Master’s degree thesis

LOG950 Logistics

Information- and Material Flows in Warehouse Management: A Case Study

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Number of pages including this page: 102

Molde, 01.06.2020

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Preface

The Master Thesis is a general requirement and final stage for the Master´s program in Logistics at Molde University College. The study for this master thesis started in December 2019 and was finalized in June 2020. This thesis has been carried out in collaboration with a Norwegian shipyard and Møreforsking Molde AS. Unfortunately, our data collection was affected by the circumstances surrounding COVID-19, which made it more complicated to gather information as planned and our thesis is therefore limited in some aspects.

We would like to show gratitude to our supervisor Steinar Kristoffersen from Molde University College, and co-supervisor and research scientist Kristina Kjersem from Møreforsking Molde. Steinar has contributed with a high level of academic competence and provided us with valuable guidance and advice on the empirical direction of our thesis. We have appreciated his insight into our case study and feel fortunate to have him involved in this research. In addition, we are grateful to Kristina Kjersem who provided us with valuable insight and discussions that helped us improve our understanding of the shipbuilding industry. We acknowledge her keen involvement with continuous support and follow up for the improvement of our thesis. We are grateful for both Steinar and Kristina for providing us with professional guidance throughout the final semester through correcting drafts, sharing theoretical insights and good advice.

We would also like to thank the case company for making the necessary arrangements for us to be able to write our thesis. Without their participation, this thesis would not have been possible to conduct. A special appreciation goes to the interview participants for their time to provide insights and valuable contributions to our thesis throughout the project.

In the end, we would like to thank our families, friends and fellow students for encouragement during the semester, giving us the motivation to create this final product.

Molde, 01.06.2020

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Abstract

This thesis aims to contribute to literature regarding information- and material flow seen in the light of warehouse management. A single case study has been conducted on a Norwegian shipyard, referred to as Shipyard X in this thesis. The case study investigates how the flow of information- and material goes through the case company´s Warehouse Management System (WMS) and if there are any challenges that cause inadequate use of the system. Since the case company has implemented a WMS adjusted to their needs, it was interesting to find out if the current use of the system works optimally (RQ1), identifying challenges (RQ2) and provide possible suggestions for better use of the WMS (RQ3).

The case study findings gave valuable insight into the current procedure for information- and material flow at the case company limited to the flow going through the WMS. Studying the case company gave us an understanding of the interdependency between the different departments and suppliers which created challenges related to coordination and the need for timely and reliable information. The challenges discovered during this case study indicates some potential causes for why the current use of the WMS does not work optimally. We identified three different issues that result in inadequate use of the WMS and therefore impact the flow of information- and material negatively. These are (1) manual access and handling, (2) underutilized capabilities in the WMS and (3) lack of technical information from suppliers.

To cope with these challenges, information sharing and technology such as Enterprise Resource Planning (ERP), WMS, barcode and Radio Frequency Identification (RFID) have been researched. Enhanced information sharing between the yard and its suppliers were found as necessary to deal with cause (3). Especially, utilization of technology such as RFID along with better integration and interface of the current IT landscape were discussed as possible solutions to facilitate a timely and reliable flow of information, thus dealing with cause (1) and (2).

Keywords

ETO, Shipbuilding activities, Purchasing in ETO, Information flow, ERP, RFID, Warehouse Management, WMS.

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List of Abbreviations

ASN	Advanced Shipment Notice
AS/RS	Automated Storage and Retrieval Systems
CAD	Computer-Aided Design
CODP	Customer Order Decoupling Point
DE	Detail Engineering
EDI	Electronic Data Interchange
ERP	Enterprise Resource Planning
ETO	Engineer-To-Order
IT	Information Technology
MRP	Material Resource Planning
OSV	Offshore Service Vessel
PO	Purchase Order
RFID	Radio Frequency Identification
RO	Research Objective
RP	Research Problem
RQ	Research Question
SKU	Stock Keeping Unit
WMS	Warehouse Management System

1.0 Introduction

In this chapter, the background of the research topic is introduced. The relevance of the study is then presented followed by the research problem and research questions. The chapter is concluded with a presentation of the thesis structure.

1.1 Background

The maritime industry is important for global trade and the global economy and creating benefits for countries all over the world. Maritime transport allows food, medicines, technology, raw materials for production and more to be shipped from and to every corner of the planet (United Nations 2016). Other important aspects of the maritime industry are areas such as extraction of minerals and energy resources, tourism and many other opportunities (Office of Ocean Exploration and Research n.d.).

This thesis focuses on the shipbuilding segment in the Norwegian maritime industry. The shipbuilding companies in Norway have a unique maritime competence, which have been developed through generations with a special ability and willingness to innovate and adapt to market trends (Norwegian Shipowners' association 2016). Shipyards in Norway are recognized in the world as being able to build advanced offshore vessels, with exceptional quality and on-time delivery (Kristoffersen 2012). This expertise has helped Norwegian shipbuilders to establish themselves in new markets (OECD 2016). Facing a weakened offshore market caused by falling oil prices and declining activity levels, it has been essential for Norwegian shipyards survival to sustain their ability to innovate and adapt to market changes (Norwegian Shipowners' association 2016). Several shipyards have therefore taken on new assignments such as cruise ships, ferries, yachts, fishing and fish-carrying vessels and more (SSB 2019).

Semini, et al. (2018) states in their article that there are several central factors that may give Norwegian shipyards a competitive advantage, viz. experienced and skilled workforce, proximity to ship designers, suppliers and customers, infrastructure, geographical benefits such as close distances to open sea, flat and informal organizational structures, etc. Although Norwegian shipyards have a competitive advantage in these areas, labor costs in Norway are high compared with other countries, forcing local shipyards to outsource parts of their production to keep up with the competition worldwide. Since the 90s, Norwegian shipyards have been offshoring most steel-related tasks to countries with a lower labor cost level. Meaning that larger ships delivered from Norwegian yards normally have a large part of their steel structure produced at locations in low cost Eastern European countries, such as Poland, Ukraine and Romania (Semini, et al. 2018). Thus, Norwegian yards focus on the outfitting of the ship, which is the activity of installing components and equipment into the vessel`s steel structure. Outfitting can include activities such as the installation of pipes and machinery, cabling and electrical systems, heating, ventilation and air conditioning, as well as accommodation and hotel functions. However, the degree to how finished the hull is when towed to Norway varies between shipyards.

Semini, et al. (2018) argues that there are four generic strategies for Norwegian shipyards for work performed abroad. The different strategies are shown in figure 1 below and show the division of work between low-cost site(s) and the Norwegian yard and indicate approximately the point in production when transfer to Norway takes place (Semini, et al. 2018).

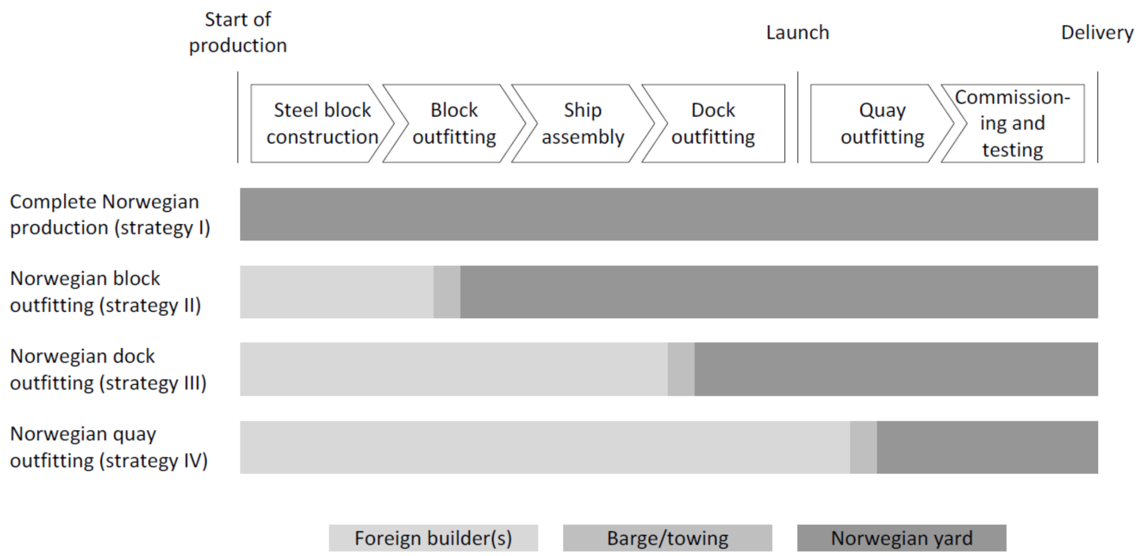

Figure 1: Strategies for Norwegian ship production and outsourcing of steel structure (Semini, et al. 2018)

The shipbuilding industry is characterized as being a project-based industry producing large and sophisticated products. Project-based industries are often distinguished with uniqueness, complexity, and uncertainty (Kvalsvik 2012; Shah and Hasan 2016). Each project has its own lifecycle and may be completely different from previous projects, as the customers often require customization. The production strategy in shipbuilding projects is often Engineer-To-Order (ETO) based, with complex activities that are interlinked, and thus creating interdependencies (Dixit, Srivastava and Chaudhuri 2014). Given the interdependencies between departments, activities and required components, it is difficult to ensure that the activities happen exactly as planned and this creates uncertainty about when the items are required. The combination of inaccurate or incomplete requirements, information and uncertain lead-times for components resulted from inadequate sourcing strategy could lead to delays in the project or high inventory carrying costs. Therefore, timely material availability and material information flow are critical for the projects to be completed on time and budget (Dixit, Srivastava and Chaudhuri 2014).

The competitiveness of a shipyard depends on factors such as – material supply, warehouse facilities, production facilities, availability of skilled labor, wage rates, labor productivity, cross-exchange rates, and in some cases, subsidies since all play a part in determining the cost and the revenue received by the shipbuilder. Materials in a shipbuilding project often account for 60 % or more of the total costs of each project and it is consequently important that materials are handled as efficiently as possible. Therefore, it is important to ensure just-in-time deliveries, quick and effective receiving process and information flow between departments, customers and suppliers involved in the project (Stopford 2009).

In this thesis, the importance of information sharing is found as a necessary focus area for optimizing key business processes such as purchasing and warehouse management. A lack of adequate information sharing across departments at the shipyard often leads to inefficient processes which in turn lead to delays in the total project. Insufficient information sharing is a common problem that several shipyards share in the region of this study (Kvalsvik 2012; Tøssebro 2013; Nordhus and Skagseth 2019). This thesis focuses on the information- and material flow going through the case company’s Warehouse Management System (WMS) from the point of creating a Purchase Order (PO) to assembling components aboard the ship. At the point of sending a PO, the purchasing department together with the Detail Engineering (DE) department, has evaluated and chosen a supplier for each component needed in the project and included information about the required specifications to the supplier. When the suppliers deliver their products to the shipyard, it is important that each supplier includes the correct description and specification in the packing slip so that the warehouse can receive the products and store the information in the shipyard's WMS. The warehouse is an important point in the lifeline of the components used in shipbuilding. Here, the components are received, stored, and later picked by the warehouse workers when requisitioned by production personnel.

Considering there are several different suppliers, and a large number of components that are assembled on a ship, it is very important that information regarding the whereabouts and specifications are registered in the shipyard's WMS. Though the shipyard in this thesis has a WMS that facilitates control over information- and material flow, it does not provide optimal levels of information sharing on their own. The necessary information on components is not always available and ready when requisitioned by the production department. These errors often occur due to inadequate use of the software. Therefore, this thesis aims to provide possible solutions for enhancing the information- and material flow going through the WMS.

1.2 Relevance of Study

This research is based on a single case study of a Norwegian shipbuilding company. The case study is a follow-up on the findings of an earlier master's thesis case study conducted at a similar shipbuilding group in Norway. Among their findings was that materials and equipment received from the shipyard's suppliers are sometimes delivered with a packing slip that is set up differently than the PO created by the procurement division. This approach makes it difficult to match the packing slip with the PO when the equipment arrives at the warehouse. Further, they found that a significant part of the purchasing strategy is based on functionality (meaning what purpose the product will serve) instead of technicality (which describes the properties and characteristics of a product in greater detail) leading to challenges regarding accurate information about the products. When a purchase is made by a supplier, the warehouse does not usually know which physical components are included in the equipment. Also, since the packing slip does not contain all components in detail, the process of receiving and registering goods at the warehouse can be time-consuming and may result in delays for the production department (Magnussen and Aarra 2019).

Therefore, we wanted to investigate how other shipyards solve this challenge mentioned above. Due to the COVID-19 limitations, we were able to collect data only from one shipyard that has developed a specific IT solution that integrates purchasing, DE, production and warehouse. Hence, it was interesting to study the solutions applied at this shipyard to find out whether they work optimally or if the shipyard is facing other challenges.

The shipyard of this study is continuously trying to improve their organization to be able to deliver products and services to the quality, time and price their customers expect. During our data collection period, the lack of information sharing was mentioned as an overall challenge at the case company, affecting all links in the project. It is widely agreed upon that good information flow is important for decreasing a shipbuilding projects lead-time and total cost, yet, many of our respondents point to a lack of timely information among project participants.

Several studies in both theoretical and practical characteristics have been devoted to emphasizing the advantages of information sharing in supply chains (e.g. Wamba and Boeck 2008; Kembro, Selviaridis and Näslund 2014; Somapa, Cools and Dullaert 2018). However, little attention has been given to highlighting the potential outcome of enhanced internal information sharing in light of warehouse management processes within an organization and especially the shipbuilding industry. Former research primarily focuses on improvements in production as a way to increase efficiency in manufacturing companies. Investigating and evaluating the case company is an opportunity to highlight the possibilities of enhancing efficiency for projects through improving information- and material flow. Therefore, research on this topic serves as a great opportunity to contribute to the field of study and as an example for similar studies and industries.

1.3 Research Problem and Research Questions

This research is based on a single case study of a Norwegian shipyard, hereafter called Shipyard X. The motivation for this research is to map and investigate any challenges related to the flow of information- and material at the case company, especially information put into the WMS that may result in inadequate work processes. Improved information flow could have a major influence on work processes by decreasing mistakes and delays in operations caused by insufficient or inaccurate information. By always having up-to-date and available information when needed, delays can be avoided and a decrease in total cost and lead-time for a shipbuilding project can be achieved. The thesis analyzes the internal parts of the case company's supply chain, starting from creating a PO and ending in shipping the goods from the warehouse to production. Due to lack of time and resources, the thesis focuses on the areas of DE, purchasing, warehousing and production, and do not consider the entire supply chain at the shipyard which also includes sales, design, suppliers and the customer.

The research objective will be met by mapping and analyzing the current procedures for information- and material flow at the shipyard by the use of a single case study. Based on findings from our literature research and practical perceptions on potential areas of improvement expressed by personnel at the shipyard, an image of how the information- and material flows internally within the case company and possible suggestions for better utilization of the WMS will be discussed. Based on this, we aim to answer the following Research Problem (RP):

RP: *How can optimal use of the WMS improve information- and material flow at Shipyard X?*

The research problem is addressed by developing three research questions. These are answered based on a literature review and empirical findings collected at the case company.

Table 1: Research questions and objectives

Research Question (RQ)	Research Objective (RO)
RQ1: Is the current procedure for information- and material flow at Shipyard X optimized with the current use of the WMS?	The objective is to identify the current procedure for information- and material flow in the WMS and map how the different departments at Shipyard X use the WMS in their daily work.
RQ2: What are the challenges preventing optimal use of the WMS?	The aim is to investigate any issues resulting in inadequate use of the system and thus working processes.

RQ3: How can Shipyard X enhance the use of the WMS?	The goal is to provide possible suggestions for enhanced use of the system by dealing with challenges identified in RQ2.

1.4 Thesis Outline

The rest of the thesis is organized as follows:

Chapter 2 introduces the theoretical background for the thesis.

Chapter 3 presents the research methodology applied in this thesis.

Chapter 4 describes the case company, a Norwegian shipyard.

Chapter 5 includes empirical findings for the case study.

Chapter 6 discusses and analyzes the empirical findings.

Chapter 7 concludes the thesis and includes reflection on practical- and theoretical implications, limitations and further research.

2.0 Theoretical Framework

This section outlines an overview of existing literature relevant to the research problem and the discussion around the research questions. As presented in the introduction, of particular interest is how optimal use of the WMS at Shipyard X can enhance information- and material flow. In order to elaborate on this, it is necessary to review literature regarding ETO, procurement in ETO projects, shipbuilding activities, information sharing, warehouse management and Enterprise Resource Planning (ERP).

2.1 Engineer-To-Order

ETO is one of four standard production strategies identified through analyzing customer involvement in the production process. The point in the supply chain where the product is linked to a specific customer order is called Customer Order Decoupling Point (CODP). The four most common CODPs are Make-To-Stock (MTO), Assemble-To-Order (ATO), Make-To-Order (MTO), and Engineer-To-Order (ETO). As seen in figure 2 below, activities in the production process performed before the CODP are driven by forecasts, while activities performed after the CODP are driven by customer orders (Olhager 2010). Therefore, the production of a one-of-a-kind product relies on receiving a customer order and developing technical specifications accordingly.

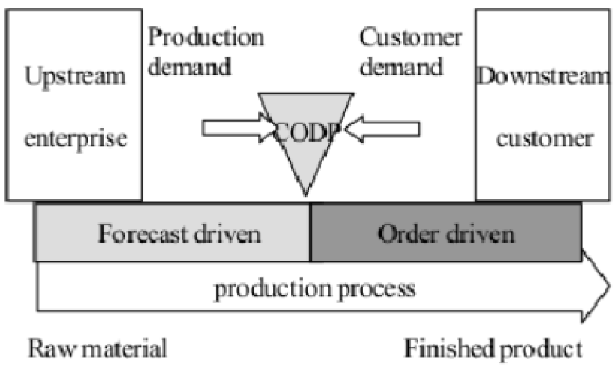

Figure 2: Customer Ordering Decoupling Point (CODP) (Salvi and Mayerle 2014)

ETO differentiates from the other production approaches by having the CODP at the beginning of the design stage and before engineering. The customer order is therefore what drives the production of the products instead of forecasts. During the projects, the company has a continuous dialogue with the customer after the order has been received. Because of this, ETO projects have design uncertainty far into the engineering and production process. This leads to variations in the specification after the design point of the project (Vaagen, Kaut and Wallace 2017), which in turn lead to delays in the project lead-time, impacting the performance of a company and its supply chain hence, increasing projects costs (Caron and Fiore 1995; Hicks, Mcgovern and Earl 2001; Stavrulaki and Davis 2010).

Companies that have ETO as their production approach, operate in complex environments with specific project demands. This approach is typically characterized by small production volume and a large variety of unique components to deliver a highly customized product to specific customer requirements. ETO companies deliver products such as drilling machines, ships, motors, thrusters for ships and cranes (Hicks, McGovern and Earl 2000). As mentioned by Tu and Dean (2011, p. 169), "the products differ on matters of colors, shapes, dimensions, functionalities, materials, processing times, etc." ETO production is typical for industries such as shipbuilding, steel fabricators, structural steel construction, special machines and construction. The main business activities of such companies are the design, project management, manufacturing, construction and assembly of capital equipment (Hicks, McGovern and Earl 2000).

Hicks, McGovern and Earl (2000) state that there are three stages of interaction between ETO companies and their customers. These are marketing, tendering and the processes after a contract have been awarded. Marketing provides ETO companies the opportunity to identify market trends, technical and non-technical customer requirements. Tendering involves the initial development of the conceptual design and defining of major components and systems. In this stage, the technical specification, delivery times, price and commercial terms are determined. Most relevant for this thesis is after the contract is awarded, where non-physical processes are carried out, such as design, DE and project planning. The following process is procurement, followed by physical processes like manufacturing, assembly and commissioning. The involvement in the physical activities by the company itself depends on the level of vertical integration. ETO companies have often reduced the degree of vertical integration due to the benefits of relying on outsourcing (Hicks, McGovern and Earl 2000).

