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► **To cite this version:**

Swapnil Bhalla, Erlend Alfnes, Hans-Henrik Hvolby. Sales and Operations Planning for Delivery Date Setting in Engineer-to-Order Maritime Equipment Manufacturing: Insights from Two Case Studies. IFIP International Conference on Advances in Production Management Systems (APMS), Sep 2022, Gyeongju, South Korea. pp.321-328, 10.1007/978-3-031-16411-8\_38 . hal-04768962

**HAL Id: hal-04768962**

**<https://inria.hal.science/hal-04768962v1>**

Submitted on 6 Nov 2024

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# Sales and Operations Planning for Delivery Date Setting in Engineer-to-Order Maritime Equipment Manufacturing: Insights from two case studies

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**Abstract.** Delivery date setting (DDS) is a challenging and competitively critical tactical decision in engineer-to-order (ETO) environments, which requires integrated planning for effective decision-making. Despite the variety of industrial contexts in DDS literature, the maritime equipment industry has been an unexplored context vis-à-vis planning needs for effective DDS. This study uses a sales and operations planning (S&OP) framework to investigate the current state of the DDS process of two maritime equipment suppliers. Findings indicate that the low market demand over the last few years has influenced the DDS process design in the companies, suggesting that the process should be reconfigured to remain effective under periods of high demand. More cases from the maritime equipment industry are needed to assess if the findings are valid across the industry.

**Keywords:** tactical sales and operations planning, delivery date setting, engineer-to-order.

## 1 Introduction

Maritime equipment such as engines, propellers, thrusters, cranes, winches, etc., for ships are complex, high-value, electromechanical products that are often customized according to the requirements of ship owners, designers, and engineers. Adopting such an engineer-to-order (ETO) strategy for delivering customized equipment allows maritime equipment suppliers to deliver technologically competitive and innovative solutions to their customers [1]. However, operating with an ETO strategy also creates substantial uncertainty in product specifications, process specifications, and delivery lead times, making delivery date setting (DDS) a complex and challenging task [1, 2]. The DDS process and effectiveness can be competitively critical for winning orders in ETO contexts [3, 4]. The planning needs for effective DDS vary across ETO companies and industry sectors [2, 5], and case studies from various ETO contexts can be found in the extant DDS literature, e.g., industrial machinery production [2, 6, 7], boiler and reactor manufacturing [8], engineered wood production [9], industrial electrical and electronic equipment [10], etc. However, there are no case studies on the DDS practices of

maritime equipment suppliers in the extant literature, and studying these practices in unexplored industrial contexts is one of the main research needs for establishing a common reference framework for tactical planning activities across ETO contexts [5]. This paper aims to contribute to this research need by investigating the DDS practices in the maritime equipment industry using the case research approach. The paper studies these practices based on a modest case sample of two case companies to ensure greater detail for the studied cases and the contextual factors affecting DDS practices in the cases. The paper investigates the two equipment suppliers' DDS practices using a tactical sales and operations planning (S&OP) theoretical framework presented in Section 2. Section 3 presents findings from the case studies. Section 4 concludes the paper by summarizing the implications of the main findings.

## 2 Theoretical framework

The ETO strategy has been widely adopted by companies producing complex, big-sized, industrial products that are often too high-value and customer-specific to be mass-produced [11]. The order-winning process in ETO environments usually entails a tendering or customer enquiry stage, where a customer's technical and commercial requirements are translated to preliminary specifications of the product and estimated commercial characteristics of order-fulfillment such as price and delivery dates [1, 12]. Setting these delivery dates is usually a tactical planning decision in ETO environments, which entails creating preliminary aggregate plans and roughly estimating quantities, flow times, and resource requirements [8, 9, 13].

