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Vertical Solution for ETO Companies Using Microsoft Dynamics AX

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MASTEROPPGAVE

Våren 2014
for stud. techn.
stud. techn. Marianne Hønsi
stud. techn. Guri Karoline Sørbø

Vertikal løsning for ETO bedrifter basert på ERP systemet Microsoft Dynamics AX
(Vertical solution for ETO companies using Microsoft Dynamics AX)

CGI er et selskap som leverer tjenester og teknologi for forretningsdrift, og har ca 70 000 ansatte på verdensbasis. Selskapet er ett av Norges ledende innen rådgivning, systemintegrering og outsourcing av IT-løsninger. Oppgaven vil løses i tett samarbeid med produksjonsvertikalen hos CGI Norge som ønsker å videreutvikle sine leveranser for å bedre kunne oppfylle kravene til IT støtte i norsk industri.

Prosjektet vil være knyttet CGI Norge og ett utvalg av deres kundeinstallasjoner innen ETO basert produksjon (som: Kongsberg Maritime, OneSubsea (Schlumberger), TTS, Linjebygg offshore, etc.).

En stor del av CGI's produksjonssatsning er rettet mot maritim- & offshorebasert industri som har en «Engineer to Order» strategi. CGI leverer ERP systemet Microsoft Dynamics AX med tilhørende verktøy til denne type kunder i Norge. Dynamics AX systemet kan settes opp ulike måter å støtte et ETO selskap, samtidig finnes det ulike andre IT-verktøy som kan brukes i samråd med ERP systemet for å kunne fylle kravene til IT-støtte i en ETO bedrift (som PLM, Prosjektplanlegging, Timefangstsystemer, DAK/DAP, etc). CGI ønsker en gjennomgang og standardisering av sine løsninger og løsningsportefølje som tilbys kunder i ETO segmentet.

Oppgaven består i å foreslå oppbygning og innhold av en bransjeløsning mot ETO bedrifter basert på ERP systemet Microsoft Dynamics AX og de løsninger som CGI og relevante partnere har innen dette.

Datagrunnlagets skal hentes fra innleverte prosjektoppgave, relevant litteratur, intervju av aktuelle resurs personer i CGI, dokumentasjon ERP systemet og andre relevante kilder.

Studenten skal besvare følgende spørsmål:

- Gi teoretisk redegjørelse av begrepet ETO. Bruk resultatene til å utvikle et konsept for å evaluere hvordan ETO kan differensieres.
- Gi teoretisk redegjørelse av ERP i ETO bedrifter og hvordan situasjonen er i dag.
- Foreslå hvilke forretningsprosesser en bransjeløsning for ETO bedrifter bør støtte.
- Foreslå hvilke systemkomponenter en bransjeløsning for ETO bedrifter basert på Microsoft Dynamics AX og CGI's løsninger bør inneholde..
- Beskrive hvordan en bransjeløsning for ETO bedrifter basert på Microsoft Dynamics AX og CGI's løsninger vil kunne støtte valgte forretningsprosesser på best mulig måte.
- Gi en forklaring på de viktigste forretningsmessige fordeler en bedrift vil kunne få ved å benytte valgte bransjeløsning for ETO bedrifter basert på Microsoft Dynamics AX og CGI's løsninger.
- I tillegg skal det lages en produktbeskrivelse på CGI's standarder som beskriver valgte bransjeløsning gjennom punktene over.

Oppgaveløsningen skal basere seg på eventuelle standarder og praktiske retningslinjer som foreligger og anbefales. Dette skal skje i nært samarbeid med veiledere og fagansvarlig. For øvrig skal det være et aktivt samspill med veiledere.

Innen tre uker etter at oppgaveteksten er utlevert, skal det leveres en forstudierapport som skal inneholde følgende:

- En analyse av oppgavens problemstillinger.
- En beskrivelse av de arbeidsoppgaver som skal gjennomføres for løsning av oppgaven. Denne beskrivelsen skal munne ut i en klar definisjon av arbeidsoppgavenes innhold og omfang.
- En tidsplan for fremdriften av prosjektet. Planen skal utformes som et Gantt-skjema med angivelse av de enkelte arbeidsoppgavenes terminer, samt med angivelse av milepæler i arbeidet.

Forstudierapporten er en del av oppgavebesvarelsen og skal innarbeides i denne. Det samme skal senere fremdrifts- og avviksrapporter. Ved bedømmelsen av arbeidet legges det vekt på at gjennomføringen er godt dokumentert.

Besvarelsen redigeres mest mulig som en forskningsrapport med et sammendrag både på norsk og engelsk, konklusjon, litteraturliste, innholdsfortegnelse etc. Ved utarbeidelsen av teksten skal kandidaten legge vekt på å gjøre teksten oversiktlig og velskrevet. Med henblikk på lesning av besvarelsen er det viktig at de nødvendige henvisninger for korresponderende steder i tekst, tabeller og figurer anføres på begge steder. Ved bedømmelsen legges det stor vekt på at resultatene er grundig bearbeidet, at de oppstilles tabellarisk og/eller grafisk på en oversiktlig måte og diskuteres utførlig.

Materiell som er utviklet i forbindelse med oppgaven, så som programvare eller fysisk utstyr er en del av besvarelsen. Dokumentasjon for korrekt bruk av dette skal så langt som mulig også vedlegges besvarelsen.

Kandidaten skal rette seg etter arbeidsreglementet ved bedriften samt etter eventuelle andre pålegg fra bedriftsledelsen. Det tillates ikke at kandidaten griper inn i betjeningen av produksjons-maskineriet, idet alle ordrer skal formidles på vanlig måte gjennom fabrikkens bedriftsledelse.

Eventuelle reiseutgifter, kopierings- og telefonutgifter må bære av studenten selv med mindre andre avtaler foreligger.

Hvis kandidaten under arbeidet med oppgaven støter på vanskeligheter, som ikke var forutsett ved oppgavens utforming og som eventuelt vil kunne kreve endringer i eller utelatelse av enkelte spørsmål fra oppgaven, skal dette straks tas opp med instituttet.