Components needed can be either standardized or highly customized and the latter tends to increase the costs, risks and completion time of the project. The customized components could be technologically advanced control systems while the standardized components can be the structural steelwork of a vessel. Many ETO companies recognize the difficulties of highly customized components and products and are trying to increase design standardization based upon modular design principles, but has been proven difficult in many cases due to diverse customer requirements (Hicks, McGovern and Earl 2000). In addition, it is challenging to keep low levels of raw material inventory, and at the same time be able to supply production successfully with the right materials to maintain promised lead-time to the customer (Bjørnland and Kjebekk 2012).

ETO companies usually have a high degree of uncertainty involved in the planning of a project with possible changes in the design of the product, high fluctuations in sales volume, uncertain lead-times from suppliers and a high diversity of components, subassemblies and products (Sjøbakk, Thomassen and Alfnes 2014). To deal with these uncertainties, the company must look at alternatives and the impact that different activities have on the completion time of the project.

2.2 Shipbuilding Production Activities

This section introduces the shipbuilding production process at a general level. Figure 3 below illustrates the different activities that normally occur for products with customized design, in this case, shipbuilding. As seen in figure 3 below, the CODP is the beginning phase of the project. Meaning that activities, before a contract is accepted and signed, are restricted to tasks required to respond to a tender invitation, e.g. the specifications booklet, arrangement drawings, system drawings, maker`s list, and cost calculations (Semini, et al. 2014). For projects with customized design, where most of the activities are performed after the CODP, the customer is typically included to a large degree throughout the whole project. Meaning that the ship is designed and engineered in close collaboration with the specific customer, where the customer typically has different requirements for major design-, engineering-, and procurement-related decisions (Semini, et al. 2014).

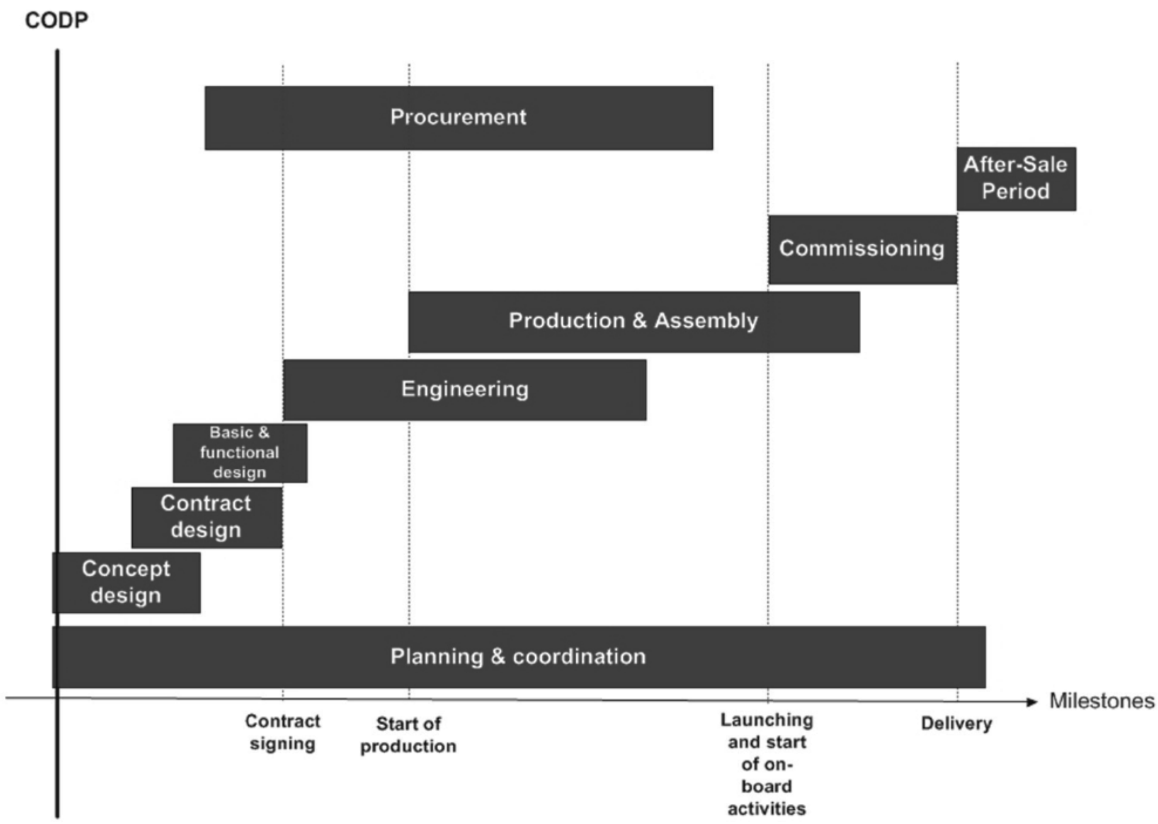

Figure 3: Key activities in shipbuilding projects (Semini, et al. 2014)

Figure 3 shows an overview of key activities in shipbuilding projects where the CODP is located at the beginning phase of the project. The different activities are often interconnected to each other and as seen from the figure above, concurrently performed. We will briefly explain the main activities and interlink between them below.

Planning & Coordination are the only activities that are carried out concurrently with all of the other activities throughout a whole shipbuilding project (see figure 3). The planning and coordination department is responsible for creating and sustaining the project schedule during the entire project (Hagen and Erikstad 2014). Therefore, it is important that planning and coordination continuously interact with all other departments operating in the specific project to ensure delivery on schedule.

Procurement is often performed by an own department designated for procurement and purchasing. The tasks within the procurement department include sourcing strategies for finding optimal suppliers, preparing and conducting negotiations with the suppliers to agree on specifications in the legal contract, using an efficient purchase order and order follow-up routines, monitoring- and control securing the supply and lastly following up and evaluating supplier relationships (Weele 2018). The procurement department often works in close cooperation with planning and coordination to inform about, e.g. delivery dates and engineering to communicate technical information regarding equipment specifications necessary to start modeling (Roald 2019).

Engineering is responsible for developing and designing technical drawings for project activities, for example, machines or manufacturing processes for production and assembly activities. The engineering/technical department works in close cooperation with the customers to ensure that requirements are withheld and to achieve customer satisfaction (Semini, et al. 2014). Close liaison with both procurement and production is also necessary to communicate information about equipment specifications and technical drawings.

Production & Assembly is responsible for the construction of the technical drawings from engineering, and hence outfitting of the vessel. Here, excellent cooperation and coordination with engineering are important to secure that technical drawings are shared. Technical drawings are necessary before the production start of, e.g. a specific component or machine to avoid any delays (Roald 2019).

2.3 Purchasing in ETO Projects

Procurement and purchasing are key business drivers and can contribute significantly to a company's bottom line and top line. Many companies spend more than half of their sales turnover on purchasing parts and services, developing supplier relationships, and more. Therefore, focus on excellent procurement strategies is essential to the company's short-term financial results and long-term competitive position (Weele 2018). Procurement and purchasing are terms that are often used interchangeably, but to experts on the subject, they have a more specific meaning (Lysons and Farrington 2016). Wiggins (2014, p. 182) defines the term "procure" as "…obtained by care or effort, to acquire or to bring about whereas the term "purchase" describes the transaction of buying and the items bought". This indicates that purchasing is a step in a much bigger process or one aspect of procurement (Wiggins 2014). Because of this, many purchasing departments have changed their name to procurement to display the importance of their department's role (Lysons and Farrington 2016). Weele (2018, p. 8) defines procurement as:

> The management of the company's external resources in such a way that the supply of all goods, services, capabilities and knowledge which are necessary for running, maintaining and managing the company's primary and support activities are secured at the most favorable conditions covering the materials, information and money flow up to the point of consumption.

The procurement of an organization needs to support a converging materials flow, where a large variety of components is to be assembled into a limited range of final products such as an offshore vessel. Procurement strategies in a company differ on what kind of components are required to manufacture a final product. A shipyards procurement would be significantly different from, for example, a car manufacturer where they produce cars in large batches controlled by a Materials Requirement Planning (MRP) system (Weele 2018). In a shipyard, the vessels that are built might be new to the organization where most of the materials required are in modular or subassembly form sourced from different suppliers with uncertain lead-times (Dixit, Srivastava and Chaudhuri 2014). The items purchased for a shipbuilding project can vary from simple standardized items from local suppliers to customized items like engines and generators, which are procured from different suppliers across the world (Dixit, Srivastava and Chaudhuri 2014).

Purchasing of materials can be carried out based on either functional or technical specifications. Functional specifications are when the specifications include what purpose the product will serve, while technical specifications describe the properties and characteristics of a product in greater detail. The benefit of choosing the first-mentioned method is that the supplier is allowed to apply their skills and knowledge into product development as long as it fits the required specifications (Hicks, McGovern and Earl 2000; Weele 2018). Typical for ETO production is that cost and lead-time are vital elements that affect a firm's competitive advantage. According to Hicks, McGovern and Earl (2000), the choice of purchasing based on technical specifications affects these elements in a negative way, because detailed specifications tend to restrict the design choices available to the supplier and, thus, increase cost and lead-time. In contrast, they state that purchasing based on functional specifications allows suppliers to develop their own design, introduce innovation and reduce costs. Therefore, they found that procurement based on functional specifications is the alternative to opt for in ETO production.

The direct interaction with suppliers starts in the procurement process, where tendering for a specific contract takes place. Normally, for ETO businesses, the tender involves the initial development of the conceptual design and the technical description of components and/or systems needed (Hicks, McGovern and Earl 2000). When ordering from a supplier, it is essential that information and instructions to the supplier are clear (Weele 2018). When a supplier is chosen, a PO is usually initiated electronically. The purchaser is accountable for detailed specifications and requirements in the PO. Normally, a PO contains the following information: an order number, a concise description of the product, unit price, number of units required, expected delivery time and date, delivery address and invoicing address. It is important that the information received from the supplier on documents such as order confirmation, packing slip and invoice is equivalent to the PO to facilitate matching at a later stage (Weele 2018). According to Weele (2018), these preparatory steps have to be performed adequately to avoid additional workload in the ordering and order handling activities.

2.4 Information Flow

Information can be defined as "processed data that turns into knowledge when combined with experience, contact, interpretation and reflection" (Gottschalk 2004). Meaning that information, data, and knowledge are three interconnected terms. Data can be individual facts without context, making it difficult to understand and is often referred to as raw data. Data become information when people assign meaning to them through interpretation, and information becomes knowledge when a person is able to link it with experience, context, interpretation, and reflection for problem-solving or explanation. The relationships between these terms are illustrated in figure 4 below.

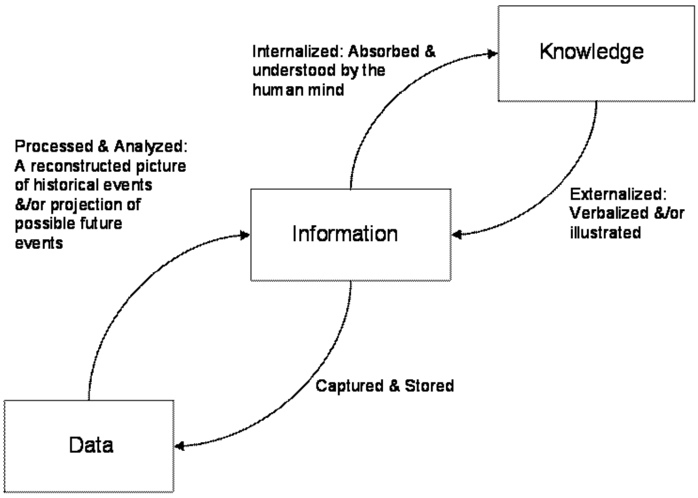

Figure 4: Relationships amongst knowledge, information and data (Liew 2007)

The information flow within an organization can be referred to as the movement of information or communication between various departments and is a vital part of any organization´s operational processes. According to Bozarth and Handfield (2016, p. 410), "one can argue that neither physical nor monetary flows could take place without information flows". A high degree of information flow integration in an organization or supply chain is a determining factor of achieving efficiency. Information sharing, which is a dimension of information flow, is considered a success factor in any business strategy and enables enhanced coordination (Wamba and Boeck 2008). By sharing data across departments, an organization can speed up the information flow, improve efficiency and effectiveness, and decrease response time to customer´s changes (Li and Lin 2006).

Information sharing includes data collection, documentation, storing, retrieving and transferring of information. Information sharing can be identified as "…a set of activities by which information is provided to others, either proactively or upon request, such that the information has an impact on another person's image of the world" (Sonnenwald 2006). Meaning that the process of information sharing includes two significant aspects, i.e. providing others with information and receiving information provided by others.

The flow of information in an organization is used as a foundation for strategical decision making, along with execution and control of daily working processes. By having a tidy information flow, an organization can gain a competitive advantage through a decrease in total costs, an increase in customer service, and more efficient business processes (Li and Lin 2006; Bozarth and Handfield 2016). ERP is one example of a computer-based information system that facilitates information flow, making it easier to share real-time information between departments and through the supply chain. Here, one person can insert data into the system, making the data to automatically flow through the system and thus making it available for multiple parties at the same time (Nousiainen 2008). The next chapter is describing ERP in a more detailed manner.

2.5 Enterprise Resource Planning (ERP)

ERP is principally an enterprise-wide-system, which comprises company mission, objectives, attitudes, beliefs, values, operating style and people who make the organization (Parthasarathy 2007). The objective is to integrate all the different business functions across a company into a single computer system that can serve all those different functions' particular needs (Parthasarathy 2007). The different functions can, for instance, be accounting and finance, manufacturing and production, human resources, procurement and distribution (Haddara 2013).

Recently, an increasing number of businesses have been looking into integrated systems, such as ERP (Parthasarathy 2007) to store, share, and disseminates data from a single database (Haddara 2013). According to Parthasarathy (2007), the reason for this shift is due to the lack of the existing system to meet the changing business requirements and the organizations need to focus on the core business in today`s competitive environment.

Drivers for implementing ERP systems

Summer (2005) argues that ERP systems may help to acquire a competitive advantage, responsiveness to customers and suppliers, productivity, and flexibility in a global economy. Seen from a business point of view, this can help to improve overall performance while reducing costs and inventory levels. This is supported by Behesthi (2006) which asserts that ERP systems have the ability to enhance profitability in an organization by reducing the time and costs of completing business activities. He further points out that the system is remarkably beneficial in providing management with information essential for strategic decision-making.

Implementation of ERP systems

The implementation of an integrated ERP system requires vast planning and changes within the organization (Beheshti 2006; Haddara 2013) and the decision of whether to adopt it or not is therefore highly critical (Haddara 2013). The resolution to implement an ERP system is a "business investment decision and can be compared with decisions about investing in buildings, warehouses, training programs, etc." (Summer 2005, p. 11). Additionally, implementing an ERP system is extremely expensive (Beheshti 2006). Therefore, the investment in such systems must provide measurable benefits that justify the cost associated with implementing it. In addition, businesses need to consider their available time and resources to implement such a system as "it is important that people working at the organization adopt the work methods outlined in the software" (Parthasarathy 2007, p. 2). To more efficiently adopt new working methods, the new system needs to be incorporated into the organizational culture through a commitment by the management. This can be done through activities such as training, team building, and recognition of success (Beheshti 2006).

2.6 Warehouse Management

2.6.1 Introduction

Warehouses play a major role in any supply chain and work as an important link between the producer and the customer. According to Grant, et al. (2006) warehousing can be defined as "that part of a firm`s logistical system that stores products (raw materials, parts, goods-in-process, finished goods) at and between the point of origin and point of consumption, and provides information to management on the status, condition and disposition of items being stored". Meaning that the supply chain is dependent on the warehouse to deliver the right product, in the right quantity to the right time (Richards 2011). The basic functions of a warehouse contain three categories that are: movement, storage and information transfer (Grant, et al. 2006).

The subsequent subsections aim to introduce theory and practices within warehouse management. The first one presents different warehouse operations, including receiving, storage, order picking, and shipping, while the next introduces theory regarding WMS. Thereafter integration between ERP and WMS is presented.

2.6.2 Warehouse Operations

In a supply chain, the warehouse can have different roles. The basic operations of a warehouse are in general to receive Stock Keeping Units (SKUs) from suppliers, store the SKUs, receive orders from customers or production, retrieve SKUs and assemble them for shipment to customers or production and ship the completed orders (Gu, Goetschalckx and McGinnis 2007).

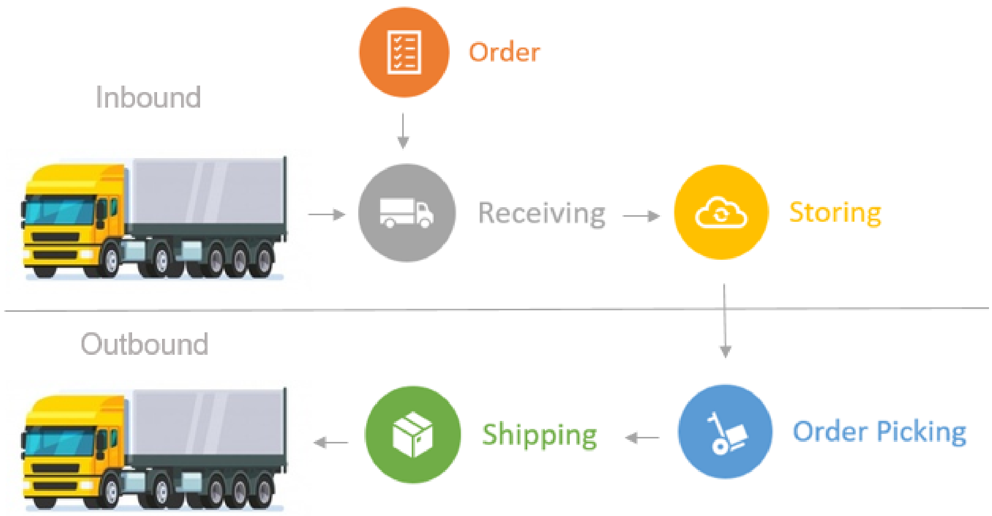

Figure 5: Inbound and outbound warehouse operations (Adapted from Gu, Goetschalckz and McGinnis 2007)

As seen in figure 5 above, receiving and shipping are the interfaces of a warehouse for incoming and outgoing material flow. Incoming shipments at the warehouse are controlled and are – if not directly needed – unloaded and put into storage. Orders are then picked from storage, prepared and shipped to the requesting party of the material through the shipping docks (Gu, Goetschalckx and McGinnis 2007). The different operations are further discussed in the subchapters below.

Ordering and Receiving Processes

Even though the ordering and receiving processes may vary from different industries and companies, the processes typically involve five steps that interact and sometimes overlap (Shabri, Gupta and Beitler 2007, p. 27). The five steps include:

1. A replenishment trigger or a PO is initiated
2. The trigger or PO is communicated to suppliers

3. The supplier ships the material and send an Advanced Shipment Notice (ASN)
4. The material is received by the buyer
5. A settlement (e.g. invoices and payments) is triggered

The PO is a document formalizing a purchase transaction between a customer and a supplier. The PO often contains "quantity of material and/or components, description and specifications, price/payment terms, delivery date and method, and payment terms" (Mitchel 1992, p. 88). The PO has often several copies, which is distributed to all parties, including the purchasing department, goods receipt (to match the PO with the packing slip to, e.g. verify that the part number, the quantity, and the agreed delivery dates are correct), accounting (to match the invoice and packing slip) and the supplier (Mitchel 1992).