DDS is a complex decision since there are various order-fulfillment activities, e.g., design, engineering, procurement, fabrication, assembly, testing, etc., whose lead times should be considered while setting delivery dates in ETO environments [9, 14, 15]. Furthermore, due to varying levels of customer-specificity of these order-fulfillment activities, variables affecting the activity lead times, i.e., product specifications, material requirements, resource requirements, etc., are often uncertain [1, 2, 4]. These characteristics of DDS in ETO companies create a uniquely complex and uncertain context for tactical planning. Extant research on DDS in ETO environments suggests formalization of the tactical planning process and integrated planning across functions as best practices for managing the complexity and uncertainty of DDS [2, 7, 9, 14, 16]. Integrated planning across functions enables cross-functional information sharing and coordination and ensures that relevant factors are considered in the planning process. Formalizing the planning process standardizes or systematizes planning and decision-making with predefined rules and procedures that ensure the involvement of relevant actors in planning and decision-making based on explicitly stated objectives or priorities.

While previous DDS research emphasizes the importance of formalizing and integrating the tactical planning process for effective DDS, the extant literature has lacked frameworks that can support companies in adopting these practices [5]. Meanwhile, sales and operations planning (S&OP) has emerged as an approach for integrated tactical planning, whose applications in ETO environments have been essentially overlooked in the extant research, despite its potential to address the complexity and

uncertainty characterizing tactical planning and DDS in ETO environments [17]. S&OP integrates tactical planning across functions and supply chains, effectively balancing demand and supply while aligning plans for operational activities with strategic objectives and constraints [18]. Linking S&OP with DDS in ETO environments, **Table 1** shows a framework of the main S&OP activities for DDS, clustered under four main planning functions for sales, engineering, procurement, and production, which also correspond to the four main supply chain functions in ETO environments [19].

**Table 1.** The theoretical framework of S&OP activities for DDS in ETO environments

<b>Planning function</b>	<b>Planning activities</b>	<b>Ref.</b>
Sales planning	Selecting customer enquiries	[2]
	Prioritizing customer enquiries	[12]
	Determining delivery lead time, date, and price	[20]
Engineering planning	Defining preliminary product specifications	[1, 12]
	Determining detailed engineering activities and resources	[1, 12]
	Estimating lead times and costs and setting due dates	[9, 10]
	Identifying external capability and additional capacity needs	[1, 9]
Procurement planning	Identifying critical items	[7, 14]
	Selecting potential suppliers	[7, 14]
	Determining procurement lead times and prices	[14, 21]
Production planning	Identifying main production activities & resource requirements	[8, 12]
	Identifying feasible production start and end dates	[8, 9]
	Estimating production costs & non-regular capacity requirements	[8]

### 3 Case studies

The Norwegian shipbuilding and maritime equipment industries are known for their high-quality, highly customized, and innovative products [22-24], with the widespread adoption of the ETO strategy [1, 21, 25]. Maritime equipment suppliers base the fundamental designs of their products on the targeted customer segments (i.e., ship types) and the requirements imposed by the codes, standards, and rules specified by ship classification societies such as DNV (Det Norske Veritas) and Lloyd's Register. Relevant systems and sub-systems can be selected from these basic designs, and their specifications may be modified and combined in different configurations to address specific customers' requirements. The level of customization offered by equipment suppliers may vary across market segments and companies [1].

The operating profits of Norwegian maritime equipment suppliers have dropped historically over the last decade [24], following the dramatic effects of the decline of oil prices in 2014-15 on the global shipbuilding industry [23, 24, 26, 27]. Demand from the higher-margin oil and gas segment has decreased, while sales and delivery of equipment to other segments, e.g., cruise ships, ferries, fisheries, aquaculture, etc., have increased significantly [24].

Maritime equipment suppliers are essential parts of shipbuilding supply chains [21, 27], whose contextual characteristics and planning needs have not received much attention in extant ETO planning and control literature, especially within DDS and tactical planning. To address this gap, this section presents the case studies of the DDS process of two Norwegian ETO maritime equipment suppliers operating in the global shipbuilding market. The first case company is a supplier of propulsion and maneuvering systems for various types of ships and is referred to as ProCo (fictitious name – short for propulsion equipment company). The second case company is a supplier of handling equipment and structures such as cranes, winches, gangways, etc., and is referred to as HanCo (fictitious name – short for handling equipment company).