Oppgaveteksten skal vedlegges besvarelsen og plasseres umiddelbart etter tittelsiden.

Innleveringsfrist: 10. juni 2014.

Besvarelsen skal innleveres i 1 elektronisk eksemplar (pdf-format) og 2 eksemplar (innbundet), ref. rutinebeskrivelse i DAIM. Det vises til http://www.ntnu.no/ivt/master-siv-ing for ytterligere informasjon om DAIM, uttak, kontrakt, gjennomføring og innlevering.

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Avtalt med hovedveileder at denne kontrakten er godkjent. Orginal versjon ligger i Appendix

Abstract

ERP systems are useful for MTS and ATO manufacturing strategies. When evaluating the ERP systems in an ETO environment there is not much research available on the matter, but the general understanding is that ERP system lacks specific business processes that are special to companies in the sector. In addition, the few studies that are available on the subject conclude that there is need for more empirical studies.

By conducting a thorough literature study on the topics ERP, ETO, and project life-cycle processes, information was gathered and used for creating a survey and interview questions. All the questions were based on how companies handled the business processes that were considered critical in an ERP solution for ETO companies. The companies that participated in the case study were in the maritime and offshore ETO segment and they were currently using the ERP software Microsoft Dynamics AX. The results from the surveys are a contribution to the empirical study this specific area of research needs.

During the evaluation of the current solutions there were areas where AX was not sufficient at all, areas where AX needed extra functionality, and areas where AX was sufficient. Where AX was not performing up to standards, new software had been implemented and most often integrated with AX. Industry specific requirements had also been included as new, customizable functionality in AX. This extra functionality was very important because of the focus on a specific industry.

In conclusion, the findings from the case studies were used to generate requirements that represented real needs to be fulfilled by an eventual solution. The general solution was therefore based on a combination of “best-practice” solutions from all three cases. Benefits of the solution were also identified.

Sammendrag

ERP systemer er gunstig for bedrifter som driver produksjon med MTS og ATO strategi. Når en ser på ERP systemer i et ETO miljø finnes det ikke mye litteratur om emnet, men den generelle oppfatning av ERP systemer er at de mangler støtte for spesifikke forretningsprosesser som er spesielle for bedrifter innen ETO miljøet. I tillegg, de få artiklene som er skrevet konkluderer med at mer empirisk data må innhentes.

Ved å gjennomføre et omfattende litteraturstudie på emnene ERP, ETO og prosesser i prosjektets livssyklus, er det bygget opp nok informasjon og kunnskap til å utarbeide en spørreundersøkelse og intervjuspørsmål. Alle spørsmålene er basert på hvordan bedriftene håndterer forretningsprosessene som er ansett som kritisk å ha støtte for i en ERP løsning. Bedriftene som svarte på spørreundersøkelsen og deltok i intervjuet var ETO bedrifter offshore- og maritimindustrien som på tidspunktet opererte med ERP løsningen Microsoft Dynamics AX. Resultatene fra disse “casene” er ansett som bidrag til å øke mengden empirisk data innen ERP i ETO, hovedsakelig rettet mot valgt industri.

Gjennom å analysere dagens bruk av systemene ble det identifisert områder der AX ikke var tilstrekkelig, områder der ekstra funksjonalitet var lagt til i AX, og områder der AX fungerte som det skulle. Der AX ikke oppfylte bedriftenes krav til funksjonalitet hadde det blitt installert ekstra software, som også ofte var integrert med AX. Krav som var knyttet til maritim og offshore industri var inkludert som ny og skreddersydd funksjonalitet i AX. Denne ekstra funksjonaliteten var veldig viktig for disse bedriftene med tanke på fokuset i industrien.

Resultatene som ble utarbeidet gjennom case studiet har blitt brukt til å utarbeide krav til hvordan en generell vertikal løsning kan se ut. Den generelle løsningen er derfor basert på en kombinasjon av “best-practice” fra alle tre bedriftene. Fordeler ved systemet har også blitt identifisert.

Preface

This Master Thesis is written for the department of Production and Quality Engineering at the Norwegian University of Science and Technology spring 2014. This is the final step of a five year educational program to become an Engineer for the program Engineering and ICT - Production and Management. The thesis is written in collaboration with NTNU and the company CGI.

The decision to write as a group of two students came naturally. We conducted a good Project Paper in the fall 2013, and to continue the work was an easy choice. Regarding the topic of ERP, it is one of the most relevant topics to write about when focusing on production and IT/ICT. In addition, it is both exciting and fun to write about a topic that is very well known, and then connecting it with ETO. By doing research on the topic, we feel that we are actively contributing to new research that has yet to be unraveled.

During the thesis we collaborated with the company CGI, which has also been a very good experience. By working together we got an aspect of how theory is used in practice to produce a product for an actual customer. Also, by choosing this type of problem to do research we got the chance to understand the role of a consultant and developed habits we probably will use for many years to come.

Lastly, we would like to thank our professor Erlend Alfnes and supervisor Odd Jøran Sagegg for their help during these months of hard work. We would also like to extend a special thanks to our mentor Cecilia Haskins.

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Abbreviations

AdTO - Adapt-to-order

ATO - Assemble-to-order

AX - Microsoft Dynamics AX

BOM - Bill of Materials

CAD - Computer aided design

CAE - Computer aided engineering

CODP - Customer order decoupling point

CTO - Configure-to-order

D - Delivery lead-time

DTO - Design-to-order

EnTO - Engineer-to-order (engineering dimension)

ERP - Enterprise Resource Planning

ETO - Engineer-to-order

ETS - Engineer-to-stock

ICT - Information and communication technology

IT - Information technology

MRP - Material Requirement Planning

MTO - Make-to-order

MTS - Make-to-stock

P - Production lead-time

PLM - Product Lifecycle Management

PMBOK Guide - Project Management Body of Knowledge

PMI - Project Management Institute

SME - Small and Medium Enterprise

WBS - Work breakdown structure

1 Introduction

1.1 Background

Enterprise Resource Planning (ERP) systems are enterprise wide integrated information systems (Koh and Saad, 2006). By integrating business procedures, applications and departments while sharing one database users have access to real-time information throughout the company (Kanellou and Spathis, 2013). ERP has drastically changed the way a company gathers, stores, and uses information (Kanellou and Spathis, 2013). ERP has had such a significant impact that it was considered one of the most important IT developments made during the 1990s (Bento and Costa, 2013).