After the PO is sent to the respective supplier, the following stage is to wait for the goods to be shipped (or provide the services) based on the specifications in the PO (Shabri, Gupta and Beitler 2007). When the supplier clarifies the shipment, an ASN is normally generated and sent immediately after the material has been shipped. An ASN is a notification of pending deliveries to the buyer and contains details including "shipment number, packing slip number, shipment date, time, estimated arrival date, total packages, weight, number and type of containers, line item number, part number, quantity shipped, etc." (Shabri, Gupta and Beitler 2007, p. 65). The document has a vital role for the party who is receiving goods as it provides visibility and information necessary for better planning and control (Shabri, Gupta and Beitler 2007).

The process of receiving materials from suppliers "consists of both physical movement and processing along with related paperwork" (Mitchel 1992, p. 88). Usually, the material receiving process begins with the receipt of material, which is accompanied by a packing slip that details what the shipment contains. In general, the packing slip contains details about (Mitchel 1992, p. 89):

- Packing slip number and ship date
- Item and/or part number
- Customer and/or PO number
- Quantity shipped
- Price

When the materials are received at, for example, the warehouse, the packages are checked up against the accompanying packing slip and the PO to verify that it is correct. If any discrepancies are found, the supplier is notified. The next step is then to send copies of the received documents to the accounting division, material planner, engineer, and the purchaser. All copies, including PO, packing slip, and receive document should be filed together until the invoice is received from the supplier (Mitchel 1992).

The last step in the process is the settlement and is often defined as the step by which the buyer verifies receipt of goods or services, the supplier invoices for delivery, and the buyer`s accounting system issue the payment to the supplier (Shabri, Gupta and Beitler 2007). Before the payment is issued, a match between the PO, the goods receipt, and the invoice is controlled.

Lately, there have been introduced several methods that aim to enhance the order and receiving processes and make it more efficient. Some of the methods broadly discussed in previous research are Electronic Data Interchange (EDI), barcode receiving and Radio Frequency Identification (RFID).

Electronic Data Interchange (EDI)

EDI is used to electronically exchange business documents (Shabri, Gupta and Beitler 2007) and revolve around paperless payment, automated inventory updating and shared data (Mitchel 1992). EDI is used globally in several industries and business functions and aims to minimize human interference to make processes faster, cheaper, and better. For instance, EDI can be used to discrete POs (or spot orders), ASNs and invoices (Shabri, Gupta and Beitler 2007). The change from manual to digital processes enables cost reduction through efficient work (less time spent on work tasks) and less errors during data entry (Shabri, Gupta and Beitler 2007).

Barcode receiving

Barcodes can commonly be defined as labels that are attached to or built into packages containing items. The labels contain "encoded data in the form of black and white patterns, which can be decoded by barcode readers" (Shabri, Gupta and Beitler 2007, p. 110). A barcode system can be used to simplify inventory tracking and management. Implementing barcodes can be a cost-effective method for reducing errors and eliminating non-value-added work by enhancing accuracy and data reading (Shabri, Gupta and Beitler 2007). However, one major limitation of barcodes is that visual contact with the barcode is required to successfully read it. In addition, Ren, Anumba and Tah (2011) argue that traditional barcodes are inadequate in different cases as it is characterized by low storage capacity and cannot be reprogrammed.

Radio Frequency Identification (RFID)

RFID is an auto-identification technology that uses radio-frequency waves to identify, track and locate individual physical items (Ramanathan, Ramanathan and Ko 2014). Implementation of RFID technology allows more effective inventory management and control of incoming and outgoing goods due to their low cost and time consumption as the RFID is scanned automatically (Alyahya, Qian and Bennett 2016). Packages, containers, pallets, and individual products are a few examples of items that can be tagged, scanned and tracked using RFID technology. The auto-identification technology unlocks the opportunity to accurate and timely data and thus enhancing real-time visibility in the supply chain (Shabri, Gupta and Beitler 2007). The capability for RFID to deliver timely information and visibility into the supply chain is based on three aspects of RFID technologies. They are "automatic data capture, real-time information, and real-time location system" (Jones and Chung 2008, p. 120).

Enhanced visibility allows better inventory control, which can reduce "inventory and cost associated, labor and assets management using inventory policies, scheduling, and decision support system information" (Jones and Chung 2008, p. 119). According to Jones and Chung (2008), previous research has suggested that operational labor can be decreased with up to 30 percent in distribution operations by using RFID technology. In warehousing, RFID technology has the ability to capture, store, rationalize, and integrate information such as product information, location, volume, and transactional data. Auto-identification of these different forms of data "allows organizations to more effectively pick/pack ship, route, track, and distribute materials" (Jones and Chung 2008, p. 325).

Storage

Storage is a major warehouse function. Three essential decisions structure the storage function, viz. 1) how much inventory that should be stored in the warehouse for an SKU; 2) replenishment time; and 3) were the SKU should be stored, distributed and moved among the different storage areas (Gu, Goetschalckx and McGinnis 2007). Both holding capacity and access efficiency are some criteria that should be considered making these decisions, where the main objective is to minimize total material handling costs (Grant, et al. 2006).

The storage function can be implemented on a temporary or semi-permanent basis. A temporary storage involves storing products only required for basic inventory replenishment and underline the movement function. A semi-permanent storage is the storage of surplus inventory that is not necessary for regular replenishment and is often referred to as safety stock. This type of storage is normally utilized for conditions such as seasonal demand, erratic demand, special deals (e.g. quantity discount), speculation or forward buying, products that require aging (e.g. cheese or wine) and conditioning of products (e.g. food such as fruit or meat) (Grant, et al. 2006). Inside the warehouse, randomized and dedicated storage are two examples of how products can be located and arranged. Randomized storage places the material in the first available slot, bin, or rack while dedicated storage places the materials in a fixed location within the warehouse (Grant, et al. 2006).

As previously mentioned, companies that have ETO as their production approach have normally small production volumes and a large variety of unique components that is to be assembled to a final product (Hicks, McGovern and Earl 2000). Thus, ETO companies do not normally have a stock of finished goods to immediately satisfy specific customer demand (Bertrand and Muntslag 1993). Even though ETO companies do not have a stock of finished goods, there are normally quite high inventory levels. This is due to the buffer in delivery time added by purchasers to avoid delays in production, and consequently, components often arrive a long time before needed in production (Longva 2009). Holding inventory to buffer for this is costly, but can still contribute to a reduced total cost due to trade-offs against production progress, customer service, etc. (Grant, et al. 2006; Gu, Goetschalckx and McGinnis 2007).

Order Picking

Order picking includes operations such as clustering and scheduling the customer orders, releasing them to the floor, picking of items from storage, etc. (Le-Duc 2005). Order picking is generally recognized as the most expensive warehouse operation, where one of the main cost areas within the picking operation is the movement between picking locations. Order picking does not only tend to be very labor-intensive but it can be challenging to automate and plan, it is prone to error and important it has a direct impact on customer service (Richards 2011). Three trade-offs are affecting the types of picking systems and processes chosen: speed, cost and accuracy (Richards 2011). As order picking is a part of the supply chain, the process has an impact on supply chain performance. Inadequate processes within order picking can, therefore, lead to unsatisfactory service and high operational cost for its warehouse, and hence for the whole supply chain (Le-Duc 2005).

The choice of an order picking method is a strategic decision since it has an extensive impact on several other decisions in warehouse design and operation (Gu, Goetschalckx and McGinnis 2007). Companies may have different order-picking strategies and techniques depending on the nature of the product, the number of items to be picked and the size of the order (Richards 2011). An overview of different picking strategies and equipment are outlined in table 2 below.

Table 2: Picking strategies and equipment (Richards 2011)

Picker	Orders	Handling equipment	Storage methods	Picking operations	Hardware and software
• Picker to goods • Goods to picker • Automated picking/Robotics	• Pick by order • Cluster picking • Batch picking • Zone picking • Wave picking • Compact picking • Order distribution system	• Pallet jacks • Powered pallet trucks • Cage/trolley • Forklift trucks • Order pickers • Conveyors • AS/RS and mini-load systems • Ergonomic workstations	• Bulk/floor storage • Conventional racking • Very narrow aisle racking • Carton flow racks • Shelving • Mobile storage • Carousels (horizontal or vertical) • A Frames	• Paper pick • Pick by label • Scanning • Voice picking • RFID (automatic or scanning) • Pick to light • Put to light	• WMS • Slotting software • Barcode scanners (handheld or wearable) • RFID scanners • Voice units

As seen from table 2, picking strategies can be divided into three categories, namely: picker to goods; goods to picker; automated picking (Richards 2011).

Picker to goods

Picker to goods is the traditional picking method, where persons in the warehouse perform order fulfillment. Within this strategy, automation is used to a minimum. Pick to order is when the picker takes one order and travels through the warehouse either on foot with a cage or trolley or with a pallet or fork truck, collecting items until the whole order is picked. The picker follows a route by reading a paper-picking list, reading instructions on a radio data terminal, or following voice commands. This method is advantageous in form of minimizing handling and cost associated with it. However, orders containing multiple SKUs and long distances between picks can be extremely labor-intensive. Overall, the picker-to-goods system requires low investment and a high workforce level, meaning that labor costs can be very high for this strategy. To significantly decrease labor costs, a solution might be to use a goods-to-picker strategy that uses automated processes (Wang, Zhang and Fan 2020).

Goods to picker

For this picking strategy, the warehouse personnel remains at a designated station and the orders to be picked are brought to them. Within this strategy, machinery can be controlled in the WMS to make the process automotive. Goods-to-picker systems may comprise Automated Storage and Retrieval Systems (AS/RS) that uses, for instance, aisle-bound cranes that retrieve one or more unit loads (container, pallets, etc.) and bring the unit to a pick position (Le-Duc 2005).

Automated picking

This strategy is used to support and enhance the work of picking personnel through the implementation of robotic or semi-robotic solutions and is optimal for high picking volumes (Wang, Zhang and Fan 2020) where speed, accuracy and productivity is required (Richards 2011). The benefits of automation are many, including (Richards 2011, p. 82-83).

- Increased space utilization;
- High bay, narrow aisle system;
- Improved control;
- Pallet tracking through enhanced WMS;
- Labor and energy savings;
- Less human intervention;
- Elimination of manual handling;
- Reduction of accidents and errors;

- Coordination of product flows, avoiding bottlenecks;
- Continuous review.

Shipping

After the orders have been picked, the next step is to ship the completed orders to the final consumer – which can be either customers or production. The final phase can, therefore, be considered as the receiving process in reverse, where the goods to be shipped are checked, packed and documents are prepared or updated (Gu, Goetschalckx and McGinnis 2007). For this case study and most other companies with ETO, the picked goods are needed in production, meaning that the process after order picking is to ship the goods from the warehouse to production by internal transport equipment.

2.6.3 Warehouse Management System

A WMS is essential in today's fast-moving environment. WMS range in combinations of scope, scale, technology and hardware usage from simple software programs tracking inventory, receiving, shipping, and pallet put-away to complex AS/RS (Wilson 2006). The software helps the planning and management of the physical arrangement and activities of a warehouse. The information in the system must be "accurate, reliable, with the right level of detail, complete and precise enough for decisions, in time, understandable, and so on" for the warehouse to utilize the benefits of a WMS (Waters 2003, p. 198). WMS can stand alone or be integrated with the company's ERP systems and support technology within the warehouse such as automation, barcodes, RFID and voice recognition. Implementing a warehouse management system has several potential benefits, where proper use of the WMS will help coordinating movements within the warehouse and processing data more quickly (Richards 2014).

It is especially important that information regarding coordination and planning of material have high reliability and quality for ETO projects such as shipbuilding because of the large quantity of material needed for the final product. Shipbuilding projects can have as much as 90.000 components needed for production (Held 2010). The importance of an effective warehouse is therefore essential for shipbuilding projects. Information technology (IT) tools can support companies to achieve "reliability, speed, control and flexibility in the warehouse operation" (Richards 2014, p. 188). According to Richards (2014, p. 189), in order to be productive and have effective handling of material flow in the warehouse, "warehouse management systems need to be able to work in real-time, manage all the processes within the warehouse and have the ability to communicate with other company systems". It is important that the WMS have the ability to interface with other systems such as account packages, ERP, MRP systems and transport management systems. This opens for the integration of back-office tasks such as order entry, inventory control, PO modules and invoicing (Richards 2014). An interfaced system enables the ERP system to receive data from the WMS when matching receipt of goods with the PO and other ERP activities like generating correct invoices for shipped orders (Friedman 2010). It is also beneficial if the system can interface with automation systems and picking technology such as voice, wearable barcode scanners and RFID systems (Richards 2014).

According to the Business Application Software Developers Association (BASDA 2009), to achieve best warehouse practice, systems need to be able to optimize movements within the warehouse, e.g. pallet put-away is coupled with pallet retrieval, known as task interleaving. Other best practices of warehouse management are attributes such as automated receipt, directed put-away, optimum pick sequences, replenishment tasks, dispatch management and warehouse mapping. Richards (2014, p. 197) expresses that "ideally, the system will be able to monitor the velocity of items within the warehouse and locate them accordingly (slotting) or alternatively provide the data in a format that can be transferred to programs that have slotting functionality".

A WMS can provide the functionality of tracking parts throughout a supply chain. Tools using electronic input such as barcode can help to track material through the supply chain system while maintaining accurate information flow to parallel physical flow. Another form of technology that can provide electronic data input to WMSs is RFID (Olson 2014). The widespread implementation of new IT, such as barcode, RFID and WMS, provides new opportunities to improve warehouse operations. The introduction of technology and WMS can improve warehouse productivity, increase utilization and increase customer satisfaction by delivering products at the right time, with the right quality and price. Other benefits of having a WMS in place are stock visibility and traceability, accurate stock levels, improved responsiveness minimized paperwork and more (BASDA 2009).

Choosing a correct WMS is important for the success of companies deciding to implement the system. The company must do substantial analysis to understand their needs and key business requirements, today and in the future, and select the solution that will best fit the business objectives. A WMS must be under assessment continuously and reviewed to improve current processes. This can be done by collecting and comparing as much information as possible about current processes and procedures and identify which processes the warehouse staff and project team find frustrating, redundant or inefficient (Richards 2014). The company must find out "which processes that would potentially be improved by introducing new technology, by how much and whether it is cost-effective or not" (Richards 2014, p. 193). The company must understand "how the warehouse communicates both internally with other departments and externally with customers, suppliers and transport companies" (Richards 2014, p. 193). If the existing processes in the warehouse are poor, it would be pointless specifying an IT solution. Costs of IT systems have reduced significantly over the years and it is therefore important to look at the opportunities of implementing these systems to be able to be competitive in a fast-moving technological world (Richards 2014).

2.6.4 Integration between ERP and WMS

The roles of ERP and WMS are different. The role of WMS is to manage the entire volume that is received at the warehouse in real-time and optimizing the handling and storing of the products and supporting the company with supervision and control of processes related to movement and storage of goods and material (Wozniakowski, Jalowiecki and Zmarzlowski 2018). ERP, on the other hand, is used for planning enterprise resources, hence the acronym "Enterprise Resource Planning", and is composed of integrated modules that manage all of the core business processes of the organization. Its main objective is to incorporate business processes within and across the functional and technical boundaries in the organization with improved workflow, standardization of business practice and access to up-to-date real-time information (Wozniakowski, Jalowiecki and Zmarzlowski 2018). These systems are usually not integrated, where companies often have an ERP system and a separate "best of breed" WMS system. WMS as a "best of breed" system is not directly integrated with the company's ERP system and is specialized to support the realization of warehouse processes and warehouse management, and it is often costly and time-consuming to implement (Wozniakowski, Jalowiecki and Zmarzlowski 2018).

The level of integration between IT systems depends on the businesses´ need for integrating item information, inventory, and visibility of incoming products, etc. WMS integrated with ERP implies that the systems "use a common database and the information is updated and shared in real-time" (Wozniakowski, Jalowiecki and Zmarzlowski 2018, p. 146), but most WMS software are interfaced instead. Interfaces between software normally use batch export and import programs that transfer the data, or a middleware product that is designed for that purpose. Therefore, interfaced IT software usually means that the ERP system and WMS run on separate databases. This opens up for a chance of duplication of a certain amount of business data. Companies have to make a decision on whether to purchase separate WMS and ERP systems or an ERP package that provides WMS solutions. Today, ERP and WMS systems are becoming more flexible and integration of WMS solutions with other advanced IT systems is relatively simple. Therefore, WMS is becoming more and more a part of the ERP system (Wozniakowski, Jalowiecki and Zmarzlowski 2018).

2.7 From Theory to Empirical Findings

In this chapter, the theoretical framework and a literature review based on former research on topics including ETO, shipbuilding activities, purchasing in ETO projects, information flow, ERP and warehouse management have been presented. The topics of ETO, shipbuilding activities and procurement in ETO projects are presented to give the reader an overall understanding of the characteristics of the Norwegian shipbuilding industry.

With this research, we aim to contribute to literature regarding information- and material flow seen in the light of warehouse management by investigating how the case company is integrating and sharing information put into the WMS and how the usage of the system affects the warehouse management process. Therefore, theories regarding information flow, ERP and warehouse management are presented to provide an underlay for further analysis. Since the shipyard of this study has implemented a WMS adjusted to their needs, it is interesting to find out if the current use of the system works optimally (RQ1), identifying challenges (RQ2) and provide possible suggestions for better use of the WMS (RQ3). Before introducing the case company, a description of the methods used during our research is performed.

3.0 Methodology

In this chapter, the methodological approach used in order to provide information and solutions in relation to the research questions is outlined. First, the research design is introduced. Second, case study research is explained and followed by an explanation of why we have chosen this method. Third, we describe the data collection methods followed by a further depiction of the different methods of gathering data to our analysis. In the end, the validity and reliability issues of this research are discussed.

3.1 Research Design

The research is carried out with a purpose to answer a particular research question, whereas the research design serves as an overall plan for the research. The choice of research design is dependent on our knowledge about an area and what ambitions we have in analyzing and explaining relationships between variables. There are three main types of research design in the pragmatic approach: "exploratory design, descriptive design and causal design" (Gripsrud, Olsson and Silkoset 2004, p. 58). The objective of exploratory research is to examine an area or problem with the purpose of gaining a better understanding. With a descriptive design, the researcher is already known with the problem area and aims to describe an accurate profile of a person, event, or situation, while the purpose of a causal design is to explain interpretations between two or several parameters (Gripsrud, Olsson and Silkoset 2004). Further, three factors influence the choice of design to answer the research problem, namely: 1) experience from the problem area, 2) knowledge of theoretical studies that identify relevant variables and 3) the level of ambition with regard to identifying the relationship between variables (Gripsrud, Olsson and Silkoset 2004).

This master thesis has a triangulated design, which means using several different research designs. First, an exploratory design was used to acquire more knowledge about the theme and by that, we expected to be able to understand and interpret the relevant phenomena in a proper way as also recommended by (Gripsrud, Olsson and Silkoset 2010). Secondly, a descriptive design was outlined to describe the various aspects of the phenomenon, while being able to integrate both qualitative and quantitative methods to gather data.

3.2 Case Study Research

The case study method is a type of research that concentrates on one thing, looking at it in detail, not seeking to generalize from it (Thomas 2011). According to Stake (2005), a case study is not a methodological choice but a choice of what is to be studied. Further, Simons (2011, p. 21) defines a case study as:

> …an in-depth exploration from multiple perspectives of the complexity and uniqueness of a particular project, policy, institution, program, or system in a `real-life` context. It is research-based, inclusive of different methods and is evidence-led. The primary purpose is to generate an in-depth understanding of a specific topic to generate knowledge and/or inform policy development, professional practice and civil or community action.