### 3.1 Description of cases

The first case company, ProCo, supplies propulsion and maneuvering systems for various types of ships, e.g., fishing vessels, aquaculture or fish farming vessels, shuttle tankers, ferries, cruise ships, offshore vessels, etc. Their product portfolio includes various standard propellers, thrusters, gearboxes, control systems, etc., that can be configured and customized according to customer requirements. ProCo has a strong strategic focus on localized manufacturing in Norway and is characterized by a high degree of vertical integration with primarily in-house engineering and production, supported by a few strategic suppliers. The second case company, HanCo, supplies specialized handling equipment such as cranes, winches, gangways, etc., for ships used in fishing, aquaculture, offshore oil and gas, offshore wind, etc. The company focuses on the engineering and development of hardware and software technology, and most of the production is outsourced to suppliers, mainly in Europe and some in Asia. HanCo's portfolio of existing product designs has continually expanded since the company was founded ten years ago, with customer requirements often driving the expansion.

In both case companies, tenders and customer enquiries are primarily managed by the sales department without much involvement from the other functions. After identifying potential customers' requirements from tender invitations, sales leads, customer enquiries, etc., engineers in the sales department prepare technical proposals with preliminary product specifications describing how the company's product technology can address the customer's requirements. In most instances, the engineering, procurement, and production departments are first involved in a customer order after contract signing or order confirmation, when the delivery date and price have already been committed using estimates based on historical data on lead times and costs from completed orders. In ProCo's case, the company's planning department, which is responsible for production and inventory planning, may be contacted by sales personnel before contract signing in some cases if the customer-imposed delivery dates are considered 'too tight'. In such cases, the master planner assesses the availability of relevant production resources and critical suppliers to meet the delivery date. For HanCo's case, many customer orders entail prototyping of newly designed modules. The sales department at HanCo estimates the workload for in-house engineering disciplines (mechanical, hydraulics, electrical and electronics, and software) as part of the DDS or S&OP process, and the need for hiring personnel with new competencies is also identified at this stage.

However, these estimates are primarily used for estimating the quoted product price. Any capacity-oriented feasibility assessment of meeting the committed delivery dates is not undertaken until after order confirmation. **Table 2** characterizes the DDS process of the two case companies using the S&OP framework of planning activities.

**Table 2.** Evidence of DDS/S&OP activities in the cases

	S1	S2	S3	E1	E2	E3	E4	Pc1	Pc2	Pc3	Pd1	Pd2	Pd3
<b>ProCo</b>	--	--	✓	✓*	--	--	--	✓#	✓#	✓#	✓#	✓#	--
<b>HanCo</b>	--	--	✓	✓*	✓*	--	✓*	--	--	--	--	--	--

**Legend:**

✓: evidence of activity found in the case      \*: activities performed by the sales department  
 --: evidence of activity not found                #: activities performed for some orders only

**S1:** select enquiries; **S2:** prioritize enquiries; **S3:** determine delivery lead time/date & price; **E1:** define preliminary specs; **E2:** determine engineering activities & resources; **E3:** estimate engineering lead times & costs; **E4:** identify external capability & capacity needs; **Pc1:** identify critical items; **Pc2:** select potential suppliers; **Pc3:** determine procurement lead times & prices; **Pd1:** identify main production activities & resource requirements; **Pd2:** identify feasible production start & end dates; **Pd3:** estimate production costs & non-regular capacity req.

### 3.2 Analysis and discussion

The analysis of the two case companies provides insights into the similarities and differences among their DDS processes, and the main contextual factors influencing their process designs. As **Table 2** indicates, many of the S&OP activities in our theoretical framework (**Table 1**) are not performed in most instances for DDS in the companies. Neither case provides evidence for the sales planning activities of selecting and prioritizing customer enquiries (S1, S2). The estimation of overall lead time and prices (S3) is primarily based on historical data in both cases, usually without any planning inputs from the other functions. Specification of the preliminary product characteristics (E1) is also handled by engineers in the sales departments in both companies. Engineering activities, workload, and capability requirements (E2, E4) are estimated in HanCo's case but only used for cost and price estimation purposes, not for capacity planning before order confirmation. In ProCo's case, procurement- and production planning activities (Pc1-3, Pd1-2) are only performed for enquiries with short delivery times.

We find the characteristically low demand for the shipbuilding and maritime equipment industry as the main contextual factor explaining the lack of evidence for many of the planning activities – S1, S2, E3, Pc1, Pc2, Pc3, Pd1, Pd2, and Pd3, in most cases for both companies. Given the low demand, the companies have focused on maximizing sales, thus overlooking the selection and prioritization of enquiries. The perceived importance of supply planning issues before order confirmation, i.e., capacity planning for engineering and production functions and supplier lead times, has also diminished in recent years due to low demand, long durations of shipbuilding projects, and surplus capacity in the upstream supply chains. As a result, the case companies have focused

on winning orders, and usually postpone planning for supply-related issues until after order confirmation in most instances.

The main observed differences between the companies' DDS processes can be explained based on the companies' vertical integration and sourcing strategies. ProCo's highly integrated production and diverse specialized in-house production equipment necessitate closer monitoring of workloads and capacity. Furthermore, their strategic focus on localized manufacturing constrains which suppliers can be used for sourcing components, necessitating closer monitoring of their availability under tight delivery schedules. In contrast, with low vertical integration and outsourced production, engineering is HanCo's core capability, and early identification of the need for new engineering capabilities and additional engineering personnel is essential for maintaining their competitive advantage. Furthermore, flexibility vis-à-vis supplier locations for outsourced production provide HanCo with higher flexibility in acquiring production capacity after order confirmation. This flexibility has possibly been amplified in recent years due to the low demand and surplus capacity in this industry, explaining the lack of HanCo's focus on procurement planning in DDS despite low vertical integration.

Experts within the maritime industry expect demand to increase in the coming years [28], which suggests that the effectiveness of the companies' DDS process could be vulnerable to these changes. With increased demand, engineering capacity planning could be challenging for HanCo, as the managers and planners report difficulties in engineering capacity planning and activity monitoring even in the current market environment. Production capacity planning is expected to be one of the main planning challenges for ProCo under increased demand since the existing backward loading-based planning functionality is inefficient for DDS, requiring multiple manual iterations. Procurement planning is expected to have higher importance for both cases in a high-demand market scenario due to increased competition for obtaining suppliers' capacities.

## 4 Conclusion

This study has provided some insights into the DDS processes of two ETO maritime equipment suppliers and the contextual factors influencing their process design. The overall market demand in the maritime industry, and the companies' vertical integration and sourcing strategies are found to be the most influential contextual factors for explaining the similarities and differences in DDS practices across the cases. While we consider the influence of the vertical integration and sourcing strategies on the DDS process design to be strategic choices, we believe that elements of the process design that the market demand has influenced should be reconsidered in the case companies for minimizing the vulnerability of their DDS processes to future demand growth expected in the maritime industry [28]. Such a reassessment of the process design can increase its robustness toward market changes. Since the paper investigates the current state of the DDS process of only two maritime equipment suppliers, it is premature to generalize the findings to other companies in this industry. However, previous findings from other industry sectors [2, 7] support the contextual factors identified in this paper, highlighting the potential for their broader relevance. The cases presented in this paper



also provide empirical support for the research need to develop effective engineering and production capacity planning tools for addressing the industrial needs of ETO companies, as highlighted in the authors' recent state-of-the-art review on DDS [5].

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