Historically, ERP evolved from Material Requirement Planning (MRP), which was one of the first systematic material planning systems (Hvolby and Steger-Jensen, 2010). The calculations done in MRP are based on the use of Bill Of Materials (BOM) that made it possible to pre-plan component manufacturing and assembly of products based on forecasts. Due to the evolution of MRP to ERP, the MRP functionality has remained important in ERP. As a consequence, certain types of manufacturing companies have realized a larger advantage from implementing ERP. Companies with strategies such as make-to-stock (MTS) and assemble-to-order (ATO) can plan ahead with MRP functionality due to the knowledge of finished BOM and routings.

The Engineer-to-order (ETO) strategy has certain qualities that will not allow it to benefit in the same way from traditional MRP and ERP software as an MTS strategy (Jin and Thomson, 2003). Throughout literature ETO has been defined many different ways. Overall it is described as delivery of a product where the product’s design comes either from modifying an existing product design, or by creating a totally new product from scratch. ETO products are almost always the result of a project (Yang, 2013). It is therefore not a surprise that project management is viewed as a core competency in ETO, along with design and engineering (Hicks, 2000). Because engineering changes are embedded in the product concept, ETO companies do not have the complete BOMs at project start. As a result, it is not possible to use the ERP system to conduct standard MRP to make the production schedule. For ETO products the final design might not be completed until late in the project, therefore in order to decrease the leadtime most ETO companies practice concurrent engineering. Questions can be asked about the ERP system‘s flexibility and if it can handle the business processes that are affected by the new design and engineering that are gradually known throughout the project. These types of questions are the fuel for this thesis, and the goal is to try to address them. Overall, the thesis will evaluate how an ERP solution can best accommodate ETO projects in the offshore and maritime industry and the other way around; how ETO projects can be managed through ERP systems.

In a Project Paper written fall 2013, by the authors (Hønsi and Sørbø, 2013), a similar research question was evaluated: *Are ERP systems useful for ETO companies? Which modules/functions in ERP systems and/or supporting systems will benefit an ETO company, with special consideration to the maritime and offshore industry?* After a comprehensive literature study, combined with a case study, the result was a list of 18 requirements/criteria for what an ERP solution should contain to best benefit an ETO offshore and maritime company. Lastly, another conclusion was made; viewing the MRP functionality as the core of the ERP system will not benefit ETO companies because of the uniqueness and uncertainty of each customer order. In contrast, support for managing projects through the system should be regarded as the core of the solution.

The results from the Project Paper (Hønsi and Sørbø, 2013) will be used as a starting point to address this thesis’ research questions at hand. By targeting the offshore and maritime industry the work will be able to find specific requirements that can be solved by ERP software. The Project Paper was a collaboration between the students and the company CGI, an ERP vendor delivering the ERP system Microsoft Dynamics AX (AX). The collaboration continued throughout this thesis as well.

As project management is put into the core of the ERP solution for ETO companies, the importance of projects in ETO companies will be discussed further in the thesis. It is therefore safe to say that the term “project” will be an important keyword after ERP and ETO. Projects can be challenging to manage and control. There are complex delivery aspects, continuous changes and updates made throughout the project, different departments collaborating, and variation in complexity and size. In addition, ETO projects often contain service and maintenance agreements on products. Therefore, being able to conduct and keep track of projects will be very important for ETO companies. Project management processes in ETO companies, should be met through ERP functionality, and help control the other business processes carried out through an ETO project in the offshore and maritime industry. This simple relationship is illustrated in Figure 1.

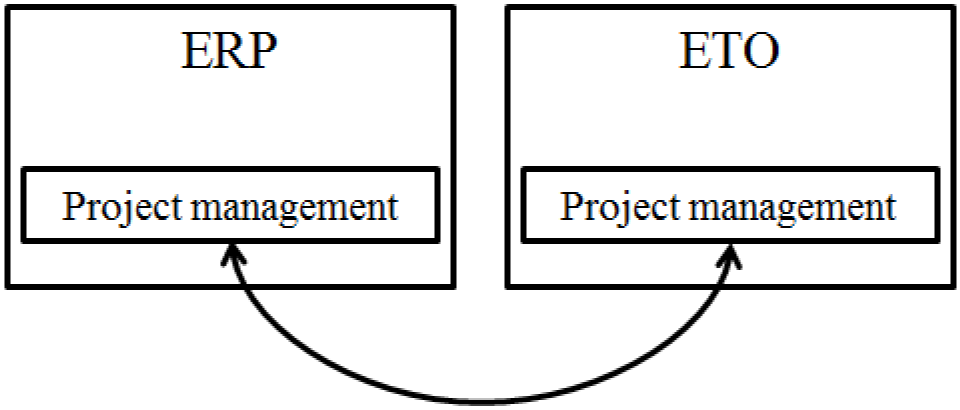


Figure 1- Representation of core functionality

To get a more detailed view of ERP the thesis will use specific software and its functionality. The software chosen is Microsoft Dynamics AX (AX), which is Microsoft's ERP solution, used by many companies worldwide. Moving into new markets and being able to keep current clients, along with winning new ones, will be important for any software provider. This is the motivation for CGI to win new customers in the maritime and offshore industry operating with an ETO strategy. From this follows the necessity to evaluate and illustrate the beneficial effects of AX in an ETO company and how AX can solve the ETO requirements.

1.2 Research Questions

The research questions are based on a continuation of the Project Paper and are formulated as follows:

- Q1:
  - How can Microsoft Dynamics AX solve the requirements of ETO project oriented production in the offshore/maritime industry?
- Q2:
  - How have these offshore/maritime companies solved the special requirements for ERP solutions today? (Case study)
- Q3:
  - What benefits can a company expect from implementing such a solution using Microsoft Dynamics AX?

