fewer participants as the project evolved.

Participation was mandatory, and engineers were prepared to discuss planning issues regarding their teams' activities. In most cases, these meetings took place every week at the project level, while at the discipline coordinator level could happen as often as required. The technical coordinator was the first to arrive in the meeting room and prepare all devices (and plans to be presented) for the meeting. All participants had to be prepared for the meeting by having a good overview of the status of their teams' activities. They were also active participants when discussing planning issues during the meeting.

An interesting observation was that at the beginning of LPP implementation, some project participants were not taking the planning meeting seriously and one of them came unprepared to the meeting saying that he does not have time to plan. The project manager pointed out that these meetings were important because all participants had to be informed about the status of the project so that they could prepare the activities for the next two weeks. The manager sent the employee back to his office to prepare for the meeting while the others would wait for him to come back. He was challenged to think about the cost of all people's waiting time while he would prepare for the meeting. This case was a one-time event, as participants in that project understood that the planning meetings are successful as long as all participants are prepared.

Planning. At the beginning of the project, the estimated number of hours needed for each activity was established by each discipline coordinator in collaboration with the technical coordinator. The final budget was based on data from previous projects combined with project teams' own analysis of possible new factors affecting the completion of the planned activities. Their plan contained a suitable level of detail and, when necessary, some more details were added as the completion dates were approaching. During these meetings, issues regarding next week's activities were discussed in order to inform the rest of the team on expected deliveries (what is needed from the others and what is delivered to the next stage). However, none of these meetings addressed the elimination of constraints as that – according to interviewed participants – was taking too much time. In one project where the team tried to use the LPS procedure of eliminating constraints, several engineers complained that some activities could be started even though not all constraints were eliminated on beforehand. That is because some of the constraints could be eliminated during the week while people worked with solving eventual constraints. However, this is a matter of evaluation of the situation and the elimination of constraints within the planned finished date.

Scheduling was approached by analyzing the re-planned activities in relation to the already planned ones, leading to discussions about which resources could be allocated in order to help solving the delays. The project planner would update the schedule based on the information received weekly (several hours before the planning meeting) from discipline coordinators, designers, hull yard, and suppliers.

Reporting was usually completed before the meeting. Each discipline coordinator reported to the project planner several hours before the start of the meeting so that the project planner would have time to re-schedule and create a plan where delayed activities were emphasized. All discipline coordinators were to collect information about the progress on each activity, the number of hours used by each engineer, analyze the data, and then estimate the budget and resources needed to complete them as planned. This information was sent to the project planner who, after each meeting, created project reports that were sent to the project manager, discipline coordinators, and other entities as agreed at the project leadership level.

Root-cause analysis was performed sometimes, however, only superficially. In those cases, the adapted RCA became a part of the lessons learned presented by the project leaders to the rest of the team or other project teams. Some project managers, tired of the reoccurrence of the same type of problem, wanted to use the RCA technique, yet, they lacked proper training, as well as time and resources to collect and analyze the data.

PPC and EVM. In some projects, the technical coordinator tried to keep track of the PPC for design- and engineering activities, however, the iterative nature of those activities proved to challenge this KPI. EVM was tested in a few projects for some of the activities within the period plan, but, the results were not conclusive due to the adaptation needed by the project teams. Among other issues, we discussed the level to which we can apply EVM for design- and engineering activities. This had to be adapted from project to project.

Communication technology. Project participants were given access to detailed project information on the Share Point (or other web solutions), as the level of trust was higher than in other types of meetings. Skype meetings were organized well, and documents were shared on-screen throughout the meeting. Each technical coordinator kept the project plan on a screen shared with all external participants, having the possibility to (when necessary) update the plan with the newest events. This type of open communication was possible, mostly due to a trustful project environment.

To summarize, this archetype of planning meeting was following many of the recommended LPS and LPP rules, proving that design- and engineering activities can be planned properly. For example, good coordination of action performed by technical and discipline coordinators, assessment, and trust among project participants are all elements of linguistic-action perspective. From LPP, dialog, and meeting culture can be recognized in those meetings. In other words, this is a good start towards using planning as a communication tool in planning design- and engineering activities. Furthermore, this type of planning meeting was following most of the rules for effective meetings as recommended by (Liker 2004). These rules refer to a general way of organizing lean meetings and can be used to define the main steps in any type of meeting, yet it does not address the planning meetings specifically. Not the type of planning meetings needed for design- and engineering activities in ETO projects.

The results of observed projects indicated that this archetype improved the outcome of the project, and those engineers can in fact plan and control their projects provided they are interested in organizing and leading such planning meetings.

On the other hand, since this archetype also lacked elements like RCA or constraints analysis, at least two possible improvements could be proposed. We argued that by using RCA in a proper way, engineers would obtain a better background for the decision-making process. Also, implementing a procedure for applying constraints analysis to design- and engineering activities, project teams would be able to reduce the number of uncontrolled peak periods by allocating resources in a more effective way. Based on such assumptions, a prescriptive model for an improved planning meeting for design- and engineering activities was proposed. This is termed lean planning meetings and is described next.

6.2.5 Lean planning meetings for design- and engineering activities

As stated earlier, structured planning meetings were observed in only a handful of the studied cases, and it seemed to be an approach that worked for the teams who were using it. One of the main reasons for that resides in the fact that those teams were led by technical coordinators and project managers who were investing time and resources in facilitating the planning process. Nevertheless, almost none of those people had been trained in how to develop such planning meetings. These were established through lessons learned and focus on continuous improvement of the project results. There is no clear methodology on how to develop and implement structured planning meetings and other teams who attempted to copy this style encountered different challenges, so the results could not be compared. Transferring the same approach to other similar teams proved to be a difficult task since much of the process was based on tacit knowledge. Therefore, in order to define and explain a planning process that can be implemented through proper training, the fourth archetype was proposed.

This archetype was identified throughout the research period as a project planning meeting that should, in theory, deliver the best project outcome. Since none of the observed meetings followed a complete LPS or LPP approach, the reasons for that had to be investigated. Among the reasons revealed by project teams were:

- Project teams were stressed by short project duration

- The network of participating organizations was quite vast, creating difficulties in implementing this type of thinking in all of them
- The concurrency of project activities resulted in drawings and documents that needed to be delivered based on insufficient information
- Iterative design- and engineering activities led often to unplanned work for the engineers and procurement teams
- Unforeseen changes in the materials and equipment to be mounted on the final product as well as change orders coming from the customer

Even though these issues were presenting serious limitations to further development of the third planning meeting archetype, we discovered teams that were interested in finding ways of continuous improvement and the additional elements proposed in the fourth archetype could be a starting point. However, the lean planning meeting for design- and engineering activities has not been tested on any ETO projects due to limitations of the research period.

Projects where LPS and LPP were tested for planning design- and engineering activities showed that these were improving the outcome of the project. That is because, according to the majority of interviewed engineers, they use over 80% of their time on searching for information and coordination and only 20% on actually drawing and modeling. One of the reasons is that people do not communicate enough during the planning meetings; instead, they rely on IT systems to search and find data, which is not always the most updated version of the information. By improving planning meetings, engineers would reduce the time used in searching for information since the whole team is prepared for each meeting, and information is shared effectively and efficiently. The ideas behind the proposed model for lean planning meeting for design- and engineering activities are first summarized and visualized in Figure 6-2, then described in some more details after. This is a type of well-structured planning meeting that can be applied within similar contexts. However, there are many different types of ETO companies and establishing what kind of well-structured meetings fit each one of them, should be based on the particularities of their context.

Figure 6-2 depicts the idea that lean planning meetings for design and engineering activities originate in the structured planning meeting since that proved to be a best practice within the industry. Defining and explaining these elements in a way that would make them easier to be adapted by other project teams could also help in implementing the three elements that transform a structured planning meeting into a lean planning meeting for design- and engineering activities. A proper RCA would help project teams to identify much better solution to problems that seems to repeat from project to project. The evolution of the market imposed a new element to the observed projects: that more and more customers were now demanding monthly reports showing the EVM (thus highlighting that LPS alone would not work, as argued in Chapter 2). Therefore, most ETO companies had to identify the proper level for such reporting and this became an important element in the proposed lean planning meeting archetype. The PPC element would be implemented only on lower levels of design- and engineering activities as a way to motivate people to apply a proactive planning process.

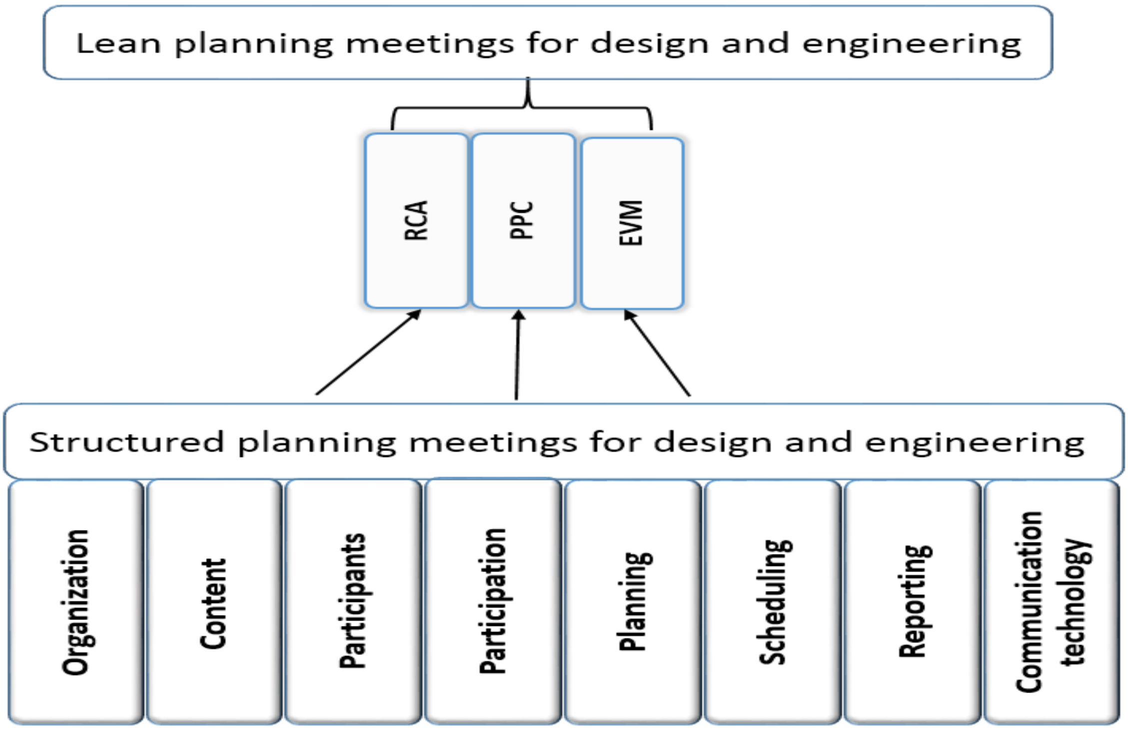

Figure 6-3: Conceptual model for lean planning meetings

Organization of these meetings should be done at the project manager level, where the importance of planning meetings is emphasized. The implication of the project manager, technical coordinator, and project planner is essential in organizing lean planning meetings throughout the project. The team establishes which day of the week to be used for planning meetings by taking into consideration the time needed for reporting on beforehand. Weekly meetings proved to offer a better overview of the status of the project, even when significant changes can happen from one day to the next. Short daily meetings within each discipline can reinforce these weekly meetings, and that would support a dynamic updating on activity status, helping the team to avoid unnecessary delays as LPS recommends. This is also an important issue in achieving a better concurrency between project activities, as this is dependent on dynamic communication and information exchange.

Content of the proposed type pf meetings should be focused on issues connected to planning and reporting. The agenda should contain only planning activities – technical issues must be approached during other project meetings dedicated to such issues. Agenda should always contain time where each discipline coordinator can discuss issues concerning eventual problems or activities that need special attention in the near future. Issues discussed during the planning meeting should concern more than two of the participants (solutions can be found either before or after the planning meeting) to avoid that a whole project team uses time on small conversations. These are also ideas recommended by both LPS, lean, and LPP.

Participants. It is not always easy to determine all the relevant participants as activities are interconnected and dependent on each other. Thus, a mix of people including project manager, technical coordinator, discipline coordinators, designer, project planner, purchaser, representatives from the production department and the hull yard as well as other relevant suppliers, should be invited to participate at these weekly planning meetings. That is because, through participation, people get access to more updated information, which is then distributed further to the rest of the project participants. Also, it is easier to achieve commitment when people participate in those meetings as argued within the LPS, lean and LPP.

Participation. Through lean planning meetings, people know what is expected from them, and they can prepare in advance with the data they need to deliver. Being prepared for the planning meeting is a must because that helps the team to keep control of the duration of the meeting and avoid unnecessary discussions and information finding.

Planning. The focus of these meetings should be on discussing eventual constraints that can affect the work on an activity, and how these should be handled. Preparation for the next weeks' activities and the elimination of eventual constraints before engineers start to work on those activities is an important planning element as demonstrated by the LPS. Eliminating constraints encourage engineers to communicate with each other and exchange information more often, as explained by the LAP in LPS and communication theory applied by LPP. Another important point to discuss should be the non-completed activities, as these must be re-planned among the already planned activities. A project manager observed that "*engineers have all general arrangements (GA) on their walls, but almost none has a master plan or a project plan on their walls.*" Post-it notes inspired by the LPS approach can support the planning activity when possible. Introducing the TMR metric as recommended by LPS, might motivate the team to focus on the preparation of activities for the next period.

Scheduling should be focused on re-planning delayed activities by considering their effect on the activities planned for the next period. Its scope is to identify the resources needed for every week ahead as well as dependencies between activities and organizations completing them. A dedicated project planner who uses the scheduling software to create reports and analysis on the status of the project is the proper team member to perform the scheduling activity.

Reporting. Each discipline coordinator should maintain a good overview of his/her teams' activities and report to the project planner regularly, weekly at least. That is because, in such a dynamic environment, delays and deviations can become difficult to handle unless the feedback loops work on an equally fast pace. The reporting method approached by LPP emphasizes the need for involving people in estimating the remaining number of hours needed for completing an activity as opposed to deducting them from the scheduling software. By encouraging people to estimate those hours, they will get more committed to delivering as planned. Reports on the status of the project should be sent to all relevant project participants so that people are informed on eventual urgent issues to be solved.

Root-cause analysis. Even though this tool is not used that much in planning design- and engineering activities, projects that used it report an improved understanding of the possible deviations from the plan. That is because recording a problem, its root cause and the applied solution will support the team to eliminate the reasons for that problem as well as make faster decisions if the same problem reoccurs in other projects. Using RCA is recommended as one of the most important elements when using both LPS and LPP as a way to help problems come to surface and to find solutions that last. Furthermore, proper application of RCA results in a better decision-making process.

PPC and EVM. As tested by LPP, PPC fits better into weekly plans that are quite detailed, while EVM seems to fit at the period plan level and above. A company delivering detail engineering services tested EVM, and the leader of the project proposed its use in the upcoming projects, arguing that for his team, it worked well and helped them define better resource allocation. However, EVM cannot be used at the week plan level, as the number of activities is too high. Therefore, it should be used as recommended by LPP at the period plan level. PPC should be adapted to be used by discipline coordinators to help his/her team to identify which activities require more time to be completed and why.

Communication technology. Facilitating communication among project participants through proper communication means gives the possibility to participate in each meeting and stay informed about the latest development within the project. Information shared throughout a common site (e.g., Share Point) should be open to all project participants according to their credentials, as this creates trust and increases information accessibility.

The fourth type of planning meeting is proposed as an improvement of the structured meetings by applying all the suitable elements from LPS and LPP, as well as the recommendations made by (Liker 2004) for effective meetings. However, achieving this type of planning meeting is dependent on several elements as described in RQ4. Before presenting them, a table summarizing the most relevant aspects of the four identified types of meetings followed by testing the hypothesis for RQ3 are presented next, see Table 6-13.

Table 6-13: Summary of the four meeting categories

Characteristics	**Business-as-usual meetings**	**Semi-structured meetings**	**Structured meetings**	**Lean planning meeting**
Organization	Little or no organization	Organized by the project managers	Organized by technical coordinators and project managers	Organized by project managers and technical coordinators
Content	Technical issues	Planning and technical issues	Planning issues	Planning issues
Participants	Varies	All discipline coordinators and relevant suppliers	All discipline coordinators and relevant suppliers	All discipline coordinators and relevant suppliers
Participation	Not mandatory	Mandatory	Mandatory and prepared	Mandatory and prepared
Planning	Not discussed	Discussed	Main topic	Planning and constrains elimination
Scheduling	Little	Activities to be re-planned	Re-planning and resources allocation	Re-planning and resource allocation
Reporting	Calculated by the system	Calculated by the system	Reported by each discipline coordinators	Reported by discipline coordinators and suppliers
Root-cause	No	No	No	Yes
PPC and EVM	No	No	Elements of EVM	PPC for weekly plans. EVM for period plan
Communication technology	Affected by lack of trust	Well organized	Well organized, high level of trust	Well organized, high level of trust

How these different archetypes of planning meetings affect the outcome of the projects is presented next. This is critical for the verification of the research.

6.2.6 Testing hypothesis RQ3

The hypothesis proposed for the RQ3 is:

Hypothesis RQ3: “*Well-structured planning meetings for design- and engineering activities improve the project outcome*”

The proposed categories of project planning meetings are based on qualitative observations as numbers and statistics on the correlations between planning meetings, and the outcome of the project does not exist yet. However, following several projects and the way planning meetings were organized together with the results of those projects, it seemed natural to propose such a correlation. One of the first facts supporting these findings is the comparison made between ten projects delivered by three shipyards to the same customer on a period of three years. The comparison was based on the number of hours used per department (as registered in the financial documents) as well as on the delivery precision. Shipyards using structured planning meetings were delivering the best results in this research.

Moreover, throughout the research period, both improvement teams observed and discussed planning meeting structures with other project planners, project managers, and technical coordinators. The categorization presented above is to some extent a result of these discussions combined with recommendation from the studied literature.

Business-as-usual types of planning meetings, or the lack of such events, were contributing to rework in many drawings and models as people lacked the necessary information to produce the required output. The projects delivered by teams using this type of meeting were always delayed and over the agreed budget. Their main approach to planning was to use some of the traditional project management approaches (create a project organization, organize the kick-off meeting, assign responsibilities to project participants, and organize project meetings when necessary). They used iterations and concurrency as excuses to use as little time as possible in planning. Communication was more of a one-way type where people were ordered to solve the problem without any means or power to do so. However, some of these companies still survive due to the key role they have in the project as well as the high level of tacit knowledge among employees.

Semi-structured design- and engineering planning meetings were somewhat better; however, projects using this type of meeting were still lacking dynamic communication and commitment among project participants. These projects were either delayed or over budget. They also used approaches recommended by traditional project management: project organization, kick-off meeting, assign responsibilities, organize project meetings when necessary, etc. However, they used some hours on planning their design- and engineering activities, mostly in the beginning of the project, but then when the pace increased, planning was less important. They adapted some of the elements of effective meetings (Liker 2004), but only partially. Still, their focus was more on the scheduling part, with little attention to the process or the social part of the planning activity.

Structured design- and engineering project planning meetings proved to help even in some of the very challenging projects, as observed in one case company. One of their projects was a very complex vessel that had to be delivered in a record short time (eighteen months), and that was achieved by a project team where both project manager and technical coordinator used structured planning meetings. Based on observations from several other projects where structured planning meetings were also conducted, it seemed reasonable to connect the quality of planning meetings with the outcome of the project as these projects were delivered on time and budget. This type of meeting followed all the elements of effective meetings as recommended within the lean literature as well as many of the elements from LPS and LPP approaches. Communication was based on dialog and trust, and people were invited to discuss all types of problems regarding the project. It was also easy to identify most of the elements recommended by the LAP since all participants were empowered to make and keep commitments. Moreover, more recent results from an ETO company using structured planning meetings for their design- and engineering activities reported that all their projects had been delivered on time in 2019. However, not all LPS elements were applied, and one of them was constraints analysis, which became a future improvement in the lean planning meeting for design- and engineering activities proposed in this dissertation. Even though the structured meetings did not follow all LPS elements, they still proved that well-structured planning meetings could improve the outcome of the project in terms of costs and better delivery precision.

Based on the arguments presented above, the testing of Hypothesis 3 is accepted.

Next, RQ4 and its hypothesis are investigated. Since it is now established that a structured planning meeting (as defined above) is highly beneficial for project planning, we keep that as the background for the RQ4. Hence, it is assumed that there is no need to spend time discussing the three archetypical meetings approaches in relation to RQ4.

6.3 Findings in RQ 4

This research question was proposed as a continuation of the RQ3 as we discovered throughout the research period that several other factors (not related to structure) were affecting the planning process and consequently, the project outcome. Observing so many project meetings during the six years of this study, it became clear that project planning meetings were dependent on the background and interest in planning of both project manager, technical coordinators as well as company leaders. Moreover, some of the existing improvement actions failed to be implemented, and we had to identify and analyze the causes of such failures. In most projects, people were interested in planning, however, they lacked both skills and training in how to plan such challenging endeavors. Based on these observations, we proposed several other elements to be considered when implementing lean or other forms of well-structured planning meetings in ETO projects. Thus, the RQ4 and its hypothesis are formulated as follows:

RQ4: Apart from meeting structure, what other elements are important to ensure the best possible communication and interaction between project participants to the benefit of the project outcome?

Hypothesis RQ4: *Individual communication- and interaction qualities among the project participants are important for improved project outcome*

The process used for identifying these elements was quite complex since these could be biased by our understanding and interpretations of the observed challenges in planning design- and engineering activities. Also, working in live projects with project participants that were working under time-pressure was impacting what we could do in terms of testing the research. The reasoning and the action research behind our findings are presented next.

6.3.1 AR steps

While participating in planning meetings, the improvement team noticed that many project participants struggled to implement the elements that would help them achieve more structure in their planning meetings. We developed several training modules for different parts of a planning meeting (e.g., how to implement prerequisites/constraints analysis and how to report on these, how to use EVM, etc.), however, we continued to have little success. So, we began to look at what other factors affect our work, and we decided to start with how people understand planning or the process of planning. This decision seemed a natural start since several engineers mentioned that they lacked explicit courses and training on how to plan a project. Later, we learned that they referred to scheduling software because that was what planning was associated with. With this in our minds, we discussed these findings with several other engineers, and all of them seemed to agree on the matter. Then, throughout these discussions, we discover other issues that affected their interest and success in developing better planning structures. When we asked about why they did not use our training material offered to all of them, elements like management support or lack of communication surfaced. So, we decided to look further than training.

While participating in planning meetings, we started to look for each of the elements described by the engineers, and soon we discovered other connecting elements. By the end of the research, the list contained seven elements that are described in more detail later in this chapter. Every time we discovered a new element, we also looked at what actions could be taken to improve that situation. However, our success was dependent on the interest each company had on developing its own people. Some companies agreed that they need to invest in their people and they wanted to do that, but it would be impossible to send all employees to all kinds of courses. The question we received back was how to teach employees to teach other employees the concepts they learned at some of the courses and workshops. This is still a valid question in many companies.

As a solution to improve those issues, we proposed several internal workshops and training programs that would address each element. However, the market changes and the high staff turnover put a stop to most of these initiatives, which also resulted in difficulties in testing and implementing the whole improvement program.

The list with the proposed elements was discussed and evaluated by engineers in several companies, and almost all of them agreed that they would like to learn how to deal with such issues. Many of them expressed their interest in participating in the development of specific training courses.

Since our testing process could not be completed, our conclusion was to propose forming a new team that would develop and test training programs that would improve engineers' knowledge of planning design- and engineering activities. We also acknowledged that the list we proposed might not be exhaustive, but these elements remained the ones we were able to identify and discuss well within the context of live projects, time and budget. In the process of identifying these elements, we also used lean literature, LAP of LPS as well as the SECI process recommended by LPP.

The list contains the following elements, which are then described in more details.

1. **Training** – do engineers receive sufficient training in planning?
2. **Management involvement** – are company leaders interested in project planning?
3. **Communication** – how does the team communicate? Is it predominantly one-way from project manager/technical coordinator to the engineers, or is two-way communication?
4. **Solution-oriented** – does the team discuss to find solutions or discuss to blame/avoid responsibility?
5. **Systematic problem solving** – does the project team approach issues systematically and solve them permanently?
6. **Background and interest** – do leading project management team members have a background- or interest in planning?

7. **Lessons learned** – do engineers practice this concept between projects?

In the subsequent section, these elements are discussed further to either accept or reject the hypothesis RQ4.

6.3.2 Training

Planning is such an everyday activity that companies assume that engineers are already good at that, and they do not need any training for that. Yet, project planning is a complex activity, especially when it comes to design- and engineering activities in ETO projects. Most of the engineers had no project planning training, but a few of them had taken courses in project management that included planning as presented by traditional literature on the topic. Very few of those engineers had taken courses in lean, and even fewer had knowledge of LPS. For many of them, planning seemed a daunting issue that required too much time, an unaffordable luxury when each project had to be delivered within a short lead time, and they were always short of time. In projects where the teams tried to implement LPP or some elements of it, engineers were offered some training in how to use the tool. But then, many of them lacked a basic understanding of how to lead project planning meetings specifically. As one project manager concluded, "*We lack routines for planning design- and engineering activities, and we need to develop a common understanding of what planning is.*" Thus, a specialized training program developed to cover project planning, and the way planning meetings should to be executed could help engineers use planning as a helping tool and not as an unpleasant job.

The issue of training engineers in planning was often discussed in different workshops, and the interest in developing customized training for planning design- and engineering activities was quite high. At one workshop, several participants (most of them engineers) discussed the idea of how to train people so that they can train other people. This issue is discussed both by lean and TWI literature as presented in Chapter 2. Yet, some company leaders state that learning is an issue dependent on people's interest in learning new things. For these type of leaders training is an overrated activity since employees learn new concepts by using them.

Nevertheless, the studied literature does not provide a structured type of training for organizing- and leading planning meetings for design- and engineering activities. The literature offers some educational input, but, as (Dinero 2005) explains, training is specific and supports people in acquiring skills through the use of what they have learned, while education is general and provides background for increasing understanding. Furthermore, Liker and Meier (2007), explain that many leaders of modern companies tend to forget that even the most talented workers need development through training in order to drive continuous improvement to new levels. In other words, companies need to develop better training in planning ETO projects.

Based on the presented arguments, it seems reasonable to state that training is an instrument in developing knowledge through the SECI model also used in both LPS and LPP. Proper training, as one of the most discussed elements in our list, can contribute to developing a better culture for planning design- and engineering activities among engineers.

6.3.3 Management involvement

During the research period, several types of management involvement in planning were observed. Some managers focused on the scheduling activity, demanding that the plan should be followed regardless of changes, and some stated: "*The purpose of making a plan is to follow it. I do not like to change the plan*". The result of this approach was little focus on the planning process, but more weight on reporting according to the plan. The planners were using this plan only for creating reports for the management team while supervisors and coordinators would keep their own plans showing a more real status of the project. These "secret" plans were used for internal coordination- and communication within each team, a type of tacit knowledge dependent on each team leaders' level of interest in planning.

In some cases, company managers considered themselves involved in planning just by asking the project team to send them project reports. Then they would decide how these reports must be changed (on paper) so that the project gets back on track. These projects never got back on track, and that was because people lacked any decision power and implicitly commitment to the plan. In those projects, the planning software made the calculations on the status of the project based on reports collected twice a month from all department leaders. Numbers were often changed to fit the desired status, as that would give people some time to deal with urgent issues. These companies never delivered on time or within the agreed budget and suffered a high employee turnover.

As lean thinking emphasizes, management involvement is crucial for implementing any improvement, concept, or procedure in a company. Without such involvement, people do not take any improvement seriously. One employee talking about LPP implementation in their company said: "*this concept is like many others before…creates some waves now, but in a year or two it will be forgotten and we will be back doing things as we have always done*. *I have been in this industry for many years, and I have tried so many concepts, but somehow we ended up coming back to our old way of doing things*". This statement was made in a company where the management team is renewed quite often.

Some managers were interested in planning and demanded that each project team must use time on preparing and updating the plans continuously. In the companies using structured project planning meetings, the management team was involved as a support for the project team. Many of these leaders were periodically participating in planning meetings showing interest in what was happening while listening to the issues discussed around the table. Management involvement was one of the success factors in implementing LPP for the production planning part of several shipbuilding projects. That is also the case in companies reporting successful implementation of LPS (Ballard 2000) or other lean concepts (Liker and Franz 2011). Therefore, based on our observations of several companies and projects, as well as recommendations from lean and lean construction literature, management involvement is a key element also in the successful implementation of well-structured planning meetings.

6.3.4 Communication

Not all meeting leaders are interested in two-way communication, as observed in several projects. In some cases, the participants were ordered to do something about the issues creating problems within a project without being given the means to solve the respective issues. The result of such an approach was a silo thinking where each participant tried to improve their own results even though that affected other parts of the project. In other words, each participant in a project should be allowed to communicate openly about the real causes of the encountered problems. This idea is summarized very well by Ballard (2014): "*if you can't say no, you can't make a promise.*"

In the business-as-usual types of meetings, the team was more preoccupied with going through the meeting and finish it as fast as possible, lacking an open dialogue. Most of these meetings were a kind of monologue where the participants could answer emails and do other types of project work. When people were asked questions about their work, a discussion on technical solutions would start. In structured planning meetings, the dialogue was an important point on the agenda, and every engineer had to come prepared to participate in discussions and the information exchange process.

LPS and subsequently, LPP were created out of the need to improve communication among project participants, to encourage people to bring problems to surface so that the team can find a solution before it becomes a crisis. This is achieved through the two-way communication or dialog as explicated by LPP, where people can speak and be heard, an essential element in leading planning meeting. Nevertheless, when asking engineers about what they see as major problems in their project planning, almost all of them answer communication. Hence, defining guidelines for how lean planning meetings would support a proper dialog within the project team, including relevant suppliers, could be a starting point for a training program focused on this issue.

6.3.5 Solution-oriented

Another observation made during the research period is that many of the business-as-usual type of meetings were often preoccupied with solving technical problems without discussing how these solutions would affect the rest of the planned activities. When these solutions were not implemented, blame was placed on suppliers. This culture of blame was sometimes taking more time of the meeting than finding a proper solution and in some cases, the proposed solution had to be redesigned since important factors were not discussed on time. That was also because several relevant project participants were not attending the meeting.

In structured planning meetings, finding solutions together within the team, and involving the suppliers was the rule. That encouraged people to discuss all project problems because they knew that they could trust receiving constructive feedback. The consequence was that project teams used less time on both finding the problems and discussing the proper solution.

This element seemed less obvious, especially within the Norwegian culture where people claim they have no reservations in discussing problems with the rest of the team. However, some of our findings show that is not always the case, and companies should indeed train their employees to be more solution-oriented when planning their projects. Consequently, we added it to our list of improving elements.

6.3.6 Systematic problem-solving

This is about solving any issue in a systematic way by analyzing its root-causes, working for eliminating the root of the problem in order to prevent reoccurrence. A systematic approach implies that every discipline coordinator goes behind the numbers or the schedule information to understand the realities of the project. They do that by asking “why” until the root causes of every problem are identified, and solutions are agreed upon. Yet, the use of this concept was not observed in any meeting, as this requires a routine for using RCA approach and interest in doing so. This concept should be part of the training program suggested earlier in this chapter.

Systematic problem solving is one of the most emphasized lean ideas since solving a problem is not only to improve the working process, but also to empower people and give them the opportunity to personal growth. Throughout the observed meetings, some project managers were actively delegating issues to be solved by other team members helping them to develop new abilities in handling planning challenges. Nevertheless, training engineers in systematic problem solving associated to the planning process can be a way to support the assessment part within the LAP as recommended in LPS.

Another reason for suggesting systematic problem-solving as an element on our list is the observation that many engineers can plan and execute their activities, but only a few of them have learned how to check and act, as recommended within the PDCA process. Therefore, we consider this an important element on the proposed list.

6.3.7 Background and interest

This element is about the background and interest a project manager or technical coordinator used when planning a project. During the research period, we observed that meeting leaders with some experience in project planning put more effort into the planning process. That was also the case when project managers and technical coordinators were interested in planning, and in learning from project to project how to improve the planning process. The term "*person dependent planning*" was often used among project participants to describe a good or bad approach to planning meetings. It refers to the person leading the meeting and his/her interest and involvement in organizing planning meetings. People were more motivated to prepare themselves for meetings where the technical coordinator was making efforts to plan and keep some control over the evolution of the project. Lack of interest from the management team resulted in a similar attitude from the rest of the project participants.

In contrast, some technical coordinators were in fact so interested in planning that they developed their own tools, including quite advanced dashboards, to be able to follow the evolution of the project. Later, these tools were connected to the scheduling software giving the project planner the possibility to create reports and send them to the project team. These are, however, exceptional cases since this requires a large amount of work and interest from those involved in the process.

These findings also show that the increased complexity in today's projects results in very few managers with the necessary skills to lead such projects.

As elements on our list, background and interest proved to be a key support in the successful implementation of structured planning meetings. It was, though, challenging to define training programs addressing such elements since they must be adapted to the background of each person in the team. Hence, it becomes even more critical to increase awareness on the matter.

6.3.8 Lessons learned

Lessons learned is also an important step both in the PDCA circle, in LPS and of course in LPP since they all emphasize it as part of the continuous improvement process needed during the project planning. However, due to short project duration, this step was less used at weekly planning meeting level while the project was evolving. Discussing with several discipline coordinators, we noted that some of them would keep an overview of the reasons for failure, but that was not done systematically.

This concept emphasized within the lean environment was observed in several projects, especially in companies using structured planning meetings. Throughout the research period, we participated in several project evaluation meetings, and in most of them, planning was seen as a key element that could be improved. All these evaluation meetings were a learning arena where experiences on solving difficulties during the project were well-formulated and clarified so that people would avoid such problems in other projects.

Most projects would have a kind of evaluation meeting, and each project manager chose own approach to organize and disseminate the results. Some project managers would have an evaluation meeting only for their project team while others invited most of the relevant suppliers. Other project managers would present the results of the evaluation to teams that were ready to start a new project at the same company. We have also observed projects where the evaluation of the results was performed at several levels: at project manager level, design phase level, detail engineering level as well as outfitting level. That was due to each team's interest in continuous improvement. In other words, there were usually some lessons-learned-sessions, but the approach varied a lot. This remark aligns well with other observations indicating that standardization of processes was a work in progress at best.

During one of the observed lessons learned meetings, the project manager presented his teams' reflections on their recently completed project. He made the following statement: "*The last few years, none of our projects have been delivered within the initial budget. Much rework in design and engineering have resulted in expensive rework in production. In our project, drawings and models sent to the hull yard were constantly delayed with three to four months. We needed better planning, yet, we felt like we have never had the time to do it properly. Prioritization of drawings was not always based on real and updated information. Engineers in Norway take things easy because they do not see the physical consequences at the hull yard."* His main conclusion was that *"nothing works without good feedback between project participants, and planning is a key instrument in achieving that.*" His reflections confirm again the need for better planning for design- and engineering activities.

Sessions where lessons learned are presented and discussed become even more important when the staff turnover is high. Finding better ways to inform project participants about what went well or bad in each project is one issue most engineers agreed upon.

6.3.9 Testing Hypothesis RQ4

Hypothesis RQ4: *Individual communication- and interaction qualities among the project participants are important for improved project outcome*

The proposed elements described above are also based on qualitative observations as well as on discussions, seminars, and workshops we participated in during the research period. We have also used recommendations from the lean literature, LAP of LPS as well as the communication and SECI model supporting LPP.

In order to achieve better planning and control in ETO projects, there is a need for improving those elements that facilitate better communication and interaction among project participants. It is easy to develop a silo type of planning when each of the participating organizations is preoccupied with improving their own part of the project without considering the effect they have on the rest of the participants. The fact that these organizations are geographically spread, use different planning processes and systems, as well as different project management approaches, it creates challenges that can be solved mainly through an active interaction among all these teams. Therefore, in all projects, the leading team must facilitate and engage people in dynamic communication based on trust and commitment. These findings are in line with recommendations proposed by Macomber and Howell (2003) from the LAP of LPS that emphasize trust as an central component of project planning. The findings are also consistent with what LPP emphasizes in terms of using dialog as a communication style during the planning meetings in order to achieve commitment among project participants. Based on the findings presented above, planning as a tool that (like many other tools) requires training, interest, and continuous improvement in order to achieve a successful and effective communication process.

Most engineers agree that there is a need for the development of skills that help them increase communication and interaction abilities both at the individual level as well as at the team level. However, each company should develop training programs adapted to their own needs as well as to teams delivering each project since many of these teams change from project to project. We assume that by ensuring proper training at several levels within a project would help propagate the same type of thinking in other participating organizations since the interdependencies between them are too tight to be ignored.

All the proposed elements can also be recognized in the lean and lean construction literature when recommending strategies for implementing new concepts or tools. These elements contribute to achieving the language-action and communication perspectives described in Chapter 2. When developing an implementation plan, we need to consider these elements since they contribute to the success or failure of our improvement programs.

The dynamic environment and complexities of ETO projects cannot be simulated in mathematical models since things are changing at a rapid pace. Therefore, developing people's abilities to deal with these complexities through a dynamic planning process could become a preferred approach. Better planning and control during the execution of an ETO project can result in an increased concurrency between engineering, procurement and production as a way to deal with shorter project duration. It can also contribute to reducing the total cost of the project through reducing delays and errors blamed on the engineering teams.

Based on the findings and the arguments presented above, Hypothesis 4 is also accepted. The acceptance of the two research hypotheses has several implications for RQ2 and are addressed next.

6.4 Implications for RQ2

The findings presented for RQ3, RQ4, and the acceptance of their hypotheses have several implications for how to provide some answers to RQ2. RQ2 concerns challenges in planning design- and engineering activities, but it also asks how these can be handled. The challenges are presented throughout Chapters 2 and 5, then summarized in Section 6.1 of this chapter. Now, it is time to address how the acceptance of the RQ3 and RQ4 hypotheses can provide insights into how to handle these challenges.

The acceptance of the research hypotheses was supported by the fact that structured planning meetings and good interaction among project participants produced better project outcomes. The implication of this approach is that by improving how people interact, we can achieve significant innovations without changing software or investing in expensive technology. The reason is that the inherent challenges of planning design- and engineering activities in ETO projects are many and complex, making it difficult to identify the real status of the project when relying only on the scheduling software. To deal with these challenges, two sets of actions based on the acceptance of RQ3 and RQ4 hypotheses are proposed.

The first set of actions offers guidance in organizing lean project planning meetings where engineers focus on planning issues as a way to increase the speed and accuracy of information as well as to achieve communication and commitment to the project plan. The second set of actions refers to the need for increased awareness about what other elements should be on place in order to succeed with the implementation of lean planning meetings.

Table 6-2 presented earlier in this chapter summarizes several challenges in planning design- and engineering activities in ETO projects. How can well-structured planning meetings for design- and engineering activities help dealing with these challenges is argued next.

6.4.1 Well-structured planning meetings and ETO context

The ETO context in Table 6-2 is divided in six groups: project-based approach, customer involvement, outsourcing, need for shorter lead-time, need for reduced project costs, and technology. In the following, implications for each group are discussed.

Since most ETO products are delivered through a project-based approach, it usually implies traditional project management approaches to deliver each project. Schedules based on CPM and PERT methods are created at the beginning of the project even though the Spec is incomplete and changes in requirements from the customer side are intrinsic parts of the business. As shown in Section 2.2.6 these scheduling methods do not fit for planning design- and engineering activities. Therefore, ETO companies need more focus on the planning process, specifically on organizing well-structured planning meetings where all relevant project participants are invited to discuss any issues affecting the evolution of the project. Moreover, adding the proactive focus from LPS, each project team would be able to prepare for the execution of each activity through an open dialog with the rest of the team.

The second challenge presented in Table 6-2, refers to collaborative customer involvement during each project. This is one of the main characteristics within ETO environment where the customer is involved in approval of drawings, documentation, materials, equipment, and completed work in production throughout the duration of the whole project. It implies a certain flexibility during the project and as mention earlier, ETO customers postpone some of the decisions about important features on the final product as long as possible. Moreover, customer involvement results in iterations both at the design-, detail engineering- and production phases. Well-structured planning meetings for design- and engineering activities can help project teams dealing with these issues through a better overview on the activities to be executed as well as through a more dynamic re-planning of project activities. The dynamic communication among project participants contributes to increased understanding of what solutions should be applied without affecting the project outcome.

The third group of relevant elements in the ETO context is outsourcing. Most ETO companies cannot afford to keep in-house all specialized competence that is necessary to deliver one-of-a- kind, highly customized products. In the shipbuilding industry, between 60-80% of the total project value is externally procured, which combined with a complex production structure, demands an increased need for better coordination between all project participants (Held 2010). Well-structured planning meetings for design- and engineering activities are organized with the sole purpose of discussing planning issues and to emphasize a proactive approach toward a more systematic problem-solving attitude. An outcome of these meetings should be better coordination of actions, as proposed by the LAP (Macomber and Howell 2003), since project teams could assess and decide proper actions together. When suppliers are involved in this process it usually leads to increased trust and commitment within the team.

Another characteristic of the ETO context is a constant competition on delivery time and often the preliminary dates seem impossible to keep even before the contract is signed. Norwegian shipbuilding industry has been using several levels of concurrency between engineering, procurement and production for many years to save calendar time, however, largely enabled by the tacit knowledge embedded within skilled workers and high level of trust between them and the management team. This model is, though, changing due to increased outsourcing, but the concurrent model is still a central issue. Well-structured planning meetings for design- and engineering activities are enabling concurrency through an open communication structure and by ensuring that project participants receive necessary information on time. Also, better collaboration, coordination, a dynamic planning process and effective coordination, are elements recommended by the studied literature, and presented in section 2.3.4, that can be enabled by well-structured planning meetings.

The idea of cutting production costs by focusing on implementing DfM approaches is gaining more terrain and many ETO companies must consider the production facilities at different suppliers when designing and engineering parts of the final product. Another evolution on the ETO environment is that customers are no longer willing to pay high price premiums for highly customized products (Rudberg and Wikner 2004), which forces ETO companies to revise their working process. As argued in Chapter 2, an effective DfM is dependent on involving suppliers in the project from an early stage (design, engineering, planning) so that they can advise on appropriate specification that can contribute to lower production costs (Gosling et al. 2015). Such involvement can be achieved through well-structured planning meetings for design- and engineering activities since these argue for early and continuous (as long as necessary) supplier involvement in the planning process. That gives them the opportunity to deliver and collect necessary information.

On the other hand, one of the issues addressed in Table 6-2 is about labor shortage due to high dependency on external workforce throughout the industry. In periods with high workload within the industry, it becomes difficult to find qualified and competent workers, a challenge that leads to higher costs on man-hours as well as increased re-work as sill levels fall. Well-structured planning meetings cannot contribute directly to improving this aspect, but it can help project teams to prepare for periods with high activity levels. From experience, they know what to expect.

The context group called technology is about how advances within 3D modelling and planning software affect the planning of design- and engineering activities within ETO projects. 3D modeling led to an increased in both the number of specialized engineers participating in each project, as well as the number of drawings and documents to be introduced in each model. Additionally, several modeling software were used both within each company and among its suppliers. In many cases, the exchange of data between various software applications requires a third one that can enable the exchange. Most engineers use a significant number of hours transferring data to and from different software. A similar situation developed for the planning software since each company chooses its own approach to project planning. Again, connecting so many different software applications is a demanding job since not all software developers agree to give access to their programming data and there can be data-technical issues. Even more, exchanging 3D modeling data with the planning software applications is done only by a very few developers, but their solutions are often too expensive and lack flexibility. They also require some level of human engagement at some point, which is prone to data errors reducing the quality of the information in the software application. Therefore, until the technology will be well developed and accessible, ETO companies should count on simpler solutions like well-structured planning meetings for design- and engineering activities as a way to improve their working process. Focusing on effective planning is a way to deal with the large number of activities as well as the challenges in connecting so many different software applications by enabling a dynamic communication among project participants. Moreover, by introducing a good RCA, these companies can identify the best technological solutions for the future.

This first set of actions summarized above are relatively easy to implement since they do not require advanced software or expensive technology. However, as the acceptance of the RQ4 hypothesis proves, successful implementation of lean planning meetings is dependent on several other elements. These are summarized next as part of the second set of actions.

6.4.2 Planning fundamentals and ETO context

As stated in Chapters 2 and 5, most engineers lack training in how to organize, structure, and lead project planning meetings. This topic is neither part of the curriculum at universities, not a training program within most ETO companies. It is simply assumed that people can plan and follow that plan since planning is a common topic in today's business environment. However, the training process cannot resume to how to structure planning meetings; it should also include topics on communication through dialog, systematic problem solving, leadership, and other relevant issues related to the planning process. These elements have a strong influence on the outcome of the training process as well as on the correct implementation of well-structured project planning meetings, as discussed in Section 6.3. In other words, to achieve a well-structured planning meeting for design- and engineering activities in ETO projects requires focus on developing employee's skills and competence on how to plan a project.

The elements discussed in Section 6.3 of this dissertations are not exhaustive and they can differ from one context to another. Nevertheless, ensuring that project teams receive proper training in organizing, leading and involving project participants in well-structured planning meetings should be part of the strategy process in any ETO company.

The acceptance of the RQ4 hypothesis brings to discussion the need to improve the understanding of the social aspects of the planning process, as discussed in Section 2.5. To make people from so many and different organizations work together (while each of them is interested in improving their own outcomes) is challenged due to silo thinking and focus on placing the blame. Therefore, making project teams aware of the negative effect of such an approach is essential for the successful implementation of well-structured project planning meetings. That is because focusing on finding proper solutions, which consider the dependencies and the chain reaction among project activities, can result in better outcomes for the whole project. As stated in Chapter 1, the competition in today's shipbuilding market is tight, so, late deliveries and cost overruns affect the chance to win new contracts.

Another element discussed in RQ4 is about the systematic problem-solving approach. This element is about training people on how to properly use RCA to avoid reoccurrence of the same problem. As stated in Chapter 5, most observed case companies do not use this technique even though some of them have implemented several other lean concepts. They argue that it takes time and resources to use the method, and the results show things they already know. However, problems identified in one project are often repeated in later projects. Moreover, solutions applied to similar problems have different outcomes since the RCA was not adequately addressed in the first place. Most of the solutions used without understanding the root-cause end up costing more than planned. Therefore, based on the findings in both literature and practice, it can be argued that to succeed in implementing any type of well-structured planning processes, project teams need to learn how to use RCA effectively.

Another critical element to consider when implementing well-structured project planning meetings is management involvement. Without proper support from the leadership, implementation of such meetings fails as exemplified in Section 6.3.3. A successful example is where leaders learn how to apply new techniques along with the rest of the team and support the implementation of this working process by showing interest and by participating in those meetings as often as possible. Lack of management involvement is also one of the most common barriers in implementing lean and lean construction concepts, as also discussed in Section 2.6.

As discussed in Section 6.3.8, not all project teams use a proper process to analyze the evolution of the project and to learn about the strengths and weaknesses of the entire process. However, learning from previous projects is a process that depends on the availability of correct data and the willingness to learn. The high staff turnover affects the lesson learned process, however, developing a more standardized approach that facilitates a continuous update can reduce the loss of relevant data. Proper lessons learned process contributes to developing solutions that can reduce the impact of the inherent challenges within ETO projects.

The two sets of actions proposed in this section are based on the acceptance of the RQ3 and RQ4 hypotheses. To sum up the implications for RQ2, there is a need for better planning of design- and engineering activities that can be achieved through organizing well-structured project planning meetings. The importance of these planning meetings within the whole planning process can no longer be ignored since most ETO companies struggle to deliver on time and within the agreed budget. However, these are not the only activities to be planned in an ETO project and, to achieve a good overview of the status of the whole project, we need to address the project planning from a more holistic perspective as proposed in RQ1. Hence, in the following, are discussed the implications of RQ2, RQ3, and RQ4 for this research question.

6.5 Implications for RQ1

The overarching RQ for this dissertation is:

RQ1: How can we improve the project planning process in ETO projects?

This research question is even larger than RQ2, and both are too large to be answered through this dissertation alone. That is because the challenges identified through both theory and practice bring to attention a much broader set of topics than covered here, as discussed earlier in Chapters 2 and 5.

Even though the industrial context was established from the beginning of the research project, the Norwegian shipbuilding is a representative ETO environment, and many of the challenges presented in the ETO literature can be identified in this industry. Consequently, it seems suitable to assume that the solutions presented in this dissertation can be adapted to other types of ETO projects, in other types of industries.

RQ1 was proposed as a result of the reviewed literature on planning ETO projects. As shown in Chapter 2, this type of project uses planning tools inspired by the traditional project management literature without adapting them to the inherent challenges of the ETO environment. The result is that most ETO projects are delivered later than planned and with significant cost overruns. That is because the standard, formal approach to project management follows a predictable, fixed, rather simple and specific model that does not consider the environment these projects are performed in, nor the business' needs (Shenhar and Dvir 2007). A typical ETO environment using mostly traditional project management tools is the shipbuilding industry, where many projects are delayed and cost more than planned reducing in this way the already low-profit margins. The data collected in this research endorses the need for improving the project planning process in ETO environment.

Throughout the data collection process, we participated in several types of project planning meetings, as shown in Table 4-1. These meetings cover almost the entire spectrum of project planning meetings within a shipbuilding project. The missing type is procurement planning meetings because these were, in some cases, organized through either engineering or production meetings, while in other cases, they were not organized at all. However, the data collected from each type of project planning meetings was discussed with project managers, and company leaders both during the project and during the lessons learned meetings. A major conclusion was that they need better control over each project, and that could be achieved through a more effective planning process.

The scope of RQ1 is to propose improvements to the planning process in ETO projects. Nevertheless, since both theory (Emblemsvåg 2014b, Little et al. 2000) and practice reveal that design- and engineering activities are not planned as well as production activities, a closer look at this issue was a natural approach. The acceptance of the Hypothesis RQ3 - that organizing well-structured planning meetings for design- and engineering activities lead to better project outcome - indicates that it improves the project as a whole, not only the outcome of these specific activities. This is also evident from the fact that design- and engineering activities set the stage for both procurement and production since over 80% of the cost of the total project are decided during the design and detail engineering phases (Gaspar 2013). Hence, improved project outcome will by default result from improved outcome of design- and engineering activities.

It should be noted that the lack of motivation in organizing well-structured planning meetings could be connected to the way project participants understand the planning process and its role in the total outcome of the project. The acceptance of Hypothesis RQ4 shows the need for more focus on developing people's knowledge about the planning process to help them communicate and interact better. A caution remark here is that due to complexities and diversities of ETO projects, developing training programs must be adapted to the context and project execution strategy applied by each company. Therefore, the proposed solutions and the acceptance of the hypotheses have several implications for the RQ1, as discussed next.

The challenges of planning design- and engineering activities originate in the context of which these are performed, namely ETO. Concurrency, iterations, network organized projects, outsourcing, and a dynamic environment are some of the ETO characteristics that pose the most challenges when planning such projects. These challenges lead to so many variables that it makes it impossible to simulate them in a model or software that can give the project team the best solution within the allotted lead-time (Grabenstetter and Usher 2015). When the complexities are so many, we need to find solutions that enable project teams to deal with them (without adding an unnecessary workload) while facilitating relevant information to arrive at the right people at the right time. In this way, project participants can make informed decisions reducing errors and delays. By proposing a solution based on well-structured project planning meetings for design- and engineering activities, the aim is to use planning meetings as a communication tool that enables the exchange of relevant information.

As presented in Chapters 2 and 5, engineering, procurement, and production phases are performed concurrently in most ETO projects. This concurrency implies that planning in each of the phases affects the planning of the other two. However, very few ETO projects organize planning meetings where these three types of activities are discussed and analyzed through the concurrent perspective. Therefore, to achieve a sufficient concurrency, ETO projects must rely on a dynamic communication process (Emblemsvåg 2014b) that contributes to an efficient distribution of relevant information between engineers, purchasers, and production employees. That implies that organizing well-structured project planning meetings for design- and engineering activities have a positive effect on the project as a total, as also proved through the acceptance of Hypothesis RQ3.

Most participant organizations in ETO projects have little knowledge about the status of the entire project because each one of them focuses on their own activities and deliverables (Eckert et al. 2006). This silo-thinking creates unbalanced relationships and a lack of trust among project participants. The literature on LPS and its LAP (Macomber and Howell 2003) recommend communication as a way to improve trust among people and commitment to the project plan. However, this cannot be achieved when project teams do not have an arena to meet and openly discuss problems or other issues regarding the project. Supported by the acceptance of the RQ3 hypothesis, this research argues that organizing well-structured project planning meetings for design- and engineering activities can reduce silo-thinking and encourages a more holistic approach to planning ETO projects.

Traditional project management literature recommends project meetings in a more general way, as shown in Section 2.2, but, little attention is paid to organizing planning meetings. Moreover, as discussed in Chapter 5, most project managers assume that their role in planning a project should be minimal and that having an advanced software is all they need in terms of planning. Nevertheless, the interconnections among phases of a project require their active involvement in organizing well-structured project planning meetings since the information they can bring in the project is crucial for the rest of the team.

Project managers should be aware of the importance of the elements presented in the RQ4 since they have a central role in ensuring the necessary support for the rest of the team. When project managers are not interested in proper planning meetings at the project level, this attitude is picked up by the rest of the team. Then the question is: how planning meetings at the project management level should be organized and structured? This is, however, a topic for another research. Here is important to emphasize the role a project manager has in the planning process of a project. They also need to be aware of the way they communicate within the project because when they promote open dialog people would trust the decision process and commit to the project.

The implications of the findings concerning RQ2, RQ3, and RQ4, are all pointing to one essential aspect: effective planning and control of ETO projects need more focus on the process around it. By doing that, projects teams can be able to deal with the inherent challenges of planning ETO projects. Moreover, by investing in developing training programs that increase the awareness about the planning process and peoples' role in it, ETO companies can increase the trust and commitment to the project.

All the ETO projects observed during this research as well as the studied literature, show a need for better planning and control of such projects. This research suggests that to implement well-structured planning meeting, ETO companies must start with analyzing the existing planning process from the contract signing to the delivery of the project. Many would say that their contractual agreements limit the freedom of communication and trust among the participants. That might be true concerning commercial details and some other key-aspects of project performance. Yet, when project after project is delivered late, and with significant cost overruns (even though they invested in expensive technologies), we need to look at simple solutions that improve the project outcome for all participants. In other words, train each project team on how to apply well-structured planning meetings to both design, engineering, procurement and production activities. Even though the results on the short run might be slow, the gains in the long run will pay for the investments.

After addressing the findings related to the proposed research questions and some of the literature supporting these findings, I now summarize this chapter.

6.6 Chapter summary

This chapter contains the analysis of the collected data. First, the challenges in planning design- and engineering activities, showing the inherent complexities of the ETO environment were discussed. Through RQ3, were identified three existing archetypes of planning meetings for design- and engineering activities followed by a fourth archetype, a prescriptive model, that brings more lean elements to the structured archetype. The acceptance of the proposed Hypothesis RQ3 shows that well-structured project planning meetings improve the outcome of ETO projects. In RQ4, some of the elements that are necessary when implementing structured and lean planning meetings were discussed. The Hypothesis RQ4 was also accepted. It shows that aspects like, e.g., training, management involvement, and systematic problem solving are necessary in order to implement well-structured project planning meetings successfully.

The acceptance of these hypotheses has implications for both RQ2 and RQ1. For RQ2, it implies that to deal with complexities in planning design- and engineering activities, ETO companies need more focus on the planning process. Two key elements are necessary: to 1) organize well-structured project planning meetings, and 2) to provide proper training in how to organize such meeting so that project participants communicate and interact better. Furthermore, it is important that the planning process, and the -system embedding it, are adjusted to the realities of each specific company – one size fits none.

The implications for RQ1 lay in the holistic perspective required when planning ETO projects and the simple fact that improved planning and execution of design- and engineering activities will by default improve the overall project planning and execution. As demonstrated and proven, that can be accomplished by using project planning meetings as a means to achieve effective communication and strong commitment among a large and challenging network of project participants.

The next chapter addresses the discussion and closing remarks.

Chapter 7

Discussion and closing remarks

7 Discussion and closing remarks

This concluding chapter summarizes the contributions to the improvement of planning ETO projects, and hopefully it will stimulate the on-going scientific debate in the field of project management. First section presents a discussion upon the findings, followed by a section about the contribution to the body of knowledge and to practice. The rest of the chapter presents critical evaluation, limitations of the research, further research and closing remarks.

7.1 Discussion

This research sets out to address the project planning paradox observed in several ETO companies where everyone agrees that planning is important, but very few of them focus on the process that makes it effective. Thus, the purpose of this research is fulfilled by examining the planning process in ETO projects through four research questions and two hypotheses as presented in Chapter 1.

To answer the proposed research questions, the applied data collection method was action research, validated later by several case studies. Because of the nature of shipbuilding projects, the action research approach became staggered in the sense that the six steps (Coughlan and Coghlan 2002) used in implementing the whole process were performed in several projects at different stages. This means that we identified problems in one project, developed solutions, and implemented them in another project. Then, we evaluated the results, collected new data from a third project, and formulated a new proposal that was implemented in a fourth project. This approach follows the recommended sequence of the action research proposed by Coughlan and Coghlan (2002), however, adapted to the realities of the shipbuilding industry. Since many shipbuilding projects have a duration from 18 – 24 months, it would be impossible to perform the research without this staggered approach.

This adaptation allowed the improvement team to participate in numerous planning- and project meetings as well as to identify the elements that influence the project planning process. Observing several different projects, performed at different companies, with different teams and diverse specifications, have improved the understanding of the challenges in the context of planning ETO projects. However, the analysis of a large amount of data collected throughout the research period had to consider the ethical requirements associated with action research. Hence, the unit of analysis was set to the project meeting level and not to the individual level, i.e., participants in these meetings. Since the main research question refers to the planning of ETO projects, direct participation, and observation of several types of planning meetings was the most appropriate method of data collection.

Although the number of ETO companies is increasing (Cutler 2005), the literature studying the ETO environment is scarce (Willner et al. 2016), under-researched, and in need for more clarity (Gosling, Hewlett, and Naim 2017). By default, literature on planning ETO projects is even scarcer. Hence, the suggestions made in this dissertation are based on observations on what works in practice as well as on research within the construction industry combined with ideas from LPP that originated in the shipbuilding industry. The construction- and shipbuilding industries are similar in many ways, but different in others as shown in Section 2.5.8. However, planning methods that work in one environment can usually be adopted or adapted to the other one. A common feature is that although projects in construction or shipbuilding seem similar (e.g., sister ships), there are always differences in the way these projects are built, managed, and planned due to the inherent ETO challenges. Since, many of the challenges in planning shipbuilding projects can be identified within construction projects, it is likely that solutions proposed here will also work in the construction industry. However, to my knowledge, this has not been demonstrated yet.

The studied literature lacks recommendations on how to plan design- and engineering activities in ETO projects as shown in Chapter 2. Using traditional approaches to plan these activities proved difficult in an environment delivering one-of-a-kind, highly customized products by involving a large network of suppliers that are geographically spread around the world. Additionally, executing phases and activities concurrently, while the customer is interested in postponing decisions as late as possible, has also received little attention within the project management and ETO literature. Considering all these challenges there is no surprise that ETO companies both in construction and shipbuilding struggle to implement both LPP and LPS in planning of their design- and engineering activities (e.g., (Emblemsvåg 2014b, Kalsaas, Bonnier, and Ose 2016)).

The purpose of the first research question was to address the planning of ETO projects from a holistic perspective since the characteristics of this environment pose numerous challenges to planning such projects. While mapping the planning process in ETO projects, it became clear that most of these projects lack a proper planning approach for their design- and engineering activities, but they focus on planning the production activities (Emblemsvåg 2014b, Little et al. 2000). Preliminary findings in the industry confirmed these aspects. Therefore, the next step was to identify the challenges in planning these activities and to find solutions in how to handle them. Hence, the emergence of RQ2.

While mapping the ETO challenges was performed through a literature review combined with observed practice, the solutions to handle them required a more in-depth analysis of the way project teams actually plan the design- and engineering activities. Some of the observed projects were delivered on time, so an analysis of factors contributing to that had to be considered. An interesting aspect was that all of these projects revealed a significant focus on the planning process both in production, in procurement and for design- and engineering activities. Consequently, RQ3 and its hypothesis were formulated.

RQ3 was formulated while observing project teams when organizing planning meetings. About 10% of the observed teams followed a determined structure for planning their design- and engineering activities. These projects were the ones delivered on time. In contrast, the majority of other projects used a combination of project- and planning meetings where most of the topics were of technical nature. The second approach led to a low level of control over the status of the project, delays, and cost overruns. Moreover, the lack of trust among project participants led to a communication process based on contractual agreements where people discussed planning issues as little as possible. The result was a silo thinking where people focused on maximizing the outcome on own activities regardless of the effect on other teams' activities. Throughout the data collection, a pattern of meetings emerged.

The observed planning meetings were categorized into four archetypes, as proposed in Section 6.2. Three of them were identified within the studied companies, while the fourth one is proposed as an improved version of the third archetype, a prescriptive model based on additional lean element. A lean project planning meeting combines elements from lean, LPS, and LPP as a solution to improve the planning of design- and engineering activities in ETO projects. This type of meeting has the scope to enhance direct communication among project participants as a way to deal with the inherent complexities of ETO projects. Moreover, the coordination of actions and correct assessment of the status of the project become easier to achieve when project participants are allowed to inform and be informed about actions affecting the evolution of the project. In other words, the proposed lean project planning meetings emphasizes the role of the language-action perspective of LPS (Macomber and Howell 2003) and the dialog proposed by LPP (Emblemsvåg 2014a), as fundamental elements within the planning process. This model is to be tested in future ETO projects.

Traditional project management has been the predominant approach applied to managing the shipbuilding projects. In some cases, several lean ideas were also partially implemented. However, the limitations of traditional project management approaches are revealed by the statistics showing delays and cost overruns in a large number of projects. Typically, most of the traditional planning methods focus on scheduling through a planning software or simpler programs. There is little attention on how to train employees in actually understanding as well as getting involved in the planning process and learn how to communicate planning issues within the team. This is typically delegated to the project planer alone. As observed in the successful projects, achieving structured project planning meetings is a process that depends on several supporting elements, but due to difficulties in implementing them in other projects, had to be identified and analyzed. Hence the formulation of RQ4 and its hypothesis. Even though our team did not have the time to develop and test training programs for the identified elements, the findings are still valid, as demonstrated in Section 6.3. Establishing training sessions where people learn how to organize well-structured planning meetings, learn how to solve problems systematically, learn how to encourage dialog, and learn from past projects will enhance employees' understanding of the planning process. The acceptance of Hypothesis RQ4 implies that companies should evaluate the existing supporting elements before implementing well-structured project planning meetings.

Today, most ETO projects have become large networks of organizations participating to the delivery of a highly customized product. Involving all these companies in the project plan is difficult and demands time and resources. There are no recommendations on how to deal with such complex issues neither through a planning software, nor through the planning process. Yet, focusing on a dynamic planning process where project participants deliver and receive relevant information on the project activities reduces the time they use for finding information.

Managerial support is one key element in implementing well-structured project planning meetings successfully. However, as shown in Section 6.3, not all managers understand the role of the planning process in ensuring communication and commitment to the plan, nor do they understand the importance of its social aspect (Ballard 2014). Moreover, very few of the observed project teams use the constraints analysis as part of the planning process, where they prepare project activities for completion. Consequently, the findings in this dissertation confirm the lean idea that managerial support is an essential element also in the successful development and implementation of a well-structured planning process.

The findings also show that many ETO companies neglect the process around the planning activity. This lack of focus indicates that project teams expect that the scheduling software would show them the status of the project without too much effort from the team. In most of the cases, planning and scheduling were synonyms reducing the whole planning activity to its system part and overlooking the importance of communication, trust, and commitment to the plan, that are essential for a successful planning process. Therefore, based on the findings from RQ2, RQ3, and RQ4, the ETO project planning process can be emphasized and improved through organizing lean planning meetings.

Recognizing the role of planning as a process that supports communication and commitment within the project team is one on the main arguments in this research. As a core part of the project management process that needed to be improved as shown in Figure 1-1 and Figure 1-2 (Zidane, Johansen, et al. 2015), planning needs to be understood as a process that enables trust and involves all relevant project participants through effective communication and commitment.

Summarizing the proposed findings: to achieve effective project planning and control, ETO companies should start by evaluating and improving employees' understanding of the planning process. Having the elements proposed through RQ4 in place will facilitate a successful implementation of well-structured project planning meetings. This type of meeting allows engineers to deal with the inherent challenges in ETO projects by developing an arena for dynamic communication and trust among project participants. Even though proposing well-structured planning meetings might seem a simple solution, it is the whole process that needs to be understood in order to succeed. Planning becomes a good tool in the decision making practice when it enables the whole project organization to communicate effectively and to proactively stay one step ahead for the execution of each activity. Hence, this represents a real improvement of the planning process in ETO projects.

This research emphasizes the importance of organizing well-structured project planning meetings as a central element of the planning process. To the best of my knowledge, this is the first research to examine the role of planning meetings in achieving an effective project planning process in the ETO environment.

7.2 Contributions to the body of knowledge

The theories reviewed in Chapter 2, were selected due to the research context and observed challenges within the shipbuilding industry, a representative ETO environment. Using abduction as a logic of argumentation implies that this research contributes to refining some of the theories presented in Chapter 2, not developing new ones. During the research period, it became clear that some of the results presented here might contribute to several of the theories presented in Chapter 2, as well as to the studied practice. Contributions to the body of knowledge follow the same sequence as Chapter 2.

Contributions to project management literature. In the beginning of Chapter 2, project management is presented as a type of operation within the OM literature. That is because, many of the applied tools in managing and planning projects were and still are inspired from OM recommendations. Hence, contribution to the project management literature, is also a direct contribution to the OM literature.

Most of the PMBOK® recommendations help manage projects, however, they are not enough to manage them successfully. That is because most of these recommendations focus on project execution without reflecting on context and chosen strategy, which in turn leads to an inappropriate definition of the objective and suboptimal strategies to accomplish them. The basic elements of project management involve some mix of scope management, activity scheduling, cost and resource management, which is, in fact, basic project control (Morris 2004b). That is probably the reason why most ETO companies use traditional project management techniques and tools in delivering their projects. Through addressing the planning challenges met by ETO projects, this dissertation contributes to the theory of project management by showing that context (e.g., ETO) and the type of project are important aspects in managing such projects. That is in line with what, e.g. (Bosch-Rekveldt 2011, Vidal 2009) argue in their research about management tools that need to be adapted to each project context and requirements.

PMBOK® and other traditional project management literature, e.g. (Kerzner 2009, Morris 2004a, PMBOK® 2013a) do not discuss the role of planning meetings for design- and engineering activities assuming that all project activities can be planned in the same way. Although, some of this literature recognize the iterative nature of design- and engineering activities and the need for concurrency, they do not recommend planning approaches able to deal with these characteristics. By proposing the implementation of well-structured planning meetings that can improve the planning for design- and engineering activities, the contribution to project management is three folded:

1) It emphasizes the need to analyze the effects of network organized projects, CE, DfM, iterations, outsourcing, and 3D modeling. i.e., the complexities of design- and engineering activities, in managing and planning projects since these issues are acknowledged as existing in one form or another in most of today's projects. Due to these complexities, there is a need to design a planning- and control process that considers the specific context of a company.

2) It emphasizes the need for creating dedicated and well-structured planning meetings where project participants discuss only planning issues. This issue is not discussed through the studied literature even though planning and scheduling are two of the most central issues in the management of projects

3) It emphasizes the need for communication and commitment as part of the social aspect of the planning process. In other words, the project management research should focus more on improving the planning process by focusing on people, and less on technical or scheduling issues since data in a software is just a mirror of the process of collecting them. For example, for years, researchers, as well as practitioners, have tried to find the code of modeling the information maturity in engineering- and procurement

documentation as a way of managing the design- and engineering activities. Yet, there is no reliable approach still developed. Big companies like for example Equinor use the coding system inherent in the Norwegian contracting system (NTK-2015), but the challenges are more or less the same as before, i.e., setting the status of the codes is still based on guesstimates and not real measurements of information maturity.

Similar to other scientific subjects, project management as a topic is too broad to be served by one single theory (Morris 2004b). Therefore, this research contributes to developing project planning theory within project management literature.

ETO represents a type of project within the project management environment and the main research area for this dissertation, so contributions to the ETO literature are presented next.

Contributions to ETO literature. The literature studying the ETO environment, in general, is scarce, so the first contribution of this research is to bring more case studies to this environment. There are only a few articles addressing issues regarding the planning of ETO projects, e.g. (Little et al. 2000, Viana, Bulhões, and Formoso 2013), and they discuss only some general aspects without reflecting on the effect of all ETO characteristics on the planning process. Hence the main research question posed in Chapter 1 of this dissertation. A central contribution here is to prove that the planning process of ETO projects can be improved through organizing well-structured planning meetings for design- and engineering activities. The interesting point is that in the literature, this rather obvious point is more or less forgotten. It is as if conducting a planning meeting is obvious – yet experience shows that it is far from real. Structured meetings are quite uncommon – only 10% in the data sample, as shown in Chapter 6 – which shows that it was perhaps high time that this was investigated.

Another contribution to the literature on ETO is through RQ2 where more holistic view of the challenges on planning design- and engineering activities in ETO projects are identified in Chapter 2 and then summarized in Chapter 6. An assessment of how these challenges affect the planning process is then presented in the findings chapter. This analysis is also a contribution to the literature on planning ETO projects since this has not been done before. There are several articles discussing management and planning challenges, however, they look at specific issues like sequencing (Grabenstetter and Usher 2015), uncertainty (Gosling, Naim, and Towill 2013b), cost estimation (Hooshmand, Köhler, and Korff-Krumm 2016), outsourcing (Willner et al. 2014), iterations (Wynn, Eckert, and Clarkson 2007), and none of them to the wholeness of ETO challenges. Nevertheless, the summary of these challenges is not exhaustive here either, but it is a starting point for understanding the ETO environment through a more comprehensive picture.

Little et al. (2000) discovered in their research (as also shown in the data sample collected for this research) that most ETO projects focus on production planning, neglecting planning for design- and engineering activities. This is also evident from the data sample even without testing of hypothesis. There were, in fact, very few structured planning meetings dedicated to this part of the project. Based on observations from projects where design- and engineering activities were planned and controlled through structured planning meetings, we identified some of the elements that made these meetings successful. Therefore, in this dissertation, ten elements that contributed to better execution of planning meetings for design- and engineering activities were proposed, discussed, and tested through Hypothesis RQ3. This is a contribution to the literature on planning of ETO projects since there is a need for a better understanding of the planning process and its basic elements.

The elements proposed through RQ4, tested, and accepted through Hypothesis RQ4, are all based on observations and discussion with engineers dealing with ETO projects. Most of the engineers interested in planning emphasized the lack of training in how to organize and lead planning meetings. This confirmed what Liker and Meier (2007) found in companies implementing lean and forgetting that people need to be trained in how to solve problems systematically. They also point to the fact that people in a company should be seen as athletes that never stop training just because they reached high-level results – they keep training even harder to improve those results continuously (Liker and Meier 2007). Being able to organize well-structured planning meetings is dependent on skills that can be developed through training, however, there is also a need for engineers to show interest in such processes. The proposed elements that can improve the engineers' capacity for organizing project planning meetings can also be seen as a contribution to the literature on the ETO environment.

Another interesting aspect of ETO projects is the way the shipbuilding industry defines several phases within the engineering phase: concept, basic design, detail engineering, production drawing, and verification (see Figure 5-8). To my knowledge, there are no other studies discussing the impact of such division on the planning process. Adding more people and several project organizations complicates the information process even more. This contribution explains some of the inherent challenges in planning these activities.

The main contribution to the ETO literature is to propose a way to implement structured planning meetings for design- and engineering activities as a way to improve the outcome of ETO projects. This is an important aspect since most ETO companies struggle to deliver their products within the agreed frames of budget and time.

Contributions to LC and LPS literature. The LC environment is continuously encouraging research on implementing lean concepts in managing and planning complex construction projects. This research contributes to the LPS literature by showing that even when the tool is just partly implemented, the benefits for the whole planning process are noticeable. LPS is a valuable tool in shipbuilding and projects using elements of it had an improved focus on the planning process. However, proper implementation of LPS is dependent on both management involvement and proper training for the employees who would use this tool as also shown within the LC literature.

Another contribution of this research is to emphasize the need for well-structured planning meetings where LPS is an important part of the planning process, but not all of it. One of the gaps identified in the LPS literature is that it does not describe project planning meetings either. The studied literature shows that LC teaches people how to implement LPS and other lean or lean construction concepts. However, an improvement would be to teach people how to organize and lead project planning meetings where LPS and other elements are properly implemented as part of the planning process of the whole project. In this way, the elements of the LAP would be better emphasized and understood by the project teams. Furthermore, the proposed lean project planning meetings, has a clear focus on the social aspect of the planning process, by creating an arena where project teams can meet and communicate issues regarding project execution.

This research also shows that there is a need for LPS and its elements in planning shipbuilding projects, however, LPS alone is not enough, as shown in Section 2.5.7. Therefore, more focus on the process around the implementation of LPS might contribute to a better understanding of its potential for effective planning of design- and engineering activities. Engineers are reluctant to implement LPS, however, if put in the context of planning meetings might increase its acceptance.

7.3 Contributions to practice

Based on the observed ETO companies, most of them lack focus on the planning process as well as on organizing structured project planning meetings for design- and engineering activities. Numerous interviews and discussions with employees in these companies reveal that most of them acknowledge that they do not use enough time on planning their projects, and the result is an increasingly chaotic state of their projects. Moreover, very few of them have participated in courses or training sessions about learning how to plan. This research brings to attention the need for training employees not only on technical improvements but also on how to plan a project by focusing on planning as a communication process.

Implementing well-structured planning meetings is dependent on the company's leadership implication and support, as well as specific training procedures developed within each company. However, any training program should be based on each company's needs, challenges, and context. That is because ETO companies are diverse, and they have different types of project organizations, different project execution strategies and therefore, different approaches to planning. Moreover, people in these companies have different backgrounds and experiences, different interests in planning, and they tend to change jobs quite often. To deal with these challenges, ETO companies should develop and refine own specific, standardized training programs so that people understand how the planning process works and what their attributes are.

Most of the engineers are interested in techniques and tools that can help them plan faster and better. However, using time on planning and updating the plan is one of the activities that is easily postponed when the pile of delayed deliverables increases. Proposing well-structured project planning meetings for design- and engineering activities contributes to helping project teams to avoid delays by actively using the constraints analysis as recommended by LPS. When delays are inevitable, a proper root-cause analysis session can help the project team solve the problem effectively.

Since many engineers complain about having to participate in too many different project meetings, the idea of developing one more type seems difficult to accept. This dissertation argues that several of the other meetings can be avoided if project teams develop well-structured planning meetings where people use proper constraint analysis. That is because by analyzing eventual constraints and eliminating these, will result in less unforeseen problems that hamper the execution of activities as planned.

As shown in Chapter 5, it was easier to implement LPP in companies having control over each project phase, but this is not an option for all ETO companies. Yet, by developing well-structured project planning meetings that involve relevant suppliers and allows them to discuss project problems, it will enhance the trust and commitment to the project plan.

This dissertation argues for more focus on the planning process at each project level, and that includes project managers and other company leaders. Project managers need to understand that organizing well-structured planning meetings is not just an activity for the rest of the team. Without active involvement in facilitating the organization of such planning meetings, the project team cannot succeed.

This research might help practitioners to understand that planning, scheduling, and reporting are three different activities within the planning process. While scheduling can be a planner's responsibility, both planning and reporting are more or less the whole team's responsibility.

Well-structured project planning meetings are meant as an arena for communication through dialog among project participants. Facilitating such an approach increases the welfare of the project participants and might reduce high-staff turnover.

The solutions proposed in this research also have a few environmental implications since better project planning results in fewer errors in several places. Delivering the right drawings at the right time, to the right people reduces the errors in production, which implies fewer materials sent to scrap. Moreover, when suppliers of components receive correct information at the right time, they will also reduce the amount of scrap.

7.4 Critical evaluation

This research started just before the oil- and gas crisis and ended after. The crisis itself turned out to complicate the research significantly and limit the access to cases where the team could test the proposed lean planning meetings and the elements proposed in RQ4.

The staggered action research (AR) applied to this research has both advantages and disadvantages. The advantages were that observing so many types of meetings organized by different teams located at different shipyards, allowed us to analyze the project planning from several perspectives and also obtain a sense of how variation can impact the results. However, since the studied literature on AR recommends a sequential approach, where the research team deals usually with the same team and quite similar projects, in the same place, this research deviates to a certain extent from this literature, due to the inherent challenges in planning ETO projects. The recommended steps in implementing AR were continuously followed, though, adapted to the dynamic ETO environment. The large amount of data collected through the research period is a result of this staggered approach, even though the initial idea was to apply a more sequential and limited approach.

Hence, I had to rely on observations in a staggered AR approach, but due to a large number of meetings in the sample, I got sufficient material to identify and describe the three archetypical meetings. This allowed me to test the hypotheses, albeit not in a statistical sense, which would have been ideal. This said, the results were so clear in favor of the hypothesized solutions that it is unlikely that a different conclusion concerning these hypotheses would have been reached if it had been possible to do a statistical analysis.

The topic of planning design- and engineering in ETO projects seemed to be largely ignored in the literature and hence, allowed me to study something novel. Yet, due to the practicalities of the research, I did not have the time or budget to bring into discussion some other possible theoretical aspects that maybe would have improved the argumentations throughout the research. Some of these theories would have been:

- Human bias in planning since throughout most of the observed projects, people had an essential contribution to the success of the planning process, while people are influenced by their own biases when making decisions
- Planning as a coordination tool could have also been a theory to use as an argument for better planning meetings for design- and engineering activities
- Better theoretical discussion on the communication, dialog and the tacit knowledge perspectives would have probably improved my argumentation, however, these are broad fields that require a different approach to the whole research

Another critical evaluation of this research is its lack of examples from the construction industry. Testing the proposed lean type of planning meeting in construction projects would have added significant improvements to it, especially in companies using LPS as their working method.

This research did not approach the topic of how to disseminate the well-structured planning meeting to the rest of the collaborating organizations in an ETO project. How, by involving their representatives in the planning process, can further improve those companies' planning process.

Nevertheless, the arguments and the theories used within this dissertation fit the purpose of this research, and in the spirit of lean thinking - there is always a place for improvement, but that is subject to further research as discussed in Section 7.5.

7.5 Research limitations

Generalization is the aim of any researcher and choosing the research methodology indirectly defines the research limitations. To build knowledge, this research combines AR and multiple case studies. Knowledge is an iterative process that becomes more mature with every new contribution and grows towards new research areas (Karlsson 2009). From this perspective, Operations Management is still expanding and moving towards new fields, including the ETO environment. As discussed throughout this dissertation, only a few sources have addressed issues regarding the planning of design- and engineering activities within the ETO context, e.g. (Grabenstetter and Usher 2015, Little et al. 2000, Wynn, Eckert, and Clarkson 2007). Therefore, it is natural to apply explorative research supported by qualitative data in order to examine fields like ETO (Edmondson and McManus 2007). Based on this reasoning, the research presented here has been initially supported by data from the AR, however, different cases in different companies.

This research involves a single industry analysis, and that limits the generalization of the findings. Nevertheless, it contains data from several different shipbuilding related companies, so the possibility for generalization is reasonable, but caution must be employed due to ETO project specificity. Moreover, as shown in Chapters 2 and 5, the context of each project must be considered when developing and implementing well-structured project planning meetings.

A significant limitation of this study is the limited PhD duration as well as the evolution of the shipbuilding market and the subsequent limitation to access new projects. The deteriorating market and margin pressure, also make the case companies less interested in trying new approaches. That limited significantly the time to test the proposed elements of the lean planning meetings in a design science way, which would have yielded more reliable results than through the staggered AR approach. A design science method would imply a more structured testing of the hypotheses, and hence potentially a more robust approach concerning the results.

The elements proposed for the RQ4 are based on observations and discussions, but there was no time to develop and test a training program, addressing these aspects. Testing these elements in relation to improving the way planning meetings are organized and structured, could result in other important issues that were not visible at the time this research was performed. Developing a training frame that can be adapted to each company's requirements to project planning would be the next step.

7.6 Future research

Throughout this dissertation, were presented several gaps in the literature and possible further research. Here are some of the topics that can be addressed by future studies:

- Further test and refine the approach to the planning of design- and engineering activities in ETO projects to other industries
- Develop a frame for training engineers in organizing and leading well-structured project planning meetings for design- and engineering activities
- Apply a design science method to implement and test the proposed type of structured planning meetings
- Closer analysis on how to further increase concurrency among phases and activities through improved planning of engineering, procurement and production

Even though the reviewed traditional project management literature acknowledges and describes network organized projects (or globally spread project organizations), they do not address the challenges on planning such projects as mentioned in Section 2.2. This gap is also a subject for further research within the project management field.

Planning of procurement activities in ETO projects is also an interesting gap within the studied literature. While project management approaches procurement activities from the perspective of handling relationships with the suppliers, there is little or no recommendations on how to plan these activities even though their outcome is closely interconnected with deliveries from design-, engineering and production activities. Moreover, within the studied LPS literature, there are no prerequisites for sound activities when planning procurement activities.

7.7 Closing remarks

This research sought to address the issues of improving the planning process in ETO projects and it was motivated by the opportunity to solve a practical problem in the shipbuilding industry. The literature review identified the peculiarities of the ETO environment and the challenges when planning such projects. The diversity of the identified challenges shows that the traditional project management approach needs additional elements that can contribute to achieving the required communication and commitment among all organizations participating in ETO projects.

The studied ETO projects were all influenced by iterations, outsourcing, network organized projects, and other ETO characteristics presented in Chapter 2. Project managers and engineers responsible for delivering the final product had to manage a network of organizations delivering and requiring information, which most of the time had to be collected from within one or several of the external organizations. Most successful project teams managed to keep up with this dynamic information exchange by organizing structured planning meetings where all relevant participants were invited to discuss issues regarding the completion of their activities and how these can be solved before they become a problem. Those structured planning meetings were also an arena for commitment where people agreed on which activities can be completed as planned as well as which ones need to be re-planned and how. Moreover, the team achieved a better coordination of actions through dialog and proper assessment of the status of each activity.

Using LPS and LPP to develop the proposed lean project planning meetings was useful since these planning methods bring to attention the need for better communication among project participants. LPS emphasizes the need for more focus on the social aspect of the planning process, which has been neglected compared to the technical aspect represented by scheduling activities in a software. A similar approach was proposed by LPP that underlines the need for more focus on the entire planning process as opposed to focusing only on the planning system represented by the scheduling software. In other words, there is a need for more focus on people and the way ETO companies train and develop their employees in understanding that planning is not just learning how to use the software. Planning is also about learning how to communicate across companies, cultures, and people in a way that creates trust and commitment to the plan.

Proposing more focus on the planning process and on organizing well-structured project planning meetings is a result of teamwork on how to improve planning in shipbuilding projects. Somehow, this proposition reflects the experience of several project managers, engineers, purchasers, and planners who have contributed with insights, reflections, and discussions throughout this research. Managers and other project participants can explore the proposed lean meetings to increase their knowledge in project planning. However, this research is not prescriptive as to the applicability of the proposed type of meetings. It is assumed that practitioners will decide which concepts and techniques are more applicable to each specific context due to the complexities inherent in ETO projects.

The mission proposed in the title of this dissertation is to contribute to solving a project planning paradox in the ETO environment by analyzing the process of generating and following a project plan. The idea was to bring awareness to the importance of the planning process since this facilitates the completion of project activities as planned. As shown in this research, organizing well-structured planning meetings is dependent on proper training and understanding of the context an ETO project is performed in. This can enable a more effective planning process, which in turn contributes to better project outcome. As D., Eisenhower stated more than seventy years ago: “Plans are nothing; planning is everything”.

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