Yin (2009, p. 1) remarks that "case studies are the preferred method when a) "how" or "why" questions are being posed, b) the investigator has little control over events, and c) the focus is on a contemporary phenomenon within a real-life context". Taking this statement into consideration, it is reasonable to argue that a case study is a preferred method for us to perform as:

1) an explorative approach is going to be used to answer questions like "how" and/or "why",
2) we have little or no control over behavioral events in the case we are going to examine,
3) the focus of our study is an existing or occurring problem in the organization at present time.

As our thesis revolves around a particular case originated from an organization, a case study research is natural to outline. The shipyard defined their problem through their collaboration with the research institute Møreforsking AS that made the case available as a master thesis for students. Since the respective organization and Møreforsking AS is the driver behind the research problem, it is logical for us to outline a single case study research. Additionally, due to limitations regarding time and resources for our master thesis it may be reasonable to conduct a single case study instead of multiple case studies. The single-case design is eminently justifiable under the conditions that it is a representative or typical case (Yin 2009). Besides, focusing entirely on a single case may allow us to gain exceptional insight into the case and the organization, and to collect information from multiple sources to easier to concentrate the data to elucidate the case problem (Baxter 2010).

3.3 Data Collection

There are two forms of data collection and analysis, namely quantitative and qualitative methods. The quantitative type of method is based on data in numerical form, which is often analyzed using statistical or econometric methods while qualitative methods are mainly the generation of knowledge one obtains by examining reasons, opinions, events, and experiences of participants in a research project. Hence, qualitative data is principally used for "analytical description and understanding of relationships" (Gripsrud, Olsson and Silkoset 2010, 80).

In this thesis, two different methods are used to elucidate the research problem, also referred to as method triangulation. By using two different methods for collecting data, we were able to strengthen the credibility of the study. This study is essentially based on qualitative data, collected from interviews, while the rest is quantitative data from questionnaires and archival records to supplement the qualitative data. The data collected from interviews and questionnaires are gathered for the purpose to answer the research questions in this specific thesis. The data collected from other sources (e.g. archival records, literature) has originally been gathered for other purposes, but is still characterized as relevant for this thesis and is used to highlight the importance of the research area and to support new findings.

We collected our primary data by conducting in-depth interviews with employees at Shipyard X to achieve flexibility and a questionnaire to get more structured answers. The interviews are a part of our explorative design where questions like how and/or why were answered to interpret our research problem. The questionnaire was used in our descriptive design to answer questions like what, who, where, how many, and how much to describe or find the connection between one or several concepts. By using qualitative interviews, we were able to go more in-depth and by using quantitative questionnaires, we were able to compare and analyze larger amounts of data more efficiently.

3.3.1 Primary and Secondary Data

To write our master thesis on this topic, both primary and secondary data were required. The first part of collecting data was to gather secondary data from relevant academic sources in order to obtain further knowledge within the field (exploratory design) and to understand which factors should be included in the research (descriptive design) (Gripsrud, Olsson and Silkoset 2004). A broad literature search using keywords such as ETO, procurement in ETO, shipbuilding activities, information flow, warehouse management and ERP were used to find relevant academic sources for our thesis. In addition, sources of evidence such as archival records, documentation and data gathered in other projects were used. The archival records were provided directly from the case company and were used to gain a better understanding of the organization, it's IT landscape and WMS. In addition, information from other research projects was used to obtain an overall understanding of the business and the shipyard industry. Particularly Roald (2019) and Longva (2009) provided significant insight into the shipbuilding process and supply chain of Norwegian shipyards, where the material management and flow through the warehouse were thoroughly explained by both. Also, it provided us with a better understanding of how internal processes at shipyards work and supplemented us with some new questions for the interview guide.

We collected our primary data from interviews and questionnaires directly from the businesses we are collaborating with in order to answer the research questions. The primary data is more specific to our research question than secondary data and it is, therefore, a more suitable method for collecting data for our research. The collection of primary data can be very time consuming and it was, therefore, consequently important for us to schedule a plan to allocate our time efficiently. The sources of primary data are further discussed in the next sections: 3.3.2 interviews and 3.3.3 questionnaires.

3.3.2 Interviews

According to Yin (2014) interview is one of the most important sources of case study evidence and is commonly characterized by guided conversations with the interview object rather than structured queries. There are mainly three different forms of structuring an interview: structured, semi-structured and unstructured.

In this study, in-depth interviews with key personnel from DE, purchasing, production and warehouse were conducted in order to understand personal experiences and opinions within the theme. The interviews had a semi-structured approach where the questions were formulated prior to the interview, but follow-up questions and the order in which the questions were asked were flexible. Interviewees were selected according to their experience within the field and our research area. The first data collection through interviews took place in February 2020 and was our first personal meeting with the case company. The interview was open and can be described more like an informal dialogue. The second meeting with the case company took place at the beginning of March 2020. Here, a semi-structured interview guide was carried out in advance and the interview guide can be found in Appendix I and II. A total of five interviews was carried out with one person from the purchasing department (see Appendix II), one person from the warehouse, two persons from the DE department and one person from the production department (see Appendix I). Some of the interviews were recorded with consent from the respondents and a summary of the answers at the end was used to clarify and validate the information collected. To mitigate the risk of bias from interviews, triangulation was conducted, based on additional sources of information including internal documents and other master thesis writing about the Norwegian shipyard industry.

3.3.3 Questionnaires

Data collection through the usage of questionnaires unlocks the opportunity to have a higher number of participants in a time-efficient matter. In addition, questionnaires make it possible to generate structural data that can be used for quantitative analysis. In our thesis, the data gathered from the questionnaires are used to complement and support the findings from the qualitative data to increase its validity. It is vital that we achieve reliable and valid measurements for the concepts and variables we aim to evaluate by using a questionnaire as also suggested by (Gripsrud, Olsson and Silkoset 2016).

A questionnaire was outlined from the findings of the interviews, where the questions in the questionnaires were used to confirm and further elaborate on the discovered problem areas. The questionnaire was sent out in March 2020 and can be found in Appendix III. We received a total of six answers from the different departments, including DE, purchasing production and warehouse.

3.4 Validity and Reliability

There are two important terms in relation to evaluating the quality of research: validity and reliability. Validity describes the extent to which a concept or conclusion accurately reflect and represent the real world that was studied, while reliability describes the extent to which the study and its methods for data collection yield the same results if it was repeated (Gripsrud, Olsson and Silkoset 2016). According to Yin (2014, p. 46-48) there are three main types of validity evidence in research and these are 1) "*construct validity* (establishing the correct operational measures for studied concepts), 2) *external validity* (applicability and generalization of findings) and 3) *internal validity* (testing causal relationship between variables)". The latter one is only of concern for causal studies (Yin 2014). Since this research uses an exploratory and descriptive approach, internal validity is not relevant for this study and is therefore not further discussed.

Construct Validity

Based on Ellram (1996) there are three elements associated with establishing construct validity: 1) using multiple sources of evidence, 2) establishing a chain of evidence, and 3) having key informants review the case study research. According to Yin (2014), data triangulation is a method to achieve a higher degree of construct validity. In this thesis, multiple sources of evidence, including interviews, questionnaires and secondary data in forms of archival records and documents are used to study the same phenomenon and hence attempt construct validity (Ellram 1996). Also, most of the interviews that were carried out were semi-structured, which can secure construct validity as the questions are pre-formulated and based on the phenomena that are intended to research. In the attempt of establishing a chain of evidence, close contact with both the supervisor and co-supervisor has been essential. The progress of the thesis including meetings, interviews, questionnaires and drafts of our paper was discussed continuously with our supervisors during the project. In addition, construct validity was supported by having key informants of the project reviewing the information gathered. Correspondence through phone and email with the interview objects and other key personnel at the case company was used to clarify issues and corroborate data.

External Validity

As mentioned above external validity refers to generalization, meaning that the conclusions of the study are applicable outside the context of that specific study. For case studies and especially single case studies, the lack of generalization has been one major criticism (Ellram 1996). As our thesis is based on a specific case in a specific company, the results may be less generalizable than if we had conducted a multiple case study. The goal of a case study is however not to represent a “sample” to obtain statistical generalization but to expand and generalize theories (Yin 2014), meaning that the generalizability of case study results tends to be qualitative in nature (Ellram 1996).

Reliability

Reliability addresses the repeatability of the study, and whether replication is possible and will achieve the same result (Ellram 1996). Meaning that if we repeat the data collection with the same method – or with other methods – we will get the same result (Gripsrud, Olsson and Silkoset 2016). The repeatability of a study may be difficult to measure for qualitative studies, as the result is highly dependent on the role of the researcher. An adverse aspect of the usage of semi-structured interviews in this thesis may be that the method is problematic from a reliability perspective. Because the order of questions and parts of the questions vary from interview to interview, it will be difficult to achieve exactly the same results if one repeats the interview or the entire study. Still, it provides higher reliability than an unstructured interview guide does as a decent number of the questions are standardized. However, by receiving similar results from the interview and questionnaire the reliability of the study can be strengthened. For this thesis, we intended to measure the reliability with the use of Cronbach´s Alfa to examine the consistency of answers in the questionnaire. Due to issues regarding data collection after the beginning of March 2020, this was unfortunately not possible as we only received a total of six answers to our questionnaire.

4.0 Case Description

To provide the reader with an overall understanding of the case, this chapter first gives a brief description of the case company, a Norwegian shipyard and its supply chain which addresses the department´s interdependency of each other. Thereafter, a brief outline of the yard's IT landscape is provided to show how information- and material flow through the different departments and IT software's. Subsequently, the shipyards WMS "Tag Manager" and how this tool should be used for optimal information- and material flow is presented. This is necessary for comparing the optimal use of Tag Manager and how it is really used, to find out where errors are made and how to correct them. A short summary and the main challenges discovered during data collection are presented toward the end of the chapter. Information in this chapter is mainly based on interviews, but also founded on internal documents provided by the case company as well as the case company´s website and previous relevant master theses.

4.1 Background Information

The thesis is written in collaboration with a Norwegian shipyard, which is referred to as Shipyard X in this paper. Due to the anonymization of the case company, limited background information about the shipyard is therefore provided. Shipyard X builds advanced vessels for challenging marine operations, delivering the highest standard of quality, execution and precision of the final product.

Shipyard X applies a complex ETO strategy, that involves the customer and a large network of project participants. To produce such complex products, Shipyard X has developed a skilled workforce, an integrated approach to design and shipbuilding, and a keen understanding of the requirements of the customers. As other shipyards in Norway, Shipyard X provides tailor-made solutions following customer's requirements. The building approach results in several design and engineering changes during the project, increasing the complexity of coordination and information flow.

For Shipyard X the focus in production is outfitting of the ship, where their core competencies are quay-outfitting, design, commissioning and testing. Due to the high labor cost in Norway, the hull production is done by an international partner in the shipbuilding group. A simplified supply chain for Shipyard X can be seen in figure 6 below.

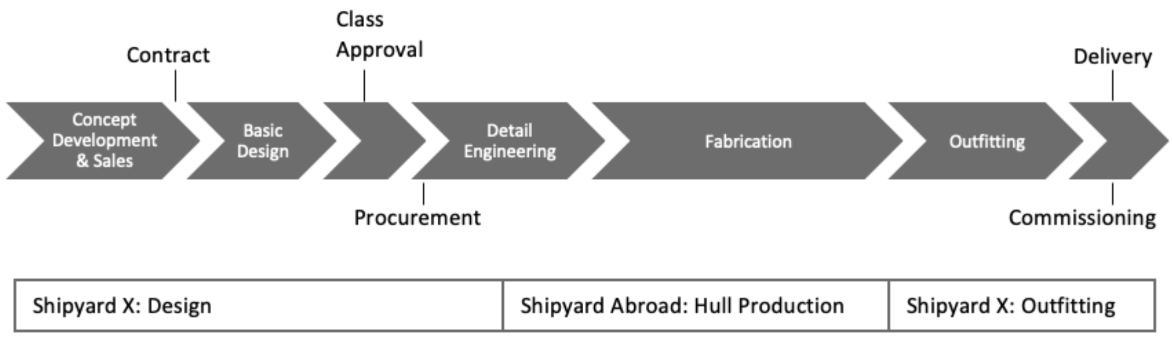

Figure 6: Supply chain for a shipbuilding project (source: internal documents)

The shipyard has earlier specialized in the outfitting of advanced vessels for the oil and gas industry such as exploration-, production- and Offshore Service Vessels (OSV) but changes in the market have given Shipyard X new assignments such as building yachts, cruise ships, naval and other specialized vessels. This has led to new challenges for the yard as these new projects have different requirements and expectations from the product and services delivered. Such change requires more and new components, workforce and suppliers. Along with it, the information- and material flow have become more intricate. Some of the challenges the yard is facing are related to the latter one, where inadequate information flow in the WMS Tag Manager was commonly mentioned by the interviewees. The WMS is used for material control at the shipyard and ideally, the system has the ability to streamline information- and material flow at the yard. Nevertheless, we found through the interview rounds that there are several problems related to the utilization of the system. The feature of required manual handling to add or change data in the system may be addressed as a potential issue for this. The next subchapter explains the supply chain of the shipyard and aims to provide insight into the interdependency among departments.

4.2 Supply Chain of Shipyard X

The shipyard involves several different departments in the process of constructing a new vessel and these are highly dependent on each other. Typical for ETO projects is also that the customer stays involved throughout the project and interacts with design if they want changes or add new features. There are different project participants involved in the supply chain: customer, sales department, design, purchasing department, DE, warehouse, production, and suppliers (see figure 7). Many of their activities are performed concurrently, so the integration, as well as the concurrencies among the departments of DE, procurement/purchasing, production and warehouse, are explained below.

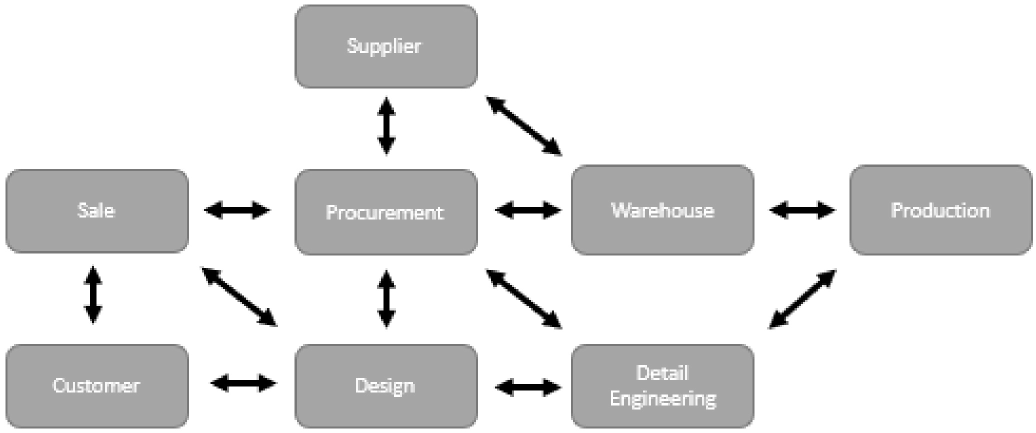

Figure 7: Supply chain of Shipyard X

Detail Engineering (DE)

The DE department is connected to procurement, design, the supplier and the production department. The typical structure of DE in projects is with project leaders on the top of the hierarchy. Under them, there are engineers who are technical coordinators from the DE department who also are technical managers of their fields in a project. Under the technical coordinators, there are discipline coordinators for pipes and machinery, hull and steel outfitting, heating, ventilation, and air conditioning, outfitting, electro and accommodation. Some of these disciplines are subcontracted. Furthermore, the projects are manned with the necessary resources for tasks such as business proceedings and drawing for each of the discipline coordinators.

The engineering department`s responsibility is to make sure that technical documentation and drawings are adequate for building vessels in a simple way. This means that components, layout and work packages should be as detailed as possible when the production team starts their work. To be able to do this, the DE department is dependent on the design department, which is not always located at the same facility. They make 3D and 2D drawings of components and are in close cooperation with the DE department at the yard. The DE department starts their work after basic design has finished designing the concept of the ship. When 2D and/or 3D models are finished, DE starts making layouts for different systems and parts of production. For DE to be able to model for instance a pump into the 3D model made by design, it requires that an engineer has all details such as weight, dimensions, and information regarding how much heat it emits and the required power supply.

The information acquired from the designer and technical specifications on equipment from suppliers is gathered in AutoCAD, which improves design quality, provides higher precision, reduces the risk of errors and reduces the time and expense of paper-based drawings and physical components. AutoCAD is an acronym for Automatic Computer-Aided Design and allows engineers to develop, modify, share and even test designs in a virtual world (Bozarth and Handfield 2016). Thus, modeling in AutoCAD provides Shipyard X with a 3D model that illustrates the details of the vessel and all parts and equipment assigned with technical specifications. Since all specifications are available in the same format and gathered into one model, it becomes easier to find the information required at later stages such as production. The AutoCAD also includes an SFI number for each component. SFI is an international grouping system developed by the Ship Research Institute of Norway (in Norwegian: Skipsteknisk Forskningsinstitutt (SFI)). The system organizes parts into levels, from the main system level to a more detailed subsystem and is used to provide functional and technical ship information (Hagen and Erikstad 2014). The details presented above are relevant for the WMS as the SFI number is inserted into the TAG number for each component in the system to provide a better overview of where in the vessel the component is to be installed.

Purchasing

When a project is started, purchasers together with DE start preparing preliminary documents and initiate the procurement process for large components, such as engines, thruster systems, pump-packages, etc. Since the purchaser usually does not have a technical background, they work closely with the DE department, as they need the right specifications and technical information to give to the supplier. The procurement department and DE are closely integrated cooperating on sending out requisitions and then evaluating offers from suppliers. The regular practice of the procurement process is tendering with a couple of suppliers and choosing the supplier with the best price and delivery conditions. The formal PO is sent out by the purchasing department and includes delivery dates as well as instructions on how to tag the components and packages according to the shipyard's WMS

Tag Manager. The purchasing coordinator makes detailed purchasing plans together with DE to make sure that the right components are ordered at the right time. The purchasing department is highly dependent on the DE department, and it is therefore important that cooperation and information sharing can proceed smoothly. When the supplier sends back an order confirmation, the purchasing department receives confirmed order lines while DE receives information about technical descriptions and specifications.

Warehouse

The warehouse is responsible for receiving goods from the supplier. When packages arrive, they register the components ordered as received and store the components. The warehouse workers inspect the goods and checks if the received quantity matches what was ordered. They also have random inspections of the state and quality of the components received. When production requests a component, the warehouse workers pick the goods and transfer them to the established time and unloading point at production.

Production

The production department is responsible for the construction and assembling of components aboard the vessel. They build the ship according to the concept and layout made by DE with the quality expected by the customer. These layouts are prerequisites for production to start their work. Production has a building schedule made by the planning department that show when tasks are to be done. The layout and design for each job are made by DE and production can find all the components needed for a job in the system layout. Production checks the WMS system in advance to see if the goods have arrived. Thereafter, they send a requisition to the warehouse and receive the required goods and equipment for the job.

As shipbuilding activities are performed concurrently at Shipyard X, there is significant interdependency and a need for integration between the different departments. Therefore, it is essential to achieve a high degree of interaction and communication throughout the shipyards supply chain. The IT landscape that supports information- and material flow at Shipyard X is, therefore, elaborated in the next section.

4.3 IT Landscape

This section gives a brief outline of the IT landscape that supports operations at Shipyard X such as purchasing, planning, DE, warehousing and production. Figure 8 below illustrates the various software and web portals used for the management of information- and material flow. The information flow is illustrated along with the mode of entry of information where manual entry means that a person manually has to access the software to insert information, make updates, or request information. Further, the information flow shows the processes for information sharing between departments and suppliers. As shown by figure 8, physical meetings, e-mail, and phone are the key tools for information sharing at the shipyard.

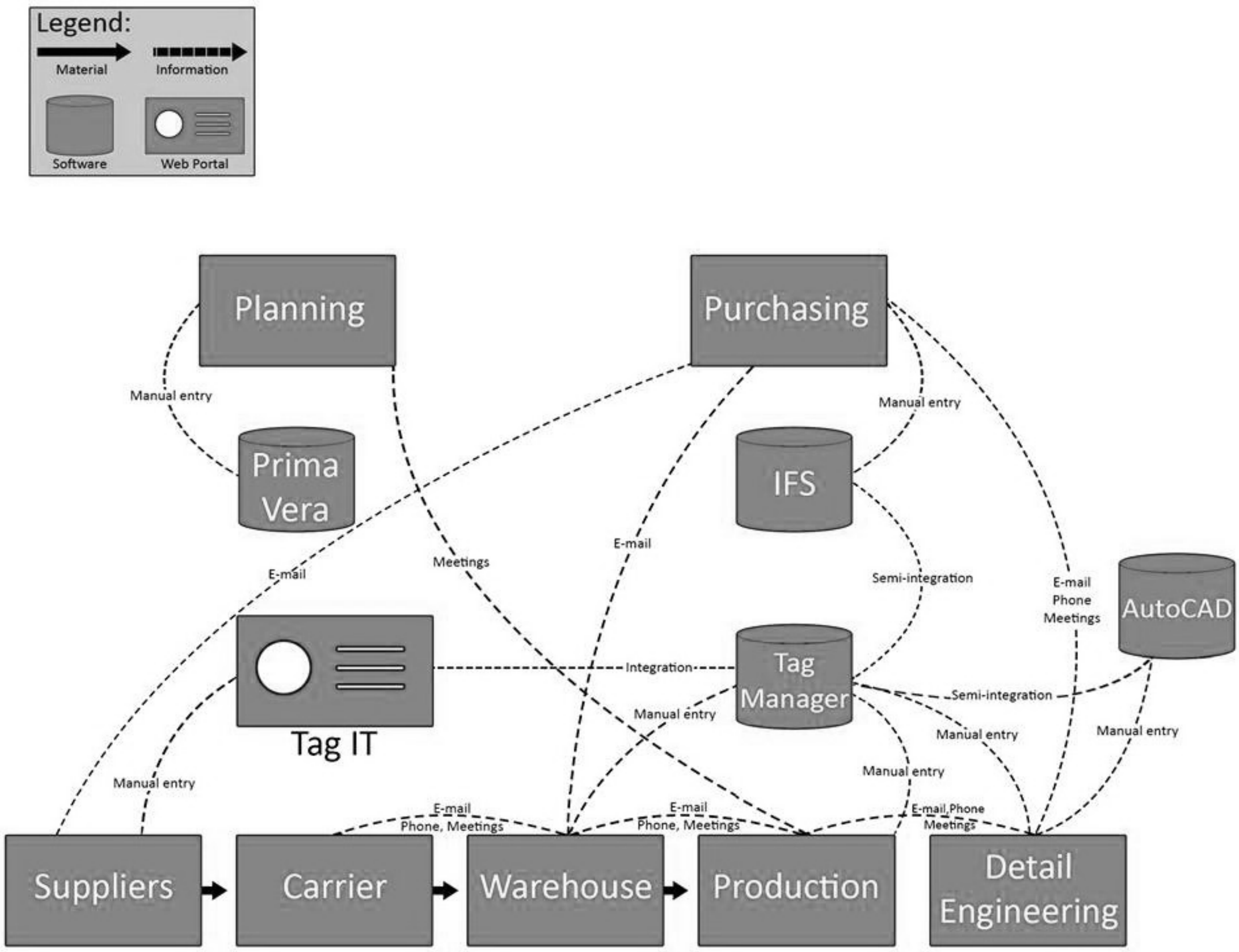

Figure 8: IT landscape at Shipyard X

As seen in figure 8 above, Shipyard X mainly uses four different software programs, namely Primavera (planning software), IFS (ERP system), AutoCAD (3D modeling) and Tag Manager (WMS software). The information obtained from our interviews with the production department, purchasing, DE and the warehouse, implies that there is a lack of interface and integration between some of these software systems. Tag Manager and IFS are labeled with semi-integration in the IT landscape as the only integration between them is the generation of PO numbers. The integration between Tag Manager and AutoCAD requires manual handling and information is therefore not automatically shared between the systems. Hence, the information is only available after manual import and the integration is thus characterized as semi-integration in figure 8. Primavera is not integrated or interfaced with any of the other software systems. Overall, this indicates an inadequate speed of information flow across departments and also with their suppliers.

4.4 General Description of Tag Manager

This section provides a general description of Tag Manager and a brief explanation about how the system is meant to work as well as what advantages the system could bring for the shipyard. Tag Manager was implemented and built over time in line with the shipyard's need for managing warehouse processes and information- and material flow. Today, this software is a fully integrated part of the shipyard´s core business.

The software system provides control over the information- material flow that is essential for the production in the shipyard to be effective. The purpose is to ensure that all necessary information about components is available and ready for production when requisitioned. In optimal use of the system, each component will be marked with a unique TAG number that follows the components from the supplier and all its steps towards production and assembly in the ship. All departments internally in the company and suppliers delivering components have a common reference when talking about it. The company's employees have access to the system and can search for a specific component to check the status, e.g. when it is planned to arrive at the shipyard, if it has arrived, or if it is already installed aboard the given placement. Typical information included in the Tag Manager component sheet is TAG number, vessel number, SFI group, name, order number, technical description and specifications, quantity, date, document attached, and a colored icon which shows the lifeline status of a TAG for a product. The TAG status codes can be seen in figure 9 below.

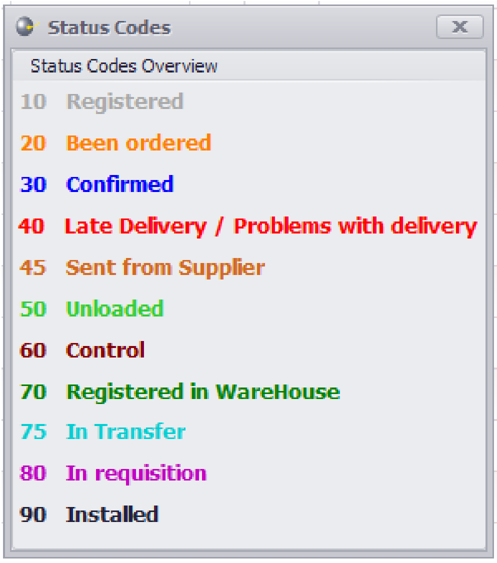

Figure 9: TAG status codes

The different status codes and the meaning of them are explained in table 3 below.

Table 3: TAG status codes and meaning (source: internal documents)

Status Codes	**Meaning**
Created (10)	Newly created but not yet ordered
Ordered (20)	The order has been sent by the purchaser to the supplier, and any TAG belonging to the order will have this status. The supplier is responsible to document this TAG.
Confirmed (30)	The DE department at the yard has looked at the documentation the supplier put in and confirmed that it is according to their drawings.
Late delivery (40)	Set automatically by the system when the delivery date has passed, and the TAG is not yet received at the yard.
Sent from supplier (45)	Set by the purchaser when they get information that the TAG is on its way to the yard. The supplier will not receive any reminders regarding late delivery if the TAG is in this status.
Unloaded (50)	Set as soon as the TAG arrives the yard.
Control (60)	TAG is being controlled to verify part number, quantity, etc.
Stored (70)	TAG has been placed in a specific storage location at the yards warehouse
In transfer (75)	TAG is being transported between yards

Requisitioned (80)	TAG has been requested by a foreman or another user to be delivered to him/her from the warehouse
Installed (90)	TAG has been delivered from the warehouse and is being installed on the vessel.

Ideally, the system should provide supply chain opportunities for both the shipyard and its supplier and improve the participants' competitive advantage by producing a reliable flow of information- and material. The success of the system is dependent on the quality of information that is put in by the company and its suppliers.

4.5 Responsibilities in Tag Manager for each department

This section explains how the WMS Tag Manager should be used by the different departments involved with the information- material flow at Shipyard X, namely: purchasing, DE, warehouse, production and in short about the yard's suppliers. The section goes through each department and briefly explains the different tasks and responsibilities related to the usage of the system.

Purchasing

The purchasing department is responsible for several functions in Tag Manager:

- Creating new TAGs (status 10)
- Making POs on already existing TAGs (status 20)
- Create PO without including TAGs (status 20)
- Linking the shipyard and its suppliers
- Follow up on PO

The DE department makes technical drawings and the purchasing department creates the TAGs linked with the drawings in order to define components before sending the order to the supplier. POs are sent to the supplier through Tag IT, and the system enables automatic reminders of deadlines for documentation and delivery time to the supplier. When the supplier starts delivery of the TAGs, the components are registered as "sent from supplier (45)" to make sure that the supplier doesn't receive any further reminders about the delivery when this is already on its way.

When POs are made without including TAGs, the supplier should fill in necessary information regarding the PO, such as supplier name, planned delivery date, technical description, specifications, TAG destinations and delivery address. The information filled in by the supplier will go through Tag IT to the shipyards Tag Inbox, which should function as a control point for the quality of data coming from the supplier. When the shipyard has accepted the supplier's description of components and delivery date, the TAGs are registered by the purchaser as "confirmed (30)". The DE department is responsible for approving the TAGs and setting this status, where the user must have permission to specific projects to be able to accept TAGs in the Tag Inbox.

Detail Engineering (DE)

The DE department is responsible for;

- Linking TAGs to drawings and layouts
- Importing AutoCAD
- Confirming suppliers' description and delivery dates of ordered components
- Edit fields with missing information if they have adequate knowledge
- Contact the supplier if there are any discrepancies

When suppliers have finished filling in the required information on TAGs, the information is received in the Tag Manager inbox, where an engineer will control that necessary technical information is included. If this is adequate, the engineer will insert the TAG in Tag Manager and set the TAG status code as "confirmed (30)". If the supplier fails to fill in adequate information, it is vital that the engineer fills in correct SFI, capacities, physical dimensions and other necessary documentation to ease operations at a later stage in the project. This is especially important for the production department as inadequate information on TAG may result in additional time spent on searching for components.

In parallel with confirming TAGs in Tag Manager, the engineers should link TAGs to drawings in order to later import a TAG-list into AutoCAD. This way, the system drawings and layout drawings made by DE consist of unique TAG numbers for the components in the drawings. This benefits the foremen of production by enabling them to search for all components needed on a specific drawing. For example, with a drawing of a hydraulic pump system, the foremen can search for all the components involved in this drawing and request them from the warehouse. According to interviewees, drawings can be linked to TAGs at any time and edited if drawings are missing or inaccurate.

Warehouse

The main functions that the warehouse workers have in Tag Manager is;

- Registering TAGs as “unloaded (status 50)” when they receive components at the warehouse
- Registering TAGs as “stored (status 70)” in a specific warehouse location
- Registering TAGs as “in transfer (status 75)” when components are transported between yards
- Register TAGs as “installed (status 90)” when delivered to production

When deliveries arrive at the warehouse for goods receipt, they are registered based on the TAG number and plotted in manually in Tag Manager. The warehouse receives the components and checks the number of packages when unloading and sign the consignment letter. Then they plot in the TAG number manually in Tag Manager. Further, the components are moved into storage and the storage location is registered in the system (status 70). When components are requested by production (“requisitioned (80)”) the picking list shows important information to the warehouse worker about which TAG number to pick, how many, from which warehouse location and who is picking them up. After components are delivered to production, they are registered as “installed (90)”.

Production

The production department´s involvement in TAG consists mainly of making requisitions on TAGs that have the status “stored (70)”. The production foremen and workers can search for TAGs to view their status, planned delivery date, and other information that is relevant for further operation. When the production worker that made the requisition picks up the components, the status of the TAGs is changed from “requisitioned (80)” to “installed (90)”. This implies that the components are assembled at its rightful place aboard the ship and the responsibility of the TAGs is shifted from the warehouse to production. If everything is done correctly, information about what is taken out of storage, which warehouse worker who picked the goods, who made the requisition and who received the goods at what time in Tag Manager.

Suppliers

The supplier finds all the orders received from the shipyard in an “order overview site” and these orders often have predefined TAGs. The supplier also has the possibility to create TAGs on products if they are not defined by the purchaser. When the supplier creates a new TAG, it is important that they fill in as much data as they can, so that it does not need to be addressed at a later point. The supplier fills in necessary general information, transport info, technical specifications and maintenance.

4.6 Summary

This chapter has sought to provide an understanding of how material and information should be handled by the case company. The different departments involved in the shipbuilding projects are presented, with a focus on the supply chain relevant to this thesis. The integration and concurrencies among the departments of DE, purchasing, production and warehouse are presented with the aim to provide the reader with an understanding of the importance of effective information flow between departments. Further, the IT landscape was presented to illustrate how the various software and web portals connect participants involved in the project. This thesis concentrates on the information- and material flow going through the WMS, and therefore the IT software focused on is Tag Manager. Hence, a general description of Tag Manager was presented to provide an idea of how the system is supposed to be used by the departments and the possible advantages optimal use could bring.

Findings from the first phase of the case study indicate a broad range of challenges, where several of them lead to undesirable repercussions. The current IT solution and WMS do not work optimally due to unutilized and improper use of Tag Manager/Tag IT by the departments and suppliers involved. Manual access and handling in the system were observed as one potential cause of inadequate speed of information flow in the WMS. Employees at the yard have to manually register information into the system which indicates that the WMS does not provide real-time information on the material flow. Additionally, due to manual access and handling, the system is more prone to human errors and information in the system can therefore not always be trusted. As a result of manual access and handling, the WMS is underutilized in relation to its technological capabilities. Technology such as barcode and/or RFID may be addressed as a solution for this. Another challenge that was mentioned by interviewees was the lack of technical information from the suppliers which affects time spent on work tasks for the DE department negatively. The technical information provided by the suppliers goes through the WMS and lack of necessary information here results in extra work for the engineers who then have to search for the information themselves. Table 4 below shortly summarizes the identified issues:

Table 4: Challenges

Inadequate use of the WMS
Manual access and handling
Underutilized technological capabilities in the WMS
Inadequate information on TAG from supplier

These challenges will be further explored in detail in the next chapter, where the findings of the case study are presented.

5.0 Empirical Findings

In this chapter, the case study findings obtained by using the data collection method described in chapter 3 are presented. The chapter seeks to answer RQ1 "*Is the current procedure for information- and material flow at Shipyard X optimized with the current use of the WMS*?" and RQ2 "*What are the challenges preventing optimal use of the WMS?*". To answer these research questions, it was necessary to first go through the current procedure for information- and material flow in the WMS and examine if there are challenges related to the use that results in inadequate work processes. The findings are a result of a selection of employees' experiences and perceptions, as well as our own observations of the case company. To investigate RQ1 and RQ2, we used mainly interviews where we got an insight into the current procedure for information- and material flow in the WMS and problems that may occur during a shipbuilding project. Questionnaires were later used to confirm the issues identified through the interviews with an aim to strengthen the credibility of the findings.

5.1 Current Procedure for Information- and Material Flow

The case company uses different processes and IT solutions related to information- and material flow. As illustrated in figure 8 above, there are mainly four different software programs used at Shipyard X, namely Primavera, IFS, AutoCAD and Tag Manager. Interviewees mentioned the lack of interface and integration between the various software system as a potential area of improvement. For example, one interviewee stated that "*the accounting system does not work functionally with Tag Manager or vice versa and that integration or interface here would have been effective in the invoicing process*".

Primavera is the planning tool used to get an overview of activities in a project from start to finish and its progression. Challenges leading to the postponement of an activity are marked in red and the activity is then scheduled at a later phase. The progress is updated on a weekly basis manually by the project planner and sent to all parties participating in the project. Only the planning department has access to Primavera which means that other departments do not receive this information before it is shared from a project planner. This may result in a lack of real-time information that could have been avoided if all departments had access. One of the reasons for this lack of access is the price per license required by the software supplier.

IFS is the shipyards ERP-system, yet the procurement function and some parts of the accounting function is the only functions used in the system. The procurement function is used to generate purchase orders, while the accounting function is mainly used to register working hours. AutoCAD is the shipyards 3D modeling software, where technical drawings and layouts are made for production by the DE department. Drawings made in AutoCAD can be integrated with Tag Manager by importing a TAG-list of components in a drawing. This enables production workers to search for all components they need on a specific drawing. However, to import a TAG-list into AutoCAD, all TAGs must previously have been linked to the drawing through Tag Manager or Tag IT. Only when all TAGs have been linked, can the TAG-list be imported into AutoCAD. Respondents have pointed out that this process is time-consuming but essential as it assists the production department.

Material

Tag Manager is the shipyards WMS and is used for material control. The shipyard splits materials into two different segments: bits and pieces and project materials, where material control is only present for the latter one. Bits and pieces are common materials used on a regular basis such as screws, bolts, gloves, etc. Materials under this category are not tagged with a unique TAG number in the WMS. Project materials are components vital for production and have often an assigned function and placement on board the ship. Some of the materials under this category differ from project to project, depending on the type of vessel to be built. Delays or lack of such materials may cause major challenges in production, making them adjust the project plan and postpone planned activities. The focus in this thesis is mainly on project-related materials as materials under the segment “bits and pieces” are not tagged in the WMS Tag Manager.

Information

As seen from figure 8, most information at Shipyard X is shared through phone, mail, or meetings. All respondents from the questionnaire agree that direct communication and mail are used daily within their department to share information (see figure 10).

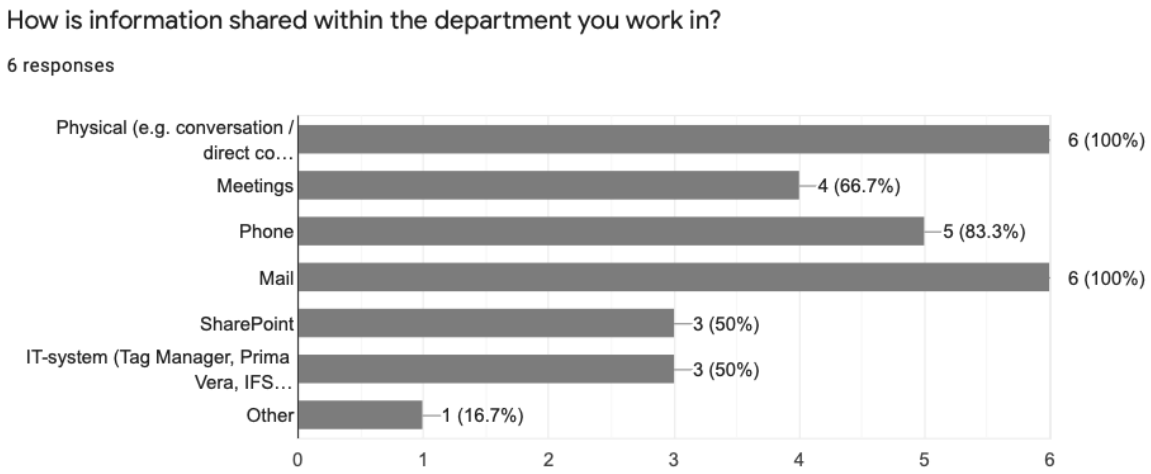

Figure 10: Information sharing within departments at Shipyard X

Respondents from DE also mentioned meetings and SharePoint as common tools for sharing information within the departments, while the respondent from the warehouse answered IT solutions such as Tag Manager, IFS and Primavera. When it comes to how information is shared across different departments, direct communication, phone, mail, meetings and SharePoint was mentioned by all respondents, while IT solutions was mentioned by a minority of the respondents. Shipyard X is today using SharePoint as a platform for information sharing between participants in ongoing projects, where all parties in each project have access to necessary information. However, the yards abroad do not have access to this platform or the software version of Tag Manager, meaning that there is a lack of information sharing and integration between the yards in Norway and international partner yards and suppliers.

During a project, Shipyard X has a weekly operating meeting with information sharing between DE, production and purchasing. The objective of these meetings is to enhance information sharing and coordination between departments and agree upon which tasks must be prioritized and the changes required in the current time schedule. In these meetings, missing technical drawings and components, and clarifications of where components are and where they should be sent and assembled are discussed on behalf of the production department's needs. In cases with missing information or constraints that prevent conducting the activities, these activities are postponed. Such constraints can, for instance, be missing or incorrect technical drawings and layouts made by DE. As a consequence of this, they sometimes find out during production that an item cannot be placed in the planned area because it is in the way of something else. Then they need to find out what has to be done, for example, if it can withstand a move, if they need reinforcements, etc. Weekly operating meetings end when the vessel has come to the phase of testing the engine and equipment installed. At this phase, the vessel is more or less complete, and the operating meeting is replaced with daily start-up meetings.

The flow of information between departments is also going through the software program Tag Manager. The information is accessed through manual entry, where internal workers can enter directly into the software Tag Manager or the web portal called Tag IT, while suppliers and international partner yards only can access the web portal. In Tag Manager, different employees from different departments can access information regarding products that are tagged in the system.

Information is shared across several different IT platforms at Shipyard X. The WMS is the IT software used to control and monitor the flow of materials in a project. Our concern is on the use of this system and how it affects the flow of information- and material and thus working processes. Figure 11 illustrates the different processes related to information- and material flow at Shipyard X and provides a more transparent presentation of the findings.

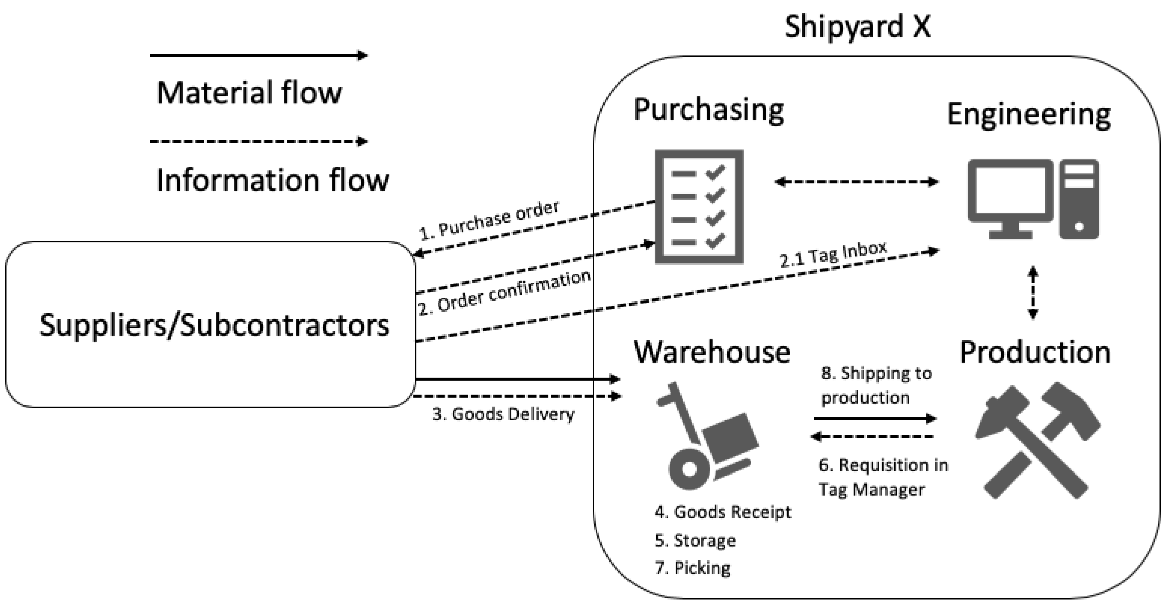

Figure 11: Processes related to information- and material flow at Shipyard X

Figure 11 illustrates the processes that are carried out in the WMS by the different departments, from creating a PO and till the goods are delivered to production. Along with the processes, the information- and material flow that follows is illustrated. The next subsections describe the processes of information- and material flow at the case company limited to the departments of purchasing, DE, warehouse and production.

5.1.1 Purchasing Order

The DE and the purchasing department work together with preparing detailed purchasing plans, basic documents, and initiates the procurement process, but it is the purchaser that creates PO when a supplier is selected. Before a PO is sent to the supplier, the specifications and technical information about the required components are discussed. This is discussed together with a technical coordinator since the purchaser usually does not have a technical background. At Shipyard X, the PO is created in Tag Manager, where the purchaser inserts necessary information such as supplier, planned delivery date, response deadline, TAG destination, delivery address. Thereafter, the PO number is requested from IFS as the PO number is generated in this system. Due to integration between Tag Manager and IFS, the PO number is automatically assigned to the PO created in Tag Manager. However, according to the interviewees, the automatically assigned PO numbers from IFS to the PO in Tag Manager is the only function that is integrated between the two software programs.

At Shipyard X, the PO is sent to the supplier through Tag IT. The PO sometimes includes instructions for the supplier on what and how to create and generate a TAG number for items in a delivery. The TAG number is standardized and consists of 8 alphanumerical characters: three letters and five numbers, e.g. VLV73025. The party who generates the TAGs varies depending on the situation. According to findings, TAG numbers are generated for each individual item by the purchaser when the component list for an order is known by the purchaser. The TAG-list is then sent to the supplier for further specification and instructions on what number to tag components with. On the other hand, TAGs are generated by the supplier when all items in an order are not known by Shipyard X. An example of this was given by interviewees - if the shipyard purchases a workshop tool package, the supplier must define TAGs on each individual item in that package via the web application Tag IT. Figure 12 below illustrates the ordering and order-confirmation in the situation where suppliers are responsible for registering necessary information on components in the web application Tag IT and linking TAG numbers to each individual item in the delivery.

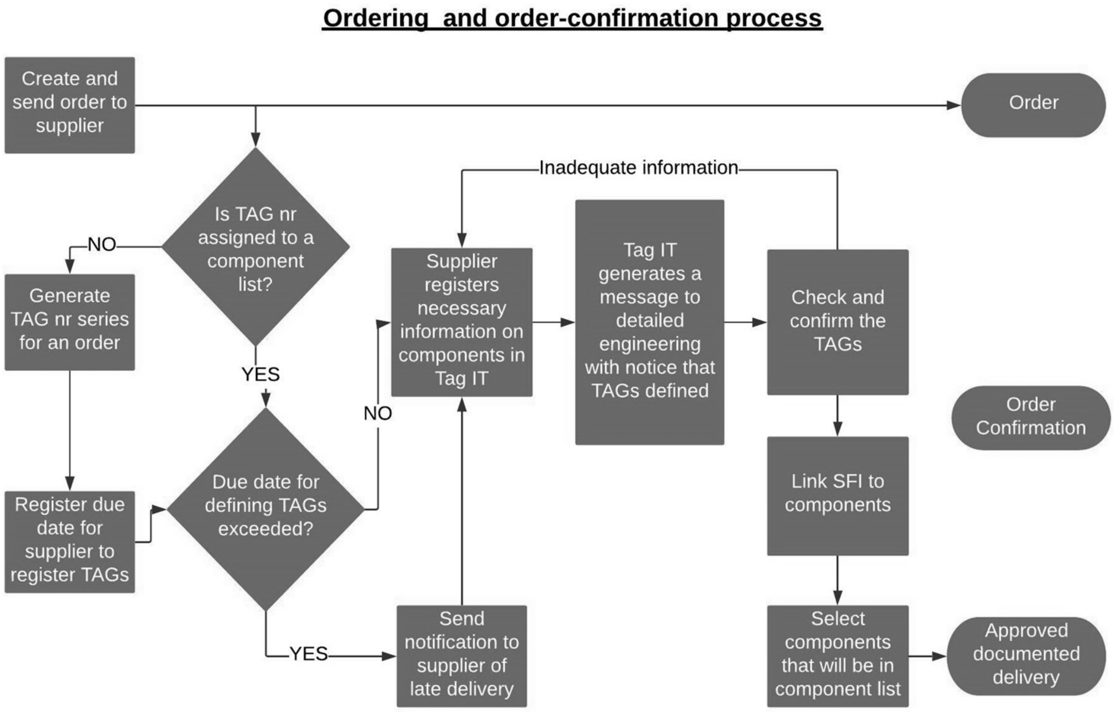

Figure 12: Order and ordering-confirmation in TAG (source: internal documents)

Figure 12 shows an overview of the process that should be followed when the supplier is responsible for generating TAGs. However, this opens for errors, as the supplier might not be trained in using the system. Sometimes, components are registered with a description that lacks necessary information (e.g. where in the vessel it should be built) where one challenge could be that the production department does not know where to assemble. Ideally, as seen from the model TAGs with inadequate information should be defined again by the supplier. This is not always the case, resulting in extra work for the DE department which is responsible for accepting TAGs.

5.1.2 Order Confirmation

Process number 2 in figure 11 is seen as information that flows from the supplier to the purchasing and engineering departments and includes confirmation of orders, delivery dates and registered TAG numbers.

Tag Inbox

Concurrent with the order confirmation, the supplier sends product description and TAG number to the DE department through Tag IT. Each supplier inserts information into the unique TAG number for respectively order line. The TAG number is received in Tag Inbox, where employees from DE have to manually go through the inbox and accept the TAG numbers to let them into the system "Tag Manager" and thus, making them available and searchable for other departments. Before accepting TAGs into the system, a quality check of technical information on the TAG number has to be performed. From here, the accepted TAG numbers can be manually registered into the planning software, Primavera.

On large projects, up to over 1000 articles lines in total are sent to the Tag Inbox which needs to be accepted before it is let into Tag Manager. Inadequate time spent on this process was mentioned by employees as an overall challenge faced by the department. Also, since the project does not have any dedicated resources for this job, an inexperienced case officer which may lack technical expertise on some components can be put on this task. As a result, TAGs with defective or insufficient information can enter the Tag Manager system causing extra work at a later stage.

Besides, the description of the equipment on TAG is sometimes unknown, with symbols or random letters and numbers instead of the product description of its functions (e.g. "VN28" instead of "seacock valve"). Figure 13 below shows an example of inadequate quality of information marked on TAG from suppliers, where the technical description does not say anything about the product.

TagNo	Project	OrderNo	Technical Description	Sup. Description
BEV28402	41622	493679	MBT 5252	MBT 5252
BEV28406	41622	493679	060N1035	060N1035
BEV28407	41622	493679	MBS 5100	MBS 5100

Figure 13: Insufficient quality of technical description. Supplier is hidden for confidentiality reasons (source: internal documents)

One of our interviewees emphasized one concrete example with poor description on TAG which led to major repercussions: "*one time, a supplier delivered 10-15 frequency converters with very poor information on the TAG where the technical description said only* *what it was supposed to be, but not where it should be installed in the vessel. This led to a lot of extra work and we had to physically seek out an employee at the supplier who was responsible for ordering. It took a couple of weeks of detective work to solve this problem and one employee from the supplier had to physically come to the warehouse and write manually on all the components where they should be placed in the vessel".* Taken this into consideration, it is reasonable to say that insufficient quality of technical description from suppliers may cause major challenges for Shipyard X and that a solution is truly necessary.

The results from the interviews were also confirmed by our questionnaire (Appendix III), where all respondents selected more than 1 on the scale where 1 is rare and 5 is often (see figure 14 below).

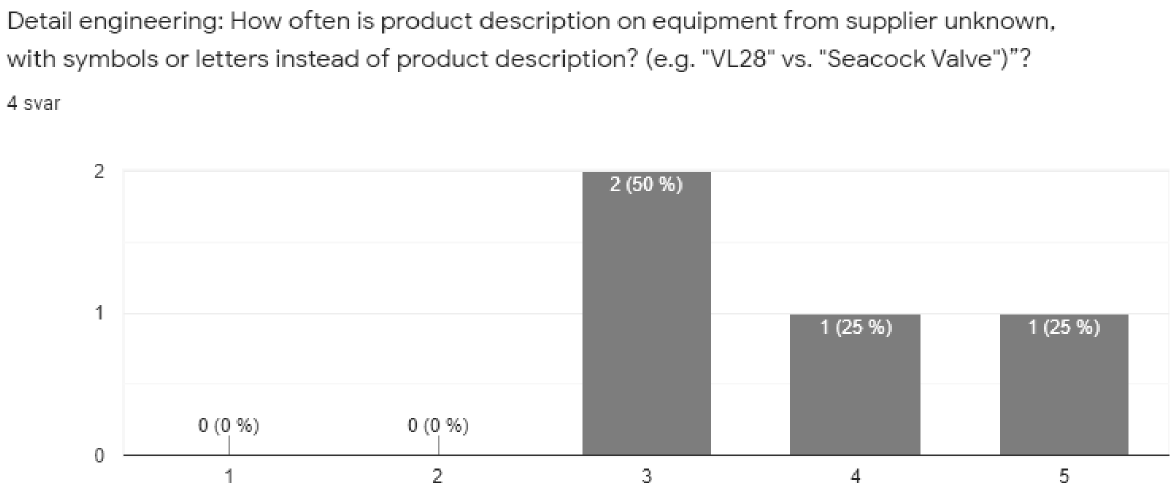

Figure 14: Technical information on TAG

According to another interviewee, also specifications such as dimensions, weight, etc. are typical information that lacks on TAG from suppliers. These specifications have not been as crucial in the past as they are now, but due to the change in the type of vessels being built this is often a necessary specification, especially for cruise ships that are extremely strict on weight. Since there is often a lack of information on product descriptions and specifications on material from suppliers, the DE department must request or search for the information themselves (e.g. in product manuals), which leads to a lot of time and resources spent on follow-up work. Typical information that is entered by DE if missing from TAGs from suppliers is SFI, color code, weight, length, physical dimensions and component list as complete as possible (e.g. pump capacity).

Ideally, the TAGs should be labeled with a good technical description of the product and preferably any additional information if needed, e.g. the number of volts (V) if there is electrical equipment. Figure 15 below shows an example of a well-defined technical description on TAG from suppliers.

TagNo	Project	OrderNo	Technical Description	Sup. Description
BEV28409	41622	493779	WET UNIT PAX 03 DX	WET UNIT PAX 03 DX
BEV28411	41622	493779	AL60-CABIN USB LED 300 S-DIM 830	AL60-CABIN USB LED 300 S-DIM 830
BEV28412	41622	493779	CHART LAMP 24V 500MM W/DIMMER	CHART LAMP 24V 500MM W/DIMMER

Figure 15: Sufficient quality of technical description. Supplier is hidden for confidentiality reasons (source: internal documents)

If we compare figures 13 and 15, it is noticeable that the text in the field in figure 15 is more complementary and contains a better description of the item compared to random letters and numbers (or abbreviated words without definition from the supplier). For example, "AL-60-CABIN USB LED…" provides the reader with information regarding where in the vessel it should be installed while e.g. "MBS 5100" does not provide this information.

5.1.3 Receiving

The receiving process includes operations of both goods' delivery and goods receipt. The WMS Tag Manager is used to complement these operations.

Goods Delivery

The employees at the warehouse use a function in the WMS Tag Manager to get an overview of incoming goods to the shipyard. Here, the employees can manage the incoming flow and delivery dates to the warehouse to better schedule time for receiving. The process can be seen as number 3 in figure 11 and consist of both information- and material flow from supplier to the warehouse. Ideally, when a supplier sends a shipment, an ASN should be generated and sent immediately to the yard to provide the warehouse employees with detailed information regarding the shipment as total packages, weight, number and type of container, etc. However, there is no requirement for the supplier of this and as a consequence, some suppliers ignore this task. Despite that, Shipyard X receives some kind of notification of incoming goods. Incoming goods are marked with a TAG status code "sent from supplier (45)" in Tag Manager and is the information flow seen as process 3 in figure 11. As the system provides TAG status codes according to the progress of material, it is easy to manage and notify late deliveries from suppliers. The system automatically generates TAG status code "late delivery (40)" if the delivery date has passed, and the TAG is not received at the yard. If code 40 is present, it is possible to automatically generate a notice of shipment delivery date to the respective supplier. However, interviewees pointed out that there is no good routine on TAGs that are in status code 40 and that this code is often not noticed before that specific component is needed in production. One interviewee stated that "*sometimes we notice that a component needed in production is in code red, even though the item should have been delivered over 2 months ago*". This indicates that there is no follow-up on materials set in code red by the system, even though the system automatically generates a notice of late delivery to the supplier. One interviewee mentioned an improved customized front page in Tag Manager with information on delayed deliveries or uncompleted work tasks as a suggestion to solve the problem.

Goods Receipt

As soon as the goods arrive at the shipyard (process 4 in figure 11) and registered by warehouse personnel, the TAG status code is changed to "unloaded (50)". The goods receipt is performed at one of the shipyards warehouse functions, where employees at the warehouse manually register receiving goods. Since a worker in the warehouse department manually has to register the incoming goods as received, the TAG status codes may not always be in real-time and thus preventing real-time delivery status of goods. The registration is done manually by inserting the order number or TAG number listed on the packing slip from the supplier into the WMS Tag Manager. Figure 16 below shows an overview of the goods receipt window in Tag Manager where employees at the warehouse can search for received goods. The boxes with a cross indicate where to enter the order number or TAG number.

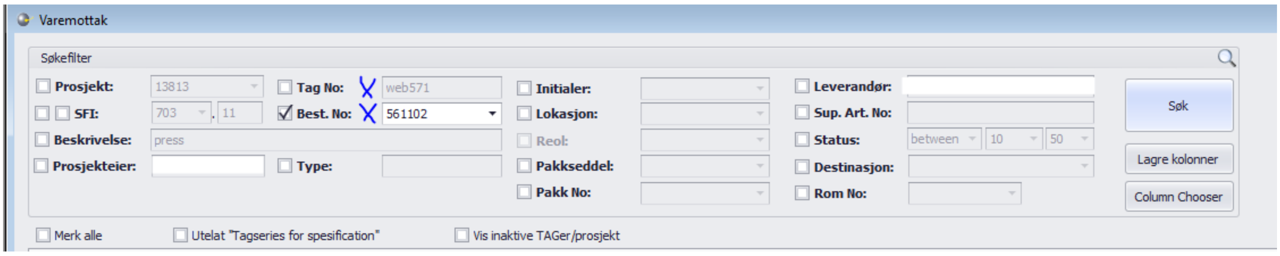

Figure 16: Overview of goods receipt in Tag Manager. Project owner and supplier is hidden for confidentiality reasons (source: internal documents)

When an employee has searched for either the order number or TAG number, a list of the equipment registered on that number is opened. An example of how the list might look like is seen in figure 17 below. The list in Tag Manager provides a standardized layout of information which makes it easier for employees to find necessary information when searching for it.

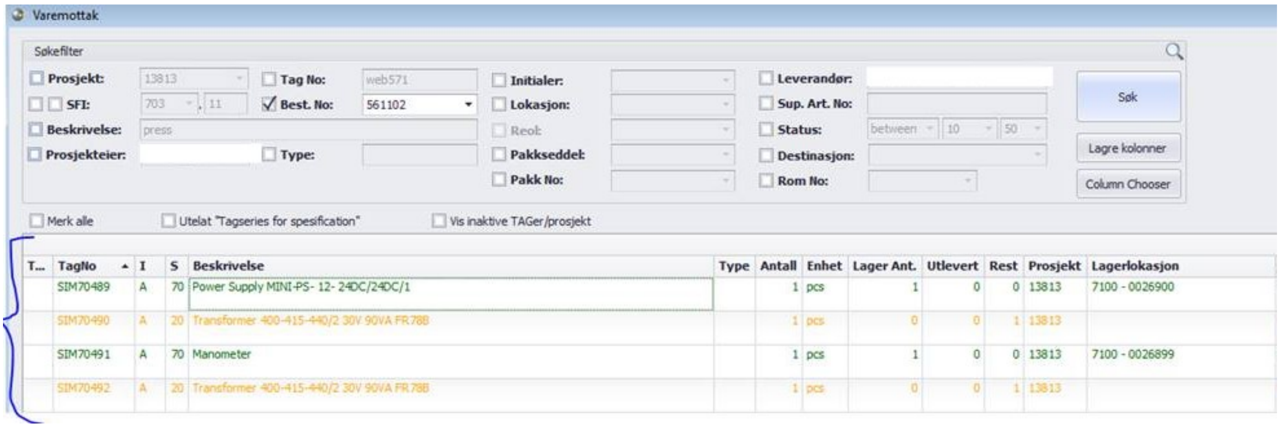

Figure 17: Overview of goods receipt in Tag Manager. Project owner and supplier is hidden for confidentiality reasons (source: internal documents)

In addition, manually verifying of the good is performed to verify that the part number, the quantity, etc. are correct. Thereafter, manual registration of the storage location the goods are to be placed is done in Tag Manager. When one employee inserts data/information into Tag Manager, the information will automatically flow through the WMS, making it accessible for multiple parties at the same time. However, the information is first available after one employee has registered it manually into the system which results in a lack of real-time information about material flow at the shipyard. Manually registering in the system may result in errors that could have been avoided if the system was set up differently, for example, with enhanced technological capabilities such as barcode or RFID.

Tag Manager and Tag IT

Several challenges related to the WMS were identified in the receiving processes which also leads to repercussions at later stages in the storage and order picking process. According to some interviewees, material control is one major challenge within the WMS that does not only affect the warehouse, but also other departments.

According to our respondents, the challenges are related to the tagging of shipment from suppliers. The volume of shipments received from suppliers is varied and can be received in a small package, pallet, container, etc. Ideally, each item received should be marked with a unique TAG number. Meaning that all components placed in the same container must have their own unique TAG number and not a common TAG number for the entire container. However, this is not always maintained by different suppliers, which results in problems regarding material control at receiving (less overview of the volume of incoming goods) and at later stages in the project.

For example, the warehouse receives a container with 12 individual items of seacock valves where the container is tagged with one TAG number, e.g. EDN83027. The TAG number is registered at the warehouse and production can now requisition the TAG. The challenges occur when production, for example, only needs one seacock valve and the production supervisor requisition the TAG number EDN83027 which consists of 12 items of seacock valves. As the TAG number includes the whole container, the warehouse personnel transfer the entire container to the unloading point at the production site, and hence the TAG status code in Tag Manager is changed to "installed (90)". The production only needs one and remove only one seacock valve from the container. The remaining inventory level of seacock valves in the container is now 11 items and there should be 11 seacock valves available and searchable in the system to, e.g. be requisitioned at a later stage. However, since the TAG number EDN83027 consisting of the remaining 11 items is changed to code 90, it is no longer marked as available in Tag Manager. As a result, inventory levels and control are misleading, making it more difficult to book and track items.

Another challenge mentioned by interviewees was the delivery of goods from the yard abroad where the hull is constructed. The problem was also related to tagging in Tag IT and the main challenges are that "*material sent to the yard abroad is often not registered in Tag*

IT, as well as parts are often not returned to us if not used". The interviewee listed the use of the website-based program Tag IT and not the software Tag Manager as a potential cause of the problem.

5.1.4 Storing

The storage function at the shipyard consist of several different warehouses. The change in market demand that led to building new types of vessels such as cruise ships is a reason for this. Cruise ships among other types of vessels require larger storing capacity than, e.g. OSVs or fishing vessels, and a change in the market demand, therefore, led to a need for an increase in storing capacity at the shipyard. According to interviewees, the shipyard had to build a new storage plus rent a new storage hall when they moved from the OSVs to the cruise ship industry. One interviewee stated that "*larger, more and other types of components are needed when building cruise ship and thus also new planning methods and larger inventory is required*".

Today, there are several different types of warehouses located locally at the shipyard and one located a few minutes away. Due to the need for extra storage capacity when involved with cruise ships, there is also one leased storage located approximately 18 km away from the shipyard. As it takes about 3-4 minutes to one of the local storages and 40 minutes to drive back and forth from the leasing storage, the amount of time spent on this operation can add up to be significantly high.

During a visit to the yard, we were given a tour around the area including all the different warehouse and storage facilities. First, the tool storage was shown. At this storage, one employee is responsible for registering in Tag Manager if tools are taken out from the storage. Employees who need tools have to register their staff card before the tool is provided such that control over who and what equipment they have taken becomes easier. Some of the items are manually picked in shelves behind the counter (e.g. protective gloves and other consumables) while other type of equipment such as components is automatically picked by an AS/RS. Figure 18 below shows the inside of the shipyard's automatic pallet storage (AS/RS) at Shipyard X.

Figure 18: The shipyards automatic pallet storage (AS/RS)

Components that do not fit into the AS/RS due to different criteria such as length and width are placed at the yard's main storage. Here, the warehouse is divided into sections where there is some shelf space and some floor space. The products are located and arranged randomly at the storage. As a result, incoming goods are often placed in the first available space. This creates challenges in the order picking process as products often are placed in front of equipment needed first. Consequently, the time spent on searching and looking for goods is increased, and the warehouse personnel often have to move components or pallets that are placed in front of the components being requisitioned from production. Overall, this results in less efficient planning and more time and resources spent on the picking process. However, one interviewee stated that "*fixed storage is not suitable due to the high throughput of goods at the warehouse*".

There is also a warehouse where goods are received. Much of the equipment here is only stored temporarily, checked and carried on to another storage, while a small number of goods are placed here. The storage has a part inside which is heat regulated, so that special equipment that needs a certain temperature can be stored here.

5.1.5 Requisition in Tag Manager

Requisition of components needed in production is mainly done by the production supervisor but all employees at the production department have access to the requisition of goods in Tag Manager. For a component to be searchable, a TAG number for the component must already be registered. When the components are registered in the system with a TAG number, one can search and find specific components by for example typing in TAG number, SFI, description or supplier. When an employee requisitions a specific TAG code in the system, the system automatically shares that information to the warehouse without any need of direct communication between the departments and concurrently, the TAG status codes changes automatically from "Stored (70)" to "Requisitioned (80)". The automatic change in the system speeds up the information flow, making the process more efficient.

It was found in the interviews that while warehouse personnel were looking for requisitioned components, that sometimes the items were not at their respective place or not delivered. In these cases, production contacts the technical coordinator that accepted the TAG for help. If the shipyard receives a component with a poor technical description from the supplier and this is accepted by the DE department, it usually becomes a problem for production at a later stage. The DE department must search for the component by looking through POs, packing slip or even contacting the supplier for more information. This takes time and affects the production schedule and can be a problem if the shipyard has hired production workers for specific jobs and cannot fulfill another job until the components are ready. Fortunately, the production department most often have the possibility to start other jobs while waiting for the right components with adequate information to arrive.

Another scenario that may cause delays in production, can be that a delivery has arrived and is in storage, but cannot be found. One of the interviewees said that these situations might occur because the employees at the goods receipt did not do a good enough job. Another reason that this might happen is if someone has taken out components without registering that it is taken out of storage and by whom. This way, the status does not change into "installed (90)", while the system still shows the component as "stored (70)". This has a low chance of happening in the automatic pallet storage facility because that system demands everyone to register when picking components. In the open storage facilities workers can physically go pick whatever they need when they have made requisitions on TAGs, such as valves and tubes without notifying the warehouse. A similar example given by another interviewee was that they often place pallets containing different equipment and components in the production area that can be picked up whenever needed. The interviewee further stated that "*the main storage is open for everyone which makes it possible for workers that are not supposed to pick to just take equipment they need without registering*". This creates challenges if required equipment is picked up and not properly registered in Tag Manager which makes the inventory status misleading. Overall, this causes the need for re-purchasing, and that may result in delays for production and higher total costs in the project. If there are critical items that are needed as soon as possible it might cause higher expenses with acquiring that component in time.

5.1.6 Order Picking

After the requisition is done by personnel in the production department (process 6 in figure 11), order picking is done by the warehouse personnel (process 7 in figure 11). The order picking method used at Shipyard X varies between the different storages, where the picker to order method is mainly used while the order to picker method is used at the automatic pallet storage. The picker follows a route by reading a picking list in Tag Manager, which is created based on requisitions from production and time needed. Normally, it takes one hour from an item is requisitioned until it is delivered to the unloading point. However, it is pointed out by interviewees that requisition often is done well in advance of production so that any delays at the warehouse does not create problems for the production schedule. If a component is urgent for production, they can call directly to the warehouse to notify them. Then the warehouse will prioritize that specific order first.

5.1.7 Shipping to Production

The requisitioned TAG number and item are delivered at the designated unloading point requested by production (8) and TAG status code in Tag Manager is changed manually by the warehouse personnel to "installed (90)". This is done either at order picking or when the TAG has been delivered to production. The process can be seen in figure 19 below.

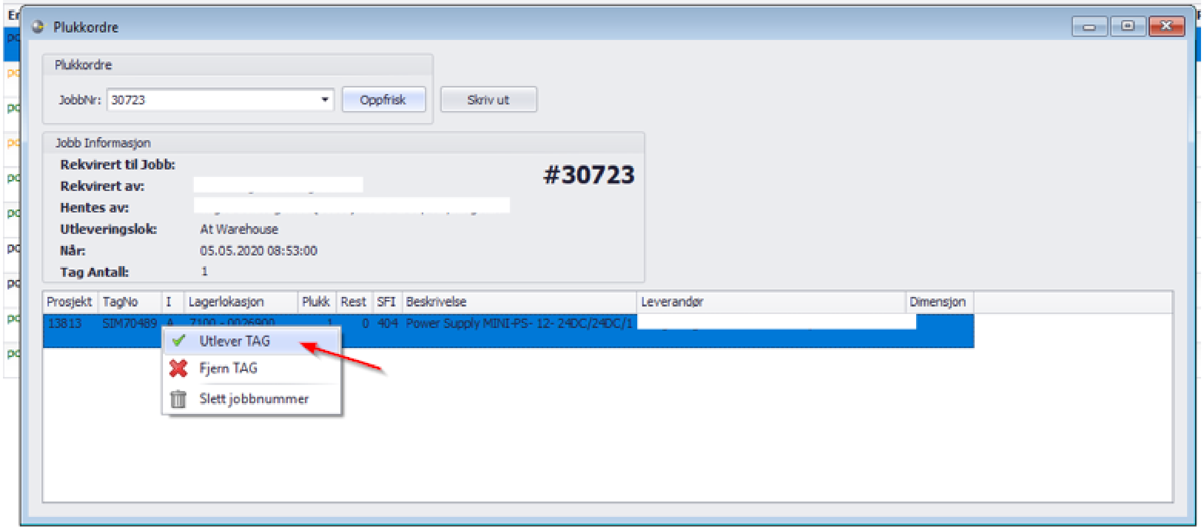

Figure 19: Confirm delivery to production. TAG status code changes from "requisitioned" to "installed". Personalia and supplier are hidden for confidentiality reasons (source: internal documents).

From here, the employee at production who requisitioned the goods is responsible for further distribution to the vessel. When a TAG is already set to code "installed 90", it is not possible to change code in the system. As mentioned above, this creates challenges if an item is not used by production and returned to the warehouse, which results in incorrect inventory levels and thus more difficult to book and track items in the WMS.

5.1.8 Summary of Main Challenges

Chapter 5.1 has outlined the empirical findings of the case study. The subchapter has given an overall understanding of how the current procedure of information- and material flow is at the case company limited to the flow going through the WMS. The chapter has been structured based on activities in a shipbuilding project – from an order is issued and till the material has been delivered to production. Several challenges have been identified (RQ2) and the examples have illustrated potential causes for why the current use of the WMS does not work optimally (RQ1). We identified three main causes that result in inadequate use of the WMS and therefore impact the flow of information- and material negatively. These challenges are summarized in table 5 below and will be further addressed in the next chapter where the challenges are discussed up against best practices and theory which can help coming up with measures of how Shipyard X can enhance the use of the WMS (RQ3).

Table 5: Summary of main challenges

Inadequate use of the WMS	Causes
Manual access and handling	- Lack of real-time information of the material flow - Prone to human errors
Underutilized technological capabilities in the WMS	- No utilization of technology such as barcode and/or RFID - Limited interface and integration with other software programs
Inadequate information on TAG from suppliers	- Increases workload for the DE department - May affect the total lead-time of a shipbuilding project negatively

These findings are analyzed and discussed in chapter 6 with the intention of leading to answers for the research question while proposing solutions for solving the research problem.

6.0 Discussion and Analysis

The findings have provided a description of several challenges and problems related to information- and material flows in the WMS that may occur during a shipbuilding project. We will now analyze and discuss the empirical findings presented in chapter 5 with an aim to answer RQ3 "*How can Shipyard X enhance the use of the WMS?"*. The improvement suggestions formulated in this thesis do not aim to propose a detailed solution but instead, aim to provide a conceptual solution with suggestions for improvements on a more general level. The suggestions are rooted in the theoretical framework and adjusted to the empirical findings in chapter 5.

As presented in chapter 1, the motivation for this case study was based on previous findings from an earlier master´s thesis conducted on another shipyard in Norway. One of their findings was related to the receiving process, where materials received from the shipyards suppliers often are delivered with a packing slip that is set up differently than the PO, creating challenges for employees at the warehouse. In addition, lack of information on components was identified, meaning that warehouse personnel do not often know which physical components that are included in the received goods. As a result, the process of receiving goods and registering them in the system is challenging and time-consuming and may result in delays for the production department who will utilize the equipment (Magnussen and Aarra 2019).

The yard we have been investigating has implemented and developed a well-functioning WMS over several years that addresses these challenges. For Shipyard X, personnel at the warehouse receives necessary information about the delivered goods. When they enter the TAG or order number into Tag Manager, they receive a standardized list of information on the equipment registered on that number. Nevertheless, it can be argued that such problems may arise if TAGs with insufficient quality of information is accepted into Tag Manager.

In the initial phase of data gathering in this thesis, it was evident that lack of adequate information sharing exists, both internally within the case yard and between other yards as for example the shipyard abroad where the steel structure is produced and with suppliers. In order to find ways on how to improve the information flow at the case company, it was vital to first gain insight into processes in a shipbuilding project and what information is needed to support these processes. According to Bozarth and Handfield (2016), one can also easily identify possible failures in the information flow by investigating the need for information. They further stated that the flow of information should be managed in a similar way as the flow of material. For example, if the production department does not have the necessary components, they cannot start that specific production process. The same applies to the information principle. Meaning that enough and adequate information is necessary at the shipyard to avoid any delays in a project and to operate in an efficient way.

Even though Shipyard X has implemented a well-functioning WMS that has a lot of potential in easing business operations; it is not efficient if not used properly. During data collection, several challenges related to the use of the WMS at the case company were identified. As stated earlier, the main causes of inadequate use of the WMS and that affect the flow of information and thus material flow negatively is inadequate information on TAG from supplier, manual access and handling in Tag Manager and underexploited technological opportunities.

Since Shipyard X have ETO as their production approach, they operate in large complex projects environments with specific project demands. Their approach of building highly advanced vessels to specific customer specifications results in small production volume and a large variety of unique components (Hicks, McGovern and Earl 2000). The complexity of the project combined with the large variety of unique components makes it essential with timely and accurate information flow to enable enhanced coordination (Wamba and Boeck 2008). The complexity of project demand and components also makes it vital to deal with the challenges mentioned in the empirical findings. The challenges related to inadequate information on TAG from suppliers create major undesirable repercussions at later stages in the project which can negatively affect the completion time- and coordination of a project. As most components "…differ on matters of colors, shapes, dimensions, functionalities, materials, processing times, etc." (Tu and Dean 2011, 169), it is extremely important that the yard receives this information from suppliers in order to ease warehouse operations and to plan for production. When such information is missing on TAG from a supplier it creates additional work for the DE department which then must request or search (e.g. in product manuals) for the information themselves. Overall, a lot of time and resources are spent on non-value-added activities for the yard and can in a worst-case scenario, result in delays for a project.

To enhance the information flow at Shipyard X, information shared across departments and with suppliers has to be accurate and the flow must be optimized with minimum delay and distortion. (Li and Lin 2006). A timely and reliable information flow provides opportunities to better coordinate the flow of resources, materials and the completion of assignments, making the whole project more efficient (Li and Lin 2006; Bozarth and Handfield 2016). An example can be the potential for proactive actions in production with enhanced information flow in the supply chain, especially from the DE department. Wamba and Boeck (2008) point out that a high degree of information flow integration in a supply chain is a determining factor of achieving efficiency and that information sharing is an important success factor for enabling enhanced coordination within the shipyard. As previously mentioned, it was found that if technical drawings and information on components are inadequate or not available on TAGs at the point of making a requisition, the production department must skip their scheduled task, and prioritize other available tasks. In the situation where activities must be postponed due to lack of needed equipment, it can lead to unnecessary labor and project expenses, especially if the shipyard has hired dedicated personnel for that activity.

If the information on the TAGs is inadequate or defective when production starts assembling and constructing of components or systems aboard the vessel, it can result in production mistakes and delays. Consequently, these mistakes would cause rework both aboard the ship and with DE having to make new drawings and the purchasing department having to reorder the components needed. When drawings and information on TAGs are missing, production must request these technical drawings from DE and the procurement process might have to start over again. As a consequence of the setback of information flow, the material flow will also stop (Bozarth and Handfield 2016) and production must skip the task and wait for correct information and receiving the components needed. The goal is that production may unlock the opportunity to begin tasks exactly on time following the project plan without having to request technical drawings which may result in delays in production. By speeding up the execution of tasks the shipyard may have the possibility to deliver the vessel before the scheduled date, receiving a bonus for early delivery from the customer (if defined in the contract).

Figure 8 presents the IT landscape of Shipyard X and illustrates activities related to information flow in the different software systems, between departments and with suppliers.

Analyzes of these flows leads to the following observation: accessing information in the various software programs requires manual handling and thus nearly all information-flow-related activities require human interference. For example, in the “receiving” process at the warehouse, there are several human interventions required such as manual data entry into the WMS and manual registering of incoming goods to Tag Manager. Manual access and handling in the WMS prevents real-time information on material in the system and creates a higher likelihood for errors. Therefore, it is reasonable to argue that the case company´s WMS has great potential to improve and to become more optimal. According to Richards (2014), a successful WMS should be able to work in real-time to achieve effective handling of material flow and to be productive. Implementation of RFID technology can be mentioned as a solution to achieve accurate and timely information flow. The capability for RFID to deliver timely information and visibility into the supply chain is based on three aspects of RFID technologies. They are “automatic data capture, real-time information, and real-time location system” (Jones and Chung 2008, 120). By enhancing technological capabilities in the WMS, Shipyard X has the potential to optimize the use of the system and thus working processes throughout a shipbuilding project.

Since existing processes in the warehouse at Shipyard X works well, it would be beneficial to provide an enhanced IT solution (Richards 2014). According to Jones and Chung (2008, 135), RFID technology also has the ability to more effectively perform warehouse operations in form of “pick/pack, ship, route, track, and distribute materials”. For example, if an item is tagged and tracked, the buyer of the item is able to automatically receive a receipt notice, indicating the arrival of the shipment at the buyer’s site (Shabri, Gupta and Beitler 2007). Overall, Jones and Chung (2008) found from previous research that operational labor can be decreased with up to 30 percent in distribution operations by using RFID technology. Therefore, a change from manual to digital processes for the case company may enable great cost reduction through enhanced efficiency (less time spent on work tasks and less errors during data entry) (Shabri, Gupta and Beitler 2007). Enhanced efficiency and thus working processes may also be beneficial in relation to a shipbuilding project’s lead-time, where delivery time to the customer may be decreased.

It was found in chapter 5 that Shipyard X has underutilized technological features that might impact the flow of information- and material negatively. Sonnenwald (2006) states that how information is shared between actors has an impact on the other parts interpretation of that information and what to make of it. In other words, it is important that the shipyard share enough and clear information to their suppliers, to make sure that the supplier gets the right idea of what is needed when they fill in information on TAGs. This way, the yard would receive more reliable and adequate information and there would be less room for errors.

Shipyard X primarily uses four different software programs: Primavera, IFS, AutoCAD and Tag Manager. As mentioned in chapter 4, there is a lack of interface and integration between the various software systems. Among the findings of the case study were that IFS is not fully interfaced or integrated with Tag Manager, AutoCAD is semi-integrated with Tag Manager requiring manual import and the planning software Primavera is only accessible to the planning department. These findings indicate insufficient speed of information flows across departments and with their suppliers. Opportunities for having an interface between these software's and allowing access to more users should be discussed. Therefore, it is interesting to find out whether integration would enable seamless information sharing across these systems to help enhance information flow in the supply chain.

Tag Manager is a "best of breed" WMS developed according to the needs of Shipyard X. In chapter 5, it was found that the only integration between IFS and Tag Manager was that when POs are generated in Tag Manager, IFS assigns PO numbers to the orders. This means that they are missing the opportunity of real-time information being shared regarding, for example, status updates on TAGs in Tag Manager. According to Richards (2014, 189), it is important that the WMS "have the ability to communicate with other company systems". Therefore, a wider integration or interface between IFS and Tag Manager could open for the integration of, for instance, back-office tasks such as order entry, inventory control, PO modules and invoicing (Richards 2014). Other benefits of interfaced systems are enabling the ERP system, IFS, to receive data from the WMS when matching receipt of goods with the PO and other ERP activities like generating correct invoices for shipped orders as also recommended by (Friedman 2010).

In figure 8, the connection between Tag Manager and AutoCAD is labeled with "semi-integration". This is because the engineers in the DE department have to link all TAGs to a specific drawing before a complete TAG-list can be manually imported into AutoCAD. The overall process of linking and importing TAGs from Tag Manager to AutoCAD was mentioned as being time-consuming by interviewees but necessary to assist the production department. Therefore, it might be interesting to look at benefits the shipyard could gain by integrating AutoCAD and Tag Manager in a better way. A potential improvement might be to have TAGs linked to drawings automatically instead of needing to link the TAGs manually and later import the TAG-list into AutoCAD. This way, the TAG-list would be automatically assigned to the specific drawing when all components have TAGs assigned. However, due to limitations in both our findings as well as our knowledge in the area, this suggestion can only be seen as speculative.

With a common database, all information would be updated and shared between the software's in real-time (Wozniakowski, Jalowiecki and Zmarzlowski 2018). By integrating Primavera, Tag Manager and the main actors involved in the supply chain, the supplier could act on new information regarding activity delays or rescheduling to earlier dates. This would help reduce the complexity of warehouse management and may contribute to reduce the total lead-time of a project. With enhanced information about upcoming production activities, the warehouse employees would be able to better plan and allocate resources according to the schedule. Although a full integration would be the best option, providing all departments with access to Primavera could be a less expensive alternative than integration. However, the price per license required by the software supplier is one of the reasons for the lack of access, meaning that the costs and benefits associated with providing all departments with access should be closely considered. From our point of view, one solution could be to extend access to the production department, as it would allow punctual updates on the progression of the project. This way, if production is delayed or in front of an activity, they could update the project plan in Primavera, giving notice to other departments. For example, the warehouse would then know what components are needed and when, and thus facilitate more effective planning.

7.0 Conclusion

This chapter concludes the main findings from the case study and reflects on practical implications, theoretical implications, limitations and possible further research on the problem area.

This thesis has investigated how the flow of information- and material goes through the case company's WMS and if there are any challenges that cause inadequate use of the system. To answer our RP, a single case study has been conducted on a Norwegian shipyard, referred to as Shipyard X in this thesis. The RP we aimed to answer during our research was:

RP: "*How can optimal use of the WMS improve information- and material flow at Shipyard X?"*.

To answer this RP, three research questions were formulated. The first research question (RQ1) was: "*Is the current procedure for information- and material flow at Shipyard X optimized with the current use of the WMS?*". Based on our empirical findings from the data collection, mainly three challenges were found that potentially result in inadequate use of the WMS and therefore impact the flow of information- and material negatively. Thus, the second research question (RQ2) "*What are the challenges preventing optimal use of the WMS?*" was answered. The identified challenges and the undesirable causes they induce are summarized in table 5 (facsimile) below:

Facsimile of Table 5: Summary of main challenges

Inadequate use of the WMS	Causes
Manual access and handling	- Lack of real-time information of the material flow - Prone to human errors
Underutilized technological capabilities in the WMS	- No utilization of technology such as barcode and/or RFID - Limited interface and integration with other software programs
Inadequate information on TAG from suppliers	- Increases workload for the DE department - May affect the total lead-time of a shipbuilding project negatively

As we identified potential causes for why the existing procedures for information- and material flow does not work optimally with the current use of the WMS (RQ1, RQ2), we wanted to investigate potential solutions to deal with these challenges. Thus, the third research question (RQ3) was formulated as "*How can Shipyard X enhance the use of the WMS?*". Building on the identified causes in RQ2 and theory regarding warehouse management, information flow and ERP, possible suggestions for optimal use of the system were discussed. The improvement suggestions included the following elements:

- Enhanced information sharing between the yard and its suppliers to avoid additional work for the DE department.
- Enhanced technological capabilities in the WMS to achieve real-time information sharing and diminish human errors. Thus, utilization of technology such as RFID was discussed as a possible solution which also decreases time spent on warehouse operations.
- Better integration and interface of the current IT landscape to facilitate a tidy flow of information. This would also reduce the need for manual access and handling in the different IT systems.

Based on these answers, our research has found that improved use of the WMS unlocks several possibilities for Shipyard X. However, most of the suggestions require new, sometimes costly investments. It is therefore important that the implementation provide measurable benefits that justify the cost associated with implementing it. Also, implementing RFID and enhancing the integration and interface between the various software systems is a business investment decision and, therefore, require vast planning.

With these implementations, the WMS will be optimized, enhancing the information- and material flow going through a shipbuilding project. Real-time visibility will increase the timeliness and reliability of the information shared across departments and with suppliers and thus the lack of timely access to needed information is diminished. By enhancing the quality of information through the WMS, an increase in productivity and financial performance may be achievable.

7.1 Practical Implications

Findings in this thesis indicate that the shipyard of this study struggle with inadequate information- and material flow that results in occurrences of incomplete information and specifications on components in the warehouse. These errors often cause waiting, rework and undesirable repercussions for the warehouse, DE, procurement and production department. We found that these errors can be traced back to the company and its supplier's use of the WMS and other IT software, and the procedures of information sharing. From our point of view, it could be wise to look at the use of the WMS, interface and integration in the IT landscape, implementation of RFID, barcode and EDI technology, etc. to enhance the information- and material flow through a shipyard. Our perspective is that Shipyard X would especially benefit from the implementation of RFID since the yards basic warehouse processes are working correctly.

Shipyards with an ETO-approach have in common that there is an extremely high volume of components acquired from several different suppliers. Every project is unique, often with new suppliers, new specifications on components with the same functions. Based on the studied theory combined with our findings at the case company in this thesis, we find it likely that the treatment of information- and material flow is an important aspect of a project's success. The importance of information sharing and timely and accurate information- and material flow is found to be fundamental to be able to handle the concurrency between departments in the project, but also handle changes that occur throughout the project. It might be beneficial for other shipyards and thus ETO companies to conduct research and testing of different improvement efforts for optimal control of information- and material flow, limited to the warehouse, but also other stages in the supply chain. Enhancing optimal information- and material flow would help companies to improve lead-time and reduce total costs.

7.2 Theoretical Implications

In this thesis, subjects on information sharing, ERP and WMS have been applied to describe how it can enhance the current procedure for information- and material flow at Shipyard X, limited to the flow going through the WMS. Our findings provide additional support to the literature regarding the complexity of interdependency and coordination in shipbuilding projects and thus ETO projects. Due to these characteristics, it is essential with timely and reliable information flow to increase productivity and avoid any delays.

There is a need for more knowledge on the importance of timely information- and material flow in the shipbuilding industry. Therefore, this thesis may contribute to fill this gap in research. The findings may also provide additional awareness of the importance of adequate and relevant information sharing between departments and with suppliers to avoid potential rework and delays. The importance of this awareness applies especially to other shipyards or similar industries using an ETO-approach.

The results from our case study show that the current procedure for information- and material flow at the case company is characterized by a low degree of automation which prevents real-time information sharing. Our research has found that improved use of the WMS with enhanced technology such as improved interface and integration in the IT landscape and implementation of RFID may unlock several possibilities for Shipyard X, where increased efficiency can be mentioned as one possible benefit. Therefore, our research complement theory regarding WMS where RFID and integration are mentioned as factors that can improve the utilization of the system with possibilities of real-time information sharing. It could be interesting for further research to study a shipyard or other ETO project-based companies that have implemented these solutions to examine whether the measures improve the processes in the WMS or not.

7.3 Limitations

The scope of this research is limited to the information- and material flow going through the shipyard's WMS Tag Manager. Thus, the empirical findings are limited to the activities performed in the software. This includes activities from an order is issued and till the material has been delivered to production and hence the focus in this thesis has been the area of purchasing, DE, warehousing and production.

As our study is based on a specific case in a specific company, the results may be less generalizable than if we had conducted a multiple case study and thus a limitation in our thesis. If we had conducted a multiple case study including several shipyards to compare the characteristics found at Shipyard X, we could have strengthened the results of this study.

Unfortunately, limited time and resources had a huge impact on the comprehensiveness of the study as we had to change the case company late in the project (February 2020). In addition, our data collection was affected by the circumstances surrounding COVID-19, which made it difficult to gather information (from the beginning of March 2020) in form of correspondence with the case company and especially in the form of interviews and obtaining answers to our questionnaire. As a result of limited time and resources for data collection, the number of respondents for our interviews and questionnaire is a limitation to the conclusion of this research.

Finally, our thesis has been mostly qualitative and therefore our findings need to be interpreted with caution as they may be subject to researcher bias. However, validation of the results by several representatives from the case company may help to deal with this weakness. In addition, the results from our interviews were reinforced by receiving similar results from our questionnaire and thus the reliability of the study can be strengthened.

7.4 Further Research

Research similar to the approach presented in this thesis can be conducted to further expand the study, for instance, including the whole supply chain of the shipyard with also the sales department, design, planning, the customer and suppliers. It would be interesting to investigate the information flow from the yard to its suppliers and vice versa to further elaborate on why there is missing or inadequate information on TAG. Therefore, further research should examine the supplier's perspective on the use of Tag IT. Studying the use of Tag IT by the supplier could give further insights into the underlying causes of why standard procedures of information sharing in the WMS are not being followed. Besides, a cross-case analysis including multiple shipbuilding companies would be interesting to conduct and investigate if the issues identified in this thesis exist in other shipyards or organizations using an ETO approach. By conducting a multiple case study, the external validity of the study could be increased. However, one has to bear in mind that a lot of time and resources may be necessary to carry out a multiple case study research.

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9.0 Appendices

9.1 Appendix I - Interview Guide 1

1. INFORMATION (5 MIN)

i. Present ourselves
ii. Topic for the interview (background, purpose)
iii. Explain what the interview should be used for and explain the duty of confidentiality and anonymity
iv. Ask if something is unclear and if the respondent have any questions
v. Inform about recording, consent to recording
vi. Start recording

2. BACKGROUND (10-15 MIN)

i. Tell us about yourself.
ii. Previous work experience?
iii. How long have you been working at Shipyard X?
iv. Which department do you work in at Shipyard X? (purchasing, engineering, warehouse, etc.)
v. What kind of experience do you have with the use of Tag Manager?

3. PRODUCTION/DETAILED ENGINEERING (DE) (30-45 MIN)

<u>A. TAG Manager/Information sharing:</u>

i. Can you briefly explain how the production/DE department are using Tag Manager?
ii. What program/system are being used in production/DE?
iii. What information in Tag Manager is relevant for your department?
iv. What information does the production/DE insert in Tag Manager?
v. What kind of training and certifications have you conducted in the WMS "Tag Manager"?
vi. How well do you think DE integrate information about product functions in Tag Manager?
vii. How does missing information about product specification and functions affect the production/DE process?
viii. Are there any missing or inadequate information in Tag Manager?

ix. Are there any other problems with information sharing which result in inefficient processes?
x. Are there any specific problems connected to the warehouse management that leads to delays in production?
xi. Are there any other Tag Manager problems that you can think of that leads to delays in your department?

B. Order Picking Process

i. Can you briefly explain the order picking process for the production department?
ii. Who is responsible for picking goods?
iii. How is Tag Manager used for order of goods for picking?
iv. How are goods picked?
v. What information do you have of the goods when you send an order requisition?
vi. How long does it take from an order requisition before you can start production or assembly of the goods?
vii. What details do you need before starting production or assembly of goods?
viii. What is the practice when receiving goods with missing or damaged components?

4. ENDING QUESTIONS (5 MIN)

i. Summarize key questions and ask if we have understood them correctly
ii. Is there anything the interview respondents will add?
iii. Interview respondents will have the opportunity to approve the interview / information

9.2 Appendix II - Interview Guide 2

1. INFORMATION (5 MIN)

i. Present ourselves
ii. Topic for the interview (background, purpose)
iii. Explain what the interview should be used for and explain the duty of confidentiality and anonymity
iv. Ask if something is unclear and if the respondent have any questions

v. Inform about recording, consent to recording

vi. Start recording

2. BACKGROUND (10-15 MIN)

i. Tell us about yourself.

ii. Previous work experience?

iii. How long have you been working at Shipyard X?

iv. Which department do you work in at Shipyard X? (purchasing, engineering, warehouse, etc.)

v. What kind of experience do you have with the use of Tag Manager?

3. PURCHASING (15-20 MIN)

i. How is a purchase order generated?

ii. What systems do you use?

iii. Is Tag Manager linked to IFS?

iv. Who generate TAG numbers for the component list? How is this done?

v. What information is necessary to insert on Tag?

vi. What is the procedure for late deliveries?

vii. What is the procedure for matching PO with packing slip?

4. ENDING QUESTIONS (5 MIN)

i. Summarize key questions and ask if we have understood them correctly

ii. Is there anything the interview respondents will add?

iii. Interview respondents will have the opportunity to approve the interview / information

9.3 Appendix III – Questionnaire

Master´s Thesis

This questionnaire was created to collect data for our master's thesis in logistics, at Molde University College. The answers to the questionnaire will be anonymous and participation is voluntary.

The questionnaire consists of a mix between multi-choice, scaled, and open-ended questions. The theme will mainly be about Tag Manager, information sharing, and work processes. It takes approx. 5-10 minutes to complete.

We appreciate every response we receive, as this helps us a lot. Thank you very much in advance.

* Required

1. Which department do you work in? *

Mark only one oval.

- Purchasing
- Detail Engineering
- Warehouse
- Production
- Other

2. Which IT system do you use in your daily work? *

Check all that apply.

- [ ] Primavera
- [ ] IFS
- [ ] Tag Manager
- [ ] Tag IT
- [ ] Other

3. How is information shared within the department you work in? *

Check all that apply.

- [ ] Physical (e.g. conversation/direct communication)
- [ ] Meetings
- [ ] Phone
- [ ] Mail
- [ ] SharePoint
- [ ] IT system (Tag,
- [ ] Primavera, IFS, etc)

Annet

4. How is information shared across departments? *

Check all that apply.

- [ ] Physical (e.g. conversation/direct communication)
- [ ] Meetings
- [ ] Phone
- [ ] Mail
- [ ] SharePoint
- [ ] IT system (Tag,
- [ ] Primavera, IFS, etc)

Annet

5. On a scale of 1-5: How easy is it to get information you need? *

Mark only one oval.

	1	2	3	4	5	
Difficult/Time-consuming	⬭	⬭	⬭	⬭	⬭	Easy/Easily accessible

6. On a scale of 1-5: How good is the quality of information available? Can you trust it? *

Mark only one oval.

	1	2	3	4	5	
Low quality	⬭	⬭	⬭	⬭	⬭	High quality

7. On a scale of 1-5: How relevant is incoming information (e.g. by mail, IT systems, meetings, etc.)? *

Mark only one oval.

	1	2	3	4	5	
Not always relevant to my responsibilities	⬭	⬭	⬭	⬭	⬭	Always relevent to my responsibilities

8. On a scale of 1-5: How often do you need to search for information yourself? *

Mark only one oval.

	1	2	3	4	5	
Rare	⬭	⬭	⬭	⬭	⬭	Often

9. On a scale of 1-5: How easy is it to search/find an item in Tag Manager? *

Mark only one oval.

	1	2	3	4	5	
Difficult/Time-consuming	⬭	⬭	⬭	⬭	⬭	Easy/Time-efficient

10. On a scale of 1-5: How often does product information on Tag Manager match the received delivery? *

Mark only one oval.

	1	2	3	4	5	
Rare	⬭	⬭	⬭	⬭	⬭	Always

11. If you did not answer 5 to the question above: what information does not match (e.g. number, type of product, product name, delivery time, color code, etc.)

12. On a scale of 1-5: How often do delays / obstacles occur due to missing information on components in Tag Manager? * *Mark only one oval.*

	1	2	3	4	5	
Rare	⬭	⬭	⬭	⬭	⬭	Often

13. On a scale of 1-5: How often do delays / obstacles occur due to incorrect information on components in Tag Manager? * *Mark only one oval.*

	1	2	3	4	5	
Rare	⬭	⬭	⬭	⬭	⬭	Often

14. If you did not answer 1 to the question above: What kind of error could it be?

15. On a scale of 1-5: How often do you have trouble using the Tag Manager system? *

Mark only one oval.

	1	2	3	4	5	
Rare	⬭	⬭	⬭	⬭	⬭	Often

16. If you did not answer 1 to the question above: Can you briefly explain what problems?

17. Detail Engineering: How much time do you use on accepting TAGs from suppliers in Tag Inbox per day?

Check all that apply.

- [ ] Under 30 minutes
- [ ] 30 minutes - 1 hour
- [ ] 1-2 hours
- [ ] Over 2 hours

18. Detail Engineering: How often do you need to change or request information from a supplier on TAGs received in Tag Inbox?

Mark only one oval.

	1	2	3	4	5	
Rare	○	○	○	○	○	Often

Detail Engineering: How often is product description on equipment from supplier unknown, with symbols or letters instead of product description? (e.g. "VL28" vs. "Seacock Valve")"? *Mark only one oval.*

	1	2	3	4	5	
Rare	○	○	○	○	○	Often

19. Detail Engineering: If you did not answer 1 of the questions above: What problems does this cause? How much time is spent on extra work related to this problem?

20. Do you have any suggestions on how to improve the flow of information in Tag? (e.g. making your work more efficient / less time-consuming) *

21. Are there any other work processes or tasks that you see as unnecessary or time-consuming / cumbersome? Suggestions for improvements / measures? *