1.3 Collaborating Company

The collaborating company CGI is a global company involved in business consulting, systems integration and IT outsourcing services. There are over 68 000 employees scattered around 40 countries in America, Europe, and Asia (CGI, 2013b), whereas in Norway there are 600 coworkers focusing on back-to-back IT business services.

Among the IT services CGI delivers, ERP systems is one of their products. On their website they list the need for such systems because of the financial situation today, where resource management is a deciding factor for being competitive (CGI, 2013a). CGI implements, integrates, and administers the ERP system they have focused on, namely Microsoft Dynamics AX and Dynamics NAV (CGI, 2013a).

The collaboration with CGI will produce benefits for both sides. The authors expect to gain knowledge on CGI's AX software solutions and experience. CGI will also provide case companies for the case study. This information will be critical in finding a solution to our research questions. As for CGI, the results of the thesis will be a product that they can use in their own work for creating a system portfolio for the industry.

1.4 Objectives and Expectations

The thesis will focus on ERP and ETO in the maritime and offshore industry, but there will also be a special focus on the aspect of projects. Due to the strategy ETO represents, many of the products are made by conducting projects in order to manage the evolution from quote to finished, deliverable product. The result of the Project Paper concluded that the most important module in an ERP solution would therefore be the project management module, which will also be one of the main focuses for this thesis. ERP software will have to shift its focus from centering on MRP, to being able to support projects and all the variables it comprises.

The requirements from the Project Paper will play an important part in the quest to find a satisfactory solution. The requirements are divided into categories, where some are very important in the case studies and interviews that were conducted for this thesis. The results of the case studies and the literature review will hopefully end up satisfying the objectives and expectations below:

- Propose a generic vertical Microsoft Dynamics AX solution based on the specifications and requirements of offshore and maritime ETO companies.
- The solution will help take a step in the right direction towards an industry standard of ERP in ETO.
- Conduct case studies on existing ETO ERP solutions in the industry to supplement the little information that exists on the subject in academic literature.

1.5 Organization of this Thesis

In the next chapter the methodology and research design is presented. The research relied on Yin's (2009) method for conducting case studies, and this is described step-by-step.

Chapter *3 Literature Review* contains the state-of-the-art and other background information gathered during the literature review. The current situation of ERP in ETO is presented, followed by a detailed description and evaluation of ETO as a manufacturing strategy. Further the ETO project life-cycle is described in detail with the important ETO business processes being identified. Clarification, characteristics, and project elements are among the ETO topics presented. The business processes that are identified as important and described in detail will be the basis for a vertical solution that should be designed in order to manage these business processes. In the last part of chapter 3, existing AX functionality that exists for the ETO business processes are identified and briefly described.

The case study companies and empirical results are presented in Chapter *4 Case Study*4 Case Studies. The empirical results review the solution used by each company with a focus on products, project dimension, and software solution and project execution.

After the case studies, the discussion analyzes the empirical results of the case company solutions with consideration to each other and the theory presented earlier in the thesis. Based on all findings throughout the work of the thesis the vertical solution is proposed and presented in a white paper based on CGI's standards, which can be found in Appendix E. White Paper

2 Methodology

The proper steps in a research methodology is to gather data, evaluate the data, and then base a discussion and conclusion on the facts gathered (Romsdal, 2013). This thesis has been conducted using a qualitative approach. As a result, the gathering of data was done by performing a literature study and conducting case studies of a set of companies. Then the data at hand was evaluated and analyzed in the discussion and conclusion.

The choice of using a qualitative approach can be defended by a series of observations. First, the research questions at hand are based on wanting to understand more on a subject that has to be learned through interpretation of text (Romsdal, 2013). The subject here is the usage of Microsoft Dynamics AX in ETO companies and the challenges and needs for these companies in terms of the system. Furthermore, there is a wish to describe how business processes can be met through the system and eventually benefit a company. There does not exist an ultimate, undisputed solution that we are supposed to find, but rather analyze and discuss how one solution is preferred over another based on the circumstances. The results are oriented towards a discovery of “if” and “how” things can be done, or at least a step in the right direction of a general solution (Romsdal, 2013). This is done by looking at previous literature research and conducting new research by analyzing present solutions using case study.

The data used during the study of the research questions can sometimes be considered subjective, which is another feature of qualitative research (Romsdal, 2013). This is especially true for company documents that have been used in marketing context. If they are to be used in a research context, they have to be handled as such. The final results are therefore based on interpretation of text and extraction of meaning from the data gathered (Romsdal, 2013).

2.1 Literature Review

By using literature review the purpose is to communicate the knowledge and ideas that have been established on the chosen topic, and discuss their strengths and weaknesses (Taylor, 2009). This information is then used to generate case study questions, and then discuss the research questions at hand together with the results from the case study.

Throughout the Project Paper the theory behind ETO and ERP was described in great detail. During this thesis, some of the topics will be covered once more, but not in the same detail. In other words, the thesis assumes that the reader has some knowledge in manufacturing strategies and ERP software. However, additional topics not covered in the Project Paper regarding ETO and ERP will be covered in detail. The literature review will be conducted by using predefined criteria to find online scientific literature. Databases that will be used are Sciencedirect, IEEE Xplore Journals, Emerald, ACM, and Google Scholar.

The thesis is a continuation of the Project Paper, and many of the literature sources used in the Project Paper are therefore still very current for this thesis' literature review. Although the articles have been through a critical source review, all the sources will be checked with consideration to new criteria. It is important that all literature used satisfies the new criteria set by this thesis. The new criteria are listed in the bullets below. In Table 1 there is a classification of connections between articles used in the literature review and keywords chosen.

Criteria on the literature:

- No additional filters applied to the articles.
- Priority is given to literature from peer-reviewed journals.
- Has to be found using predefined key-words.
- Keywords can be combined during searches for literature.
- Snowball effect is allowed if article contains keyword.

Table 1 - Classification of articles and keyword

KEYWORD	ARTICLE
Enterprise Resource Planning / ERP	• Bento and Costa, 2013 • CGI • Hvolby and Steger-Jensen, 2010 • Kanellou and Spathis, 2013 • Koh and Saad, 2006 • Galy and Sauceda, 2014 • Holsapple and Sena, 2005 • Botta-Genoulaz and Millet, 2005 • Davenport et al., 2004 • Shaul and Tauber, 2013 • Aslan et al., 2012 • Davenport, 1998 • Zach and Olsen, 2011 • Olsen and Sætre, 2007 • IFS a; IFS b; IFS, 2001; IFS 2012 • Somers and Nelson, 2001
Engineer-to-order / ETO	• Wikner and Rudberg, 2005 • Gosling and Naim, 2009 • Hicks et al., 2000 • Porter et al., 1999 • Amaro et al., 1999 • Yang, 2013 • Pandit and Zhu, 2007 • Jin and Thomson, 2003 • Bertrand and Muntslag, 1993 • APICS,2013 • Cameron and Braiden, 2004 • Konijnendijk, 1994
Material Requirement Planning / MRP	• Hvolby and Steger-Jensen, 2010 • Jin and Thomson, 2003
AX	• Technet Library (Microsoft) • Luszczak, 2013 • Columbus, 2013 • Forbes, 2013 • Ehrenberg, 2011
Project Management	• Yang, 2013. • Hvam et al., 2006 • Pinto, 2010. • Project Management Institute, 2000. • Project Management Institute, 2013. • Cameron and Braiden, 2004 • Elfving et al., 2005 • Lester, 2014 • Kliem,2002
Engineering and Design (including	• Handfield, 1994. • Pandit and Zhu, 2007

concurrent)	• Salter and Gann, 2003. • Shishank and Dekkers, 2011 • Ming et al., 2008
Research Methodology	• Romsdal, 2013. • Yin, 2009. • Soy, 1997. • Taylor, 2009 • Halldorsson and Aastrup, 2003
Manufacturing	• Porter et al., 1999
Manufacturing Strategy	• Olhager, 2003 • Semini et al., 2014 • Mello et al. 2012
Configure-to-order	• Chen-Ritzo et al., 2011 • Sabin and Weigel, 1998

Regarding the literature review, some key points were made during the Project Paper that are still relevant for this thesis's methodology (Hønsi and Sørbø, 2013). First, there does not exist much literature specializing in offshore and maritime industry, and especially not on ERP in the industry. Therefore, the information about the topic will be based on the case study described below, and previous case study material from the Project Paper. In addition, the publishing dates of the articles used are of relevance, especially for ERP literature. Because ERP is a constantly developing area of research, the newer the articles are the more up-to-date and relevant the information will be.

As well as publishing dates, the publishing place is important. Some of the information used during the literature review will be white papers and company documents made for sales and marketing purposes. This information will be very subjective, and needs to be handled as such. Although, handled in a critical view there still may be thoughts, information and results that can be useful for the thesis.

2.2 Case Study

A case study is a distinctive form of empirical inquiry (Yin, 2009) that provides an in depth understanding of an organization, phenomenon, or occurrence in the real world (Romsdal, 2013). According to Yin (2009), research questions that are based on "how" and "why" are more suitable to conduct case studies to get its data. In this case, it is established that the question at hand is "how" does an AX ERP solution fit into an ETO company? The thesis also looks at "how" companies have solved this type of problem before. Consequently, the case study can help researchers gain an understanding of a certain phenomenon that is not well enough developed in the research community and in literature.

To conduct the case study in a systematic approach, the thesis has adopted Yin's (2009) method on how to plan and execute case studies. The steps are illustrated in Figure 2 below. As Yin (2009) explained, it is a linear but iterative approach.

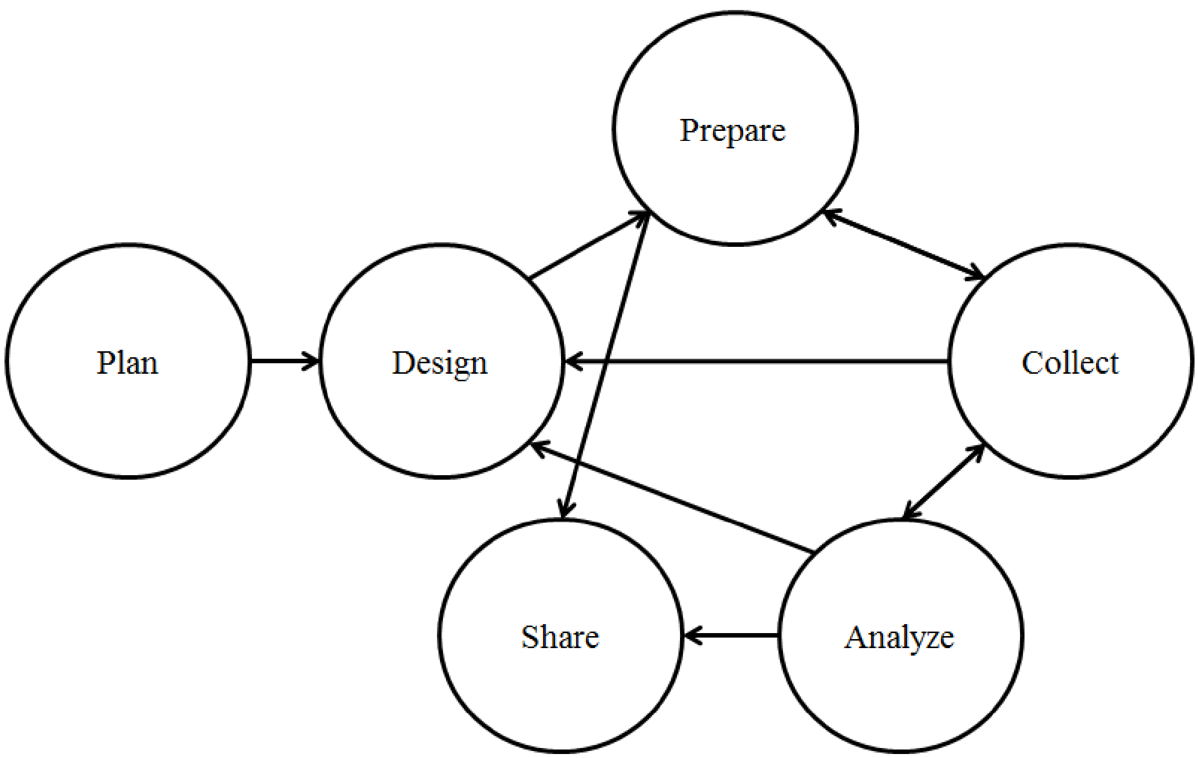


Figure 2 – Yin's (2009) method for execution of case study

2.2.1 Plan

The first step is to plan the case study. It is prominent to define research questions, identify why to use a case study, and understand the strengths and weaknesses of the method. The research questions have been defined, as well as why to use a case study. To refresh, the reason for choosing case studies is to understand a complex phenomenon, which also is one of the strengths for this method. Because there is not enough written information in the academic arena, case studies provide an excellent opportunity to gather information from people who physically work with the phenomenon. Another strength of using a case study is that the method can use multiple sources and techniques in the data gathering process, both qualitative and quantitative. The researcher determines in advance what evidence to gather and what analysis techniques to use with the data to answer the research question (Soy, 1997).

On the other hand, weaknesses of the method must also be taken into consideration. Unfortunately, there is some prejudice towards case study as a research method. Some case studies have been considered subjective because of biased influences steering the results, while others have not conducted inquiries in a consequent, systematic manner which has made studies sloppy (Yin, 2009). Another challenge is the aspect of generalization when the researcher has only done one case study. Although, according to Yin (2009), this can be justified by being aware that case studies are generalizable to theoretical propositions and not populations or universe.

Regarding the interviews, there are also some weaknesses. The interviewee talks about personal experience in their own conception of the topic, while the interviewer must remember/note down their interpretation of the answers. This might lead to misconception of what the interviewee was trying to formulate. Also, because the interviewer must write down information during a conversation, some information might not be noted down due to lack of time and trying to listen while simultaneously writing. On the other hand, there are great advantages by conducting interviews. Employees with expertise will give the interviewer unique information that does not exist anywhere else.

2.2.2 Design

The second step is to design the case study. It is important to define the unit of analysis and what cases are likely to be studied. The design must also be evaluated with consideration to case study quality. First of all, the type of case study chosen is a multiple case study conducted with semi-structured interviews and a survey. By organizing multiple interviews with separate companies the goal is to answer Q2, which researches ERP systems currently functioning in ETO companies. The survey will be used to gather information that can easily be compared to each other, and is based on the criteria generated from the Project Paper, as well as a comprehensive literature study. By interviewing independent companies the results can be compared in the discussion part of the thesis. This will in turn help answer Q1 on what solution can be considered "best" in an unbiased way that is less subjected to prejudice. The unit of analysis is therefore the maritime and offshore industry's use of ERP software for ETO production. The thesis focuses on entire companies within the industry and how the system is implemented to make daily work more efficient.

The reason for choosing multiple case studies is to get more usable data for evaluating the research questions. Another reason is because the phenomenon of ERP in ETO in the chosen industry may not be a unique event, and therefore a single case study may not capture enough of the event. Because there is no definitive, right way to answer Q1, the more the researchers can observe of the phenomenon, the better the findings can be documented and defended. Regarding the number of cases to evaluate is highly dependent on time and contacts. Multiple case studies take more time to both establish connection with companies, and to conduct the interviews. Fortunately, CGI has connections that can be used. For this thesis three cases have been identified.

2.2.2.1 Procedure

The case study is divided into two sections. First the survey is conducted, followed by the semi-structured interviews. In total, the time to conduct both parts has been set to an hour and was conducted by phone. The reason for having the interview by phone is to respond quickly when the interviewee has time. This increases the chance of getting an interview, as the ETO employees' schedules are very busy. If there were problems in contacting ETO company employees, the CGI consultants working on the solution was interviewed instead. Both the survey and the semi-structured interview were sent to the interviewee before the interview so that he/she could prepare and look at the questions during the interview. Lastly, when conducting the interview the answers were noted down on a computer to keep for later reference. There was never considered any use of recording device, this was to make the interviewed person more comfortable.

The survey questions are based on the requirements from the Project Paper, as well as this thesis' literature study. The questions have been formulated as "yes" and "no" questions to make the results easier to compare with each other, and to be able to make some kind of statistical result. The results of the survey will also give a pinpoint on how well the solution currently is, based on the fact that a solution satisfying all requirements is considered to be a complete solution for ETO.

The questions used during the semi-structured interview are also based on the requirements from the Project Paper, as well as "discoveries" made during the literature study. Because the total interview is only one hour, the thesis chose to focus mostly on the topics project management, change management, and engineering and design phases. The questions for the semi-structured interview were designed to be more open questions than the survey. The goal of the interview is to get deeper knowledge on how the solution works, and how it fits into the ETO strategy. This information will be very useful when creating a generic vertical solution, and mapping how companies have solved bringing ERP into ETO today.

When choosing to compare results from these three cases there has to be set some criteria to the interviewee and the companies being interviewed, which are shown below in the bullet points and Table 2. There must also be made some assumptions about the use of the ERP solution in the companies.

Criteria for companies:

- Selected from the companies that characterize themselves as offshore and maritime industry
- Must conduct production or provide service
- Projects conducted by the company must fall under the ETO category.
- The company must use an AX ERP solution.

Table 2- Criteria for interviewees

	Criteria for interviewee from CGI:	**Criteria for interviewee from case company:**
Degree of knowledge of the ERP system	Know how the entire system works	Must know how some part ETO project functionality works
Degree of work with implementation	Must have worked on or with the implementation team	Preferably yes, but no experience is also accepted
Position in company	ERP consultant	Work on ETO projects, or ETO project manager
Use of system	Administration, implementation, maintenance	Must use the ERP system for ETO work.

Assumptions:

- The ERP system is functioning and in use
- Users of the system know how to use the software

The reason for creating the assumptions is to eliminate the human aspects of the ERP system, and only focus on the software and how its processes work. In real life, the human aspects cannot be neglected. This is due to the system being dependent on the people who use it, and how they use its functionality. Normally there are a lot of resources dedicated to IT-support and teaching users correct practice through change management. Users are often used to previous systems and how company processes work, and it may therefore be challenging to effectively convert over to new systems. It can be challenging both in the sense of learning the system and using it in an effective and correct way.

In addition to the assumptions leading to neglecting of the human factor of the ERP system, this thesis does not look into the aspect of implementation of the system. This process can be very complex (Hønsi and Sørbø, 2013), and does affects the ERP software considerably. On the other hand, once the finished ERP software is taken into use the general implementation process is over. The challenges and processes of the implementation were covered in the Project Paper, while this thesis chooses to focus more on the functionality of the solutions that exist and are taken into use.

When looking at the criteria for the companies that qualify for a case study, the companies must first of all classify themselves to be in the offshore and maritime industry. Second, the companies must either conduct some kind of ETO production or provide service/maintenance on ETO products. The reason for wanting to look at both production and service is to capture all aspects of the industry. In the Project Paper there was identified a requirement that was special for ETO maritime and offshore industry, namely that contracts often contained an agreement on performing service and maintenance on the finished product after delivery. In other words, the service aspect will be important when creating a generic vertical ERP solution for the industry. Lastly, the ETO production must be conducted as a project.

The reason why the thesis has chosen to focus on the ERP software AX is its role in the collaborating company CGI. They are ERP vendors, and offer the software to their customers. By choosing AX, the thesis has access to CGI’s client base that is critical for answering the research questions. As a result, the literature study based on ETO and maritime and offshore industry is a general study, but when committing to AX the thesis chooses to only look at this particular software and the surrounding software that has the possibility to integrate with AX. Therefore, this thesis focuses only on generating a solution for AX, and neglects other ERP software vendors that may solve the requirements in other manners.

The interviewed personnel, preferably ETO employees, also have some criteria that need to be assessed. First of all the employees have to have experience with AX and the total software solution in use. Because users of company software sometimes are bound by a part of a system, the thesis prefers an employee that has either implementation or ETO project experience. Employees that work close with vendors during the implementation process know what business processes that are important, and usually have experience from multiple parts of the system. Employees that work on ETO projects know how different project life-cycles are executed in the system, which will benefit our thesis as well. By talking to the industry company users the thesis gets more information on what people with maritime and offshore background want from the software, as well as learn more on experiences from users that might not have the same technical background. Regarding CGI personnel, implementation experience is critical. Their experience from the software can be helpful in getting a deeper understanding of functionality and capabilities of the software solutions.

2.2.2.2 Quality of research

The quality of research is based on defending the work done and data gathered, and show the credibility of it all. Because the chosen method is qualitative, and is sometimes not understood well by "classical" researchers (Romsdal, 2013), it is important to use known methods to uphold the scientific findings of the thesis.

There are multiple methods that are used throughout literature. Two central concepts in any discussion of the credibility of scientific research are "validity" and "reliability" (Silverman, 2006). Reliability usually refers to the degree to which the findings of a study are independent of accidental circumstances of their production, and if researchers could conduct the study again with the same results (Silverman, 2006). To satisfy reliability in qualitative research Silverman (2006) wants to make research process transparent through describing research strategy and data analysis, as well as being "theoretical transparent" by constantly presenting what interpretations are made. By using Yin's (2009) method for conducting and explaining case study, as well as evaluating the process of the literature study, the research process has become "transparent" in this methodology chapter. Also, throughout the thesis there will be put weight on theoretical transparency, where interpretations are emphasized.

Validity is the extent to which an account accurately represents the phenomena to which it refers (Silverman, 2006). There are two types of error that can occur and they are; type 1 - believe a statement when it is not true, and type 2- reject a statement when it is true (Silverman, 2006). A method used to check validity is triangulation (Silverman, 2006). This method is used by comparing different kinds of data and methods to see whether they corroborate each other (Silverman, 2006; Yin, 2009). Yin (2009) expresses that the use of triangulation, and use of multiple sources, is very important in case study research. In the case study there will be use of three different sources. These are the survey, the semi-structured interview, and written documentation.

2.2.3 Prepare

This stage consists of preparing for the case studies, which includes training for the case study, making protocols for the execution, and if possible conducting a test case. This thesis did the preparation stage by first getting an evaluation on the survey/interview questions by multiple supervisors. By letting them look over the questions, valuable feedback was used to focus the questions towards getting the information wanted from the process.

The preparation stage was also a time where reflection towards behavior during the interviews had to be evaluated. Because the interviewees are people with personal experience some of the answers will be biased, which the interviewers need to be aware of. This is especially true for personnel who have been in the process of developing and implementing the ERP solutions that are in use. Due to knowledge in the field, the interviewers can also be biased because of predetermined conclusions on what answers to questions may be, before the question is even asked. In other words, as Yin (2009) has explained, a good interviewer must ask good questions, interpret the answer, be a good listener, and be flexible and adaptive during the interviews.

2.2.4 Collect and Analyze

This stage captures the important parts of collecting and analyzing the data gathered from the case studies. This should be done as previously defined in the design and preparation stages. The information gathered from the interviews were written down as notes by both researchers and kept for later reference. The analysis of information will be done in chapter *4.2 Empirical Results* and *5. Discussion.*

First, the empirical results from the semi-structured interviews will be sorted into predetermined subchapters for each company. The sub-chapters are organized with consideration to the products offered, project dimensions, and project execution and software solution. The subchapter “Project Execution and Software Solution” will be divided into headings that follow the business processes in ETO companies, as explained in chapter *3.3.7 Business processes in ETO companies in offshore and maritime industry* in the literature review.

Then, the results from the survey will be presented in a table. The survey is based on answering yes/no according to existing functionality in the “Total Software Solution”. The total software solution incorporates AX and all other software that operate some functionality critical to project execution. This includes software that is not integrated with AX. To separate the integrated and not integrated software an additional column is added next to “Total Software Solution”. This column asks “Integrated with AX?”. The column uses both “yes” and “no” answers, but will also give some explanations when needed. If a box has no answer in the “Integrated with AX?” column, it is either because the functionality lies in AX or the survey question does not consider the AX integration aspects.

The results from the interviews and survey, as well as the theory from the literature review, will then be discussed in comparison to each other in chapter *5 Discussion.* There will be focus on advantages and disadvantages of the solutions with regard to conducting a project. The discussion will then propose an industry specific AX solution.

2.3 Final Remarks; Quality of Research

By conducting the literature review, then the case studies, there is enough information gathered using qualitative methods to write the master thesis. When discussing the quality of the case study, reliability and validity was mentioned as the traditional way of defending the credibility. However, as a result of choosing qualitative method one of the characteristics is that each case study will be hard to duplicate (Romsdal, 2013), which goes against the reliability of the findings. Because of this, and other characteristics of the qualitative method, validity and reliability may not be enough to satisfy the credibility of the total research (Romsdal, 2013).

Halldorsson and Aastrup (2003) recognized that change of focus from quantitative to qualitative methods should also be reflected in change of criteria for evaluating the quality of the research. They presented alternatives relating to research quality and its trustworthiness, namely credibility, transferability, dependability, and conformability.

Credibility is ensuring correct interpretation of informants' understanding of reality (Romsdal, 2013). This is important because Halldorsson and Aastrup (2003) claim that the reality is constructed by and exists only in the minds of the respondents and their particular context. Credibility can be satisfied by the use of triangulation of information, as explained in chapter *2.2.2.2 Quality of Research*. Other methods can be to discuss with other researchers, conduct negative case analysis, or checking of raw data (Romsdal, 2013).

Transferability is the extent to which the study is able to make general claims about the world (Halldorsson and Aastrup, 2003). In other words, are the findings of one study relevant in other contexts (Romsdal, 2013)? This way of thinking copes with time and space being vulnerabilities, where they could change both context and the people in the research. In other words, just because knowledge is acquired in a context it does not mean that it can't be relevant for other context or timeframes (Halldorsson and Aastrup, 2003). As a result, it is important that researchers provide detailed accounts for data collection and analysis (Romsdal, 2013).

Dependability is the degree to which research depends on the researcher's interests, theoretical perspective and previous research experience (Romsdal, 2013). Dependability is achieved by documenting logic of process, which the methodology chapter is all about. Conformability demonstrates how findings can be confirmed through data itself, and not the researcher's biases (Halldorsson and Aastrup, 2003). This can be achieved by ensuring logical links between data and conclusions (Romsdal, 2013).

By always focusing on these quality methods, there is a wish to keep the quality and credibility of the research at an acceptable level.

3 Literature Review

3.1 Current Situation ERP in ETO

ERP systems are widely used throughout the manufacturing industry, and its functionality connects and manages information flows within organizations, and gives employees up-to-date and real-time information of the current state of the business (Aslan et al., 2012). Documentation on ERP software is extensive on topics such as implementation and critical success factors aimed at adoption in mass production companies. Unfortunately, there is far less information available when looking into the ETO aspect. Nevertheless, some literature exists that discusses the topic. This information will be the basis when evaluating the current situation.

3.1.1 Benefits of ERP in general

Due to the lack of research conducted on ERP in ETO some general information on ERP has been evaluated with concern to benefits that companies expect from ERP systems. The definition and evolution are explained in the introduction, but what benefits and motivations exist for adapting to such large systems? Why should companies use ERP?

3.1.1.1 Replace legacy systems with lacking functionality

Literature thoroughly debates different motivation and benefits wanted from installing ERP systems. One of the main motivations from earlier studies was to get rid of legacy systems that did not provide enough functionality (Botta-Genoulaz and Millet, 2005; Holsapple and Sena, 2005; Kanellou and Spathis, 2013). The systems are known to be challenging to update and may not interface with other critical software, which is becoming increasingly important as competition and globalization increases (IFS, 2012).

3.1.1.2 Real time and easy access to information

In addition, better flow of information, and making it real-time, will improve information management aspects (Bento and Costa, 2013). Having information in one database will also get improve the aspect of redundant information (Botta-Genoulaz and Millet, 2005; Kanellou and Spathis, 2013) and interfacing the information will improve management of performance indicators (Botta-Genoulaz and Millet, 2005; Holsapple and Sena, 2005). ERP vendors claim that by implementing the software and its business processes, the company will evolve to benchmark standards and best practice processes of conducting business transactions (Davenport et al., 2004). Lastly, another important benefit that increases business performance is the possibility of ERP software increasing the decision making process (Holsapple and Sena, 2005).

3.1.1.3 Increase efficiency and productivity

Many of these benefits are intertwined, and are dependent on each other, but mainly implementation is often based on wanting the company to become more effective and productive. As Galy and Sauceda (2014) have put it, ERP systems transform organizational processes by streamlining planning with up-to-date data that are integrated across departmental lines that include production information and customer input. They also propose a division of benefits into three categories; operational, tactical/managerial, and strategic. The operational aspect is tied to performance that leads to improved supply chain efficiency, faster reporting, more visible data, and higher capacity for quality analytics. Managerial benefits are linked to improved decision making, up-to-date reporting mechanisms, and better resource and performance management. Finally, strategic benefits are expectation towards support of business growth through information sharing with stakeholders, differentiation and promotion of sales through e-commerce and CRM functionality, and reduction of costs.

3.1.2 Identified benefits in literature

To summarize literature, the next list shows the most prominent benefits wanted from implementation of ERP systems found in the literature on ERP software (Botta-Genoulaz and Millet, 2005; Holsapple and Sena, 2005; Hvolby and Steger-Jensen, 2010; Aslan et al., 2012; Bento and Costa, 2013; Kanellou and Spathis, 2013; Shaul and Tauber, 2013):

- Reduce size and cost of an organization’s IT costs
- Decentralize information processing by making it real-time
- Implement functionality to simplify processes in accounting, finance, and other administrative functions
- Achieve balance between decentralization and control among functions to avoid redundancy, ensure synergy, and manage performance indicators
- Electronically exchange information to reduce costs

- Employ new technology to keep pace with/surpass competitors
- Reengineer and/or standardize company processes
- Integrate operations and data
- Optimize SC and inventory
- Increase business flexibility
- Increase productivity
- Support globalization strategy
- Enhance a decision maker's ability to process knowledge and handