

# Implementing Lean in Engineer-to-Order Industry: A Case Study

Kristina Kjersem, Lise Halse, Peter Kiekebos, Jan Emblemståg

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# From first planner to last planner

## Applying a capability model to measure the maturity of the planning process in ETO

Gabriele H. Jünge<sup>1</sup>, Kristina Kjersem<sup>2</sup>, Mikhail Shlopak<sup>3</sup>, Erlend Alfnes<sup>1</sup>,  
Lise Lillebrygfjeld Halse<sup>2</sup>

<sup>1</sup>Norwegian University of Science and Technology, Trondheim, Norway

<sup>2</sup>Molde University College, Molde, Norway

<sup>3</sup>Møreforskning Molde AS, Molde, Norway

Gabriele.junge@ntnu.no, Kristina.kjersem@himolde.no,  
Mikhail.shlopak@himolde.no, Erlend.alfnes@ntnu.no,  
Lise.L.halse@himolde.no

### Abstract.

Engineered-to-order (ETO) networks are dynamic and hard to define, and their planning and control functionalities are commonly affected by the actions of suppliers and customers. Frequently, projects experience delays, budget overruns, and quality defects. Consequently, there is a need for project management that synchronizes engineering and production processes throughout the network.

The aim this study is to develop a project planning maturity model (MMPP) in order to improve project performance in ETO manufacturing networks. Moreover, a multiple case study approach is used to test the applicability of the developed maturity model. The results of the case studies from three ETO case companies show that there is (1) no or low degree of standardization of the planning processes, and (2) there is little or no integration between engineering and production planning processes.

**Keywords:** Maturity model, project planning, project management, Engineered-to-order (ETO)

## 1 Introduction

Planning is the process of thinking about and organizing the activities required to achieve a desired goal by creating and maintaining a plan. In managing and controlling projects, planning is an important factor that can contribute to both success and failure of meeting the projects objectives. As early as 1988, Pinto and Slevin [1] listed a number of factors that contribute to project success during the execution phase, such as *defined project goal, effective communication, commitment from senior management and project planning and monitoring*. In 2002, Cook-Davies [2] complemented this list

by adding *scheme for performance measurement and report* (e.g. Earned value) as a success factor to project success. Measuring how well the process of planning is performed can be a difficult task due to its complexity and interdependence with other processes.

The term project maturity is used as measurement of an organization's ability to execute projects. [3]. As shown by Project Management Institute (PMI) many maturity models exist (PMI, 2015). Many of these models are rather limited in scope and focus on the categorization of the actual behavior of the organization. Our research objective is to create a deeper understanding of the maturity of the project planning process by presenting a maturity model that can map the maturity of the project planning process within ETO networks. ETO networks are dynamic and hard to define, and their planning and control functionalities are frequently affected by the actions of suppliers and customers which typically may result in excessive inventories, long lead times low customer satisfaction and poor resource allocation [4]. Many projects experience delays, budget overruns, and quality defects [5]. Design changes are inevitable and make it difficult to coordinate projects with multiple subjects and actors [6, 7]. Excellent and successful ETO projects require rapid reaction capability for adaptation [8]. Consequently, there is a need for project management that synchronizes engineering and production planning in the value chain. Despite the significant challenges associated with this, little research has been done in this area [4], and more specifically little has been done related to integration of project management (activity-based) and production planning and control (material based) as a way of responding effectively to design changes.

ETO products are highly customized and contain a variety of components. Main products have complex structures where some components are highly customized (as a management system and advanced technological equipment), while others are standardized (as some steel components) [9]. This high complexity means that companies need to coordinate the engineering, procurement, manufacturing, assembly and installation in supply chains efficiently. Ordinary ERP systems are not well suited to handle the myriad of product specifications and parameters in an ETO supply chain and support to manage design changes are extremely limited [10]. There is a great need for planning methods that can assist the chaotic production in complex ETO environment [8].

This paper therefore aims at highlighting the challenges of an ETO project based production, and argues that an integrated and well-structured planning process can enhance project and ultimately overall business performance. This is done by applying known theories within lean construction and project management as well as performance measurement literature.

## **2 Theoretical discussion**

### **2.1 Project Management and Earned value management**

In managing and controlling projects, planning is an important factor that can contribute to both success and failure of meeting the projects objectives. As early as in 1988, Pinto and Slevin [1] listed a number of factors that contribute to project success

during the execution phase, such as *defined project goal, effective communication, commitment from senior management and project planning and monitoring*. In 2002 Cook-Davies [2] complemented this list by adding *scheme for performance measurement and report* (e.g. Earned value) as a success factor to project success. Measuring how well the process of planning is performed can be a difficult task due to its complexity and interdependence with other processes.

Earned value management (EVM) is a technique to measure project progress by comparing the baseline of the project with reported physical results, the resources consumed and the remaining hours to the completion per activity [11]. A good performance metrics used by EVM is the Cost Performance Index (CPI). CPI calculates and predicts costs at completion of the project within a finite range of values after only 15-20 per cent completion of the project [12].

## **2.2 Lean construction, Last Planner System and Lean Project Planning**

Lean construction applies production-based ideas from lean thinking to project delivery within construction industry [13]. In such projects, lean changes the way projects are managed during the building process. Lean Construction is based on lean production philosophies that thrive to maximize value and minimize waste expressed in specific project management techniques [14]. Ever since the 90s, lean construction community has recognized the need for a change in the way traditional project management plan and measure activities in a project. One of the best examples is the invention of Last Planner System (LPS) by Ballard [15] [16]. The role of LPS is to increase planning reliability by decreasing workflow variability, through recognizing and removing activity constraints, identifying root causes for non-completion of plans and monitoring its improvements by means of Percentage Plan Complete (PPC).

Kalsaas [17] and Emblemstvang (2014a) point out that LPS is not able to handle advanced engineering design work and needs a better instrument to measure physical progress for such activities. By introducing Lean Project Planning (LPP) Emblemstvang attempts to combine elements of LPS and EVM [18]. LPP is based on Lean thinking and applies the Plan Do Check Act (PDCA) cycle, a basic problem-solving approach, which in LPP context involves making problems visible, finding proper solutions, checking the result and acting on deviations [18].

## **2.3 Maturity models**

The planning process as well as organization as such, evolve over time and have to pass several stages of development or maturity. Ever since the late 70s, different types of models have been used to map and measure this path of development.

Nowadays, maturity models are widely used and a systematic mapping study undertaken by Wendler [19] showed that alone in 2009 and 2010, 62 academic articles on maturity models were published. The focus of these publications is still software engineering and as up-today there are few maturity models on planning.

A maturity model consists of a sequence of maturity levels for a class of objects. It represents an anticipated, desired or typical evolution path of these objects shaped as discrete stages. This definition by Becker et al. [20] serves as a starting point for the conceptual design of our maturity model on project planning where we combine elements of LPS and LPP to design a project planning process that will reduce the challenges observed within ETO manufacturing organizations in regards to planning.

### **3 Method**

This study is based on a case study and as there is little previous research in this field, this topic calls for qualitative research approach [21]

The choice of method is closely related to the type of research question [22]. The purpose of this study is to explore and describe the applicability of performance measurement tools (maturity model) in order to map the engineering and production planning processes in ETO networks. The elements of the maturity model are drawn from theories of project management, lean planning as well as performance measurement literature and selected in cooperation with planning and project management personnel from the case industry. Studies undertaken by Bitici et al. [23] showed that maturity models with certain characteristics, promote organizational learning as well as enabling efficient and effective assessment of the performance management practice of the organization.

The empirical basis for this study has been based on three case studies representing three ETO manufacturing companies in the maritime industry in Norway. These aforementioned companies deliver highly complex and special heavy lifting as well as pressure tank equipment for the offshore industry. The main business activities of the said case companies are designing, manufacturing and testing and commissioning and engages 500 hours of engineering, 500 hours dedicated to procurement, fabrication and production, as well as up to 2000 hours of assembly and testing. Lead times can vary from nine to 12 months. Each solution is highly customized and designed to meet individual customer requirements.

This Norwegian industry experiences increased global competition and cost pressure. Many Norwegian manufacturing companies are therefore moving some or all of their operations to low-cost countries. Changes in customer requirements are frequent throughout the entire project execution phase which requires detailed and real time planning with proper change order management systems in place. Effective planning and control is a key to success for companies in such project, low volume environment.

The main data collection was undertaken through semi-structured, focused interviews and observations as well as discussion and site visits over a one and a half year period in close cooperation with key personnel.

## 4 Results

The following part presents the findings of our study. Our case industry can be characterized by: (1) ETO manufacturing environment, (2) Project based production, (3) Expressed need for improved planning process (few resources dedicated to planning, little competence), (4) Plans are too difficult to update (plans are drawn at an early stage but not updated, and lose therefore validity and value), (5) planning is done at a high managerial level without including the person that are executing the activities. Further our case industry has (6) outsourced production which leads to phased based project management and, (7) many changes from customers lead to a need of flexible and dynamic planning.

**Table 1.** Maturity model for project planning (MMPP)

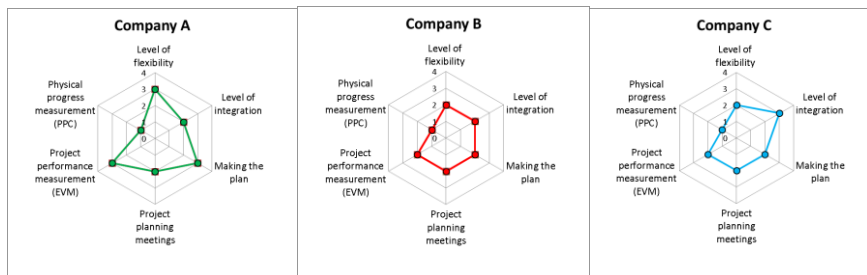
Parameters/ Process	First planner/ Ad hoc	Second Plan- ner/Standard- ized.	Third Planner/ De- fined	Last Planner/ Op- timized
<b>Level of flexi- bility</b>	The plan is created at the beginning of the project. No updates at later stages.	Random updates of high level activities only.	Pre-set updating dates at all level of activities.	Updates as often as required – all level of activities.
<b>Level of inte- gration</b>	No common plan for all project disciplines. Some disciplines have their own plan.	Some project disciplines are taking other proj. disciplines into consideration when making the plans.	Some project disciplines are taking other proj. disciplines into consideration when making the plans. No common plan exists.	One integrated plan for all project disciplines.
<b>Making the plan</b>	The plan is created at the high management level.	Each discipline makes own plans.	Some project disciplines are involved in creating a common plan. No commitment from participants.	All project disciplines participate and commit to one common project plan.
<b>Project plan- ning meetings</b>	Random plan meetings no formal agenda.	Regular plan meetings with no formal agenda nor obligatory participation.	Regular plan meetings with formal agenda, obligatory participation with no formal reporting.	Regular plan meetings with formal agenda, obligatory participation for all project disciplines with formal reporting.
<b>Project perfor- mance meas- urement (EVM)</b>	No or random reporting.	Reporting at project top management level.	Reporting from some project disciplines on a standardized report.	All project disciplines report on a standardized report. (Integrated EVM).
<b>Physical pro- gress measure- ment (PPC)</b>	No physical progress reporting.	Physical progress reporting at project management level.	Physical progress reporting from some project disciplines on a standardized report.	Physical progress reporting from all project disciplines on a standardized report. (Integrated PPC).

In order to structure and improve the process of planning a maturity model for project planning (MMPP) was designed (table 1). The elements of the maturity model are drawn from elements of LPS and LPP and selected in cooperation with planning and project management personnel from the case industry resulting in six parameters for

evaluation as presented in table 2. The planning process is enhanced by lean project planning and evolves over time, starting with poor planning at the first planner level moving to second and third and finally evolving to the final – *the last planner* – level of maturity. After designing the MMPP a first As-Is measurement was undertaken. The results are presented in figure 1 and briefly explained in following conclusion.

**Table 2.** Six parameters of the maturity model for project planning (MMPP)

<p><b>1. Level of flexibility</b> -This parameter defines how flexible the plan is, expressed in how often and at what level the activities within the project plan are updated.</p> <p><b>2. Level of integration</b> -This parameter defines how integrated the plans are - are all disciplines (e.g. design and engineering, steel work and piping) integrated in one common plan?</p> <p><b>3. Level of autonomous planning</b> - This parameter defines the way the plan is made – Is it a typical top-down approach or do all disciplines engage and commit to one common plan?</p> <p><b>4. Project plan meetings</b> - This process defines the existence and regularity of dedicated project plan meetings. Do all disciplines have to attend?</p> <p><b>5. Project performance measurement (EVM)</b> -The fifth parameter defines how project performance is measured? Ultimately we are looking for Earned Value management reports from all disciplines.</p> <p><b>6. Physical progress measurement (PPC)</b> - Finally the last parameter defines the level of usage of physical progress measurement (PPC).</p>
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**Fig. 1.** First AS-IS measurement of the planning process

## 5 Conclusion

In order to structure and improve the process of planning, a maturity model for project planning (MMPP) was designed. The elements of the maturity model are drawn from elements of LPS and LPP and selected in cooperation with planning and project management personnel from the case industry resulting in six parameters for evaluation. A first As-Is measurement of the planning process within three ETO companies operating in the Norwegian offshore supply industry was presented. We see especially low maturity in regards to the integration of all project disciplines and physical progress measurement. Meetings and information exchange processes (updating the plan) are not

standardized. This confirms our observations of an ETO industry characterized by informal planning and information exchange. Maturity in any organizational process evolves over time. In alignment with performance measurement literature we believe that by mapping and visualizing the steps to maturity organizations can succeed more easily with implementing a well-functioning and standardized planning process.

## 6 Future research

Wendler [19] points out that most of the contributions within MMs look at the design process of models or the applicability of existing models to other areas but that too few contributions within MMs focus on validation and implementation of models. The conceptual maturity model presented in this paper will be further developed and validated and maintained in collaboration with the Norwegian offshore supplier industry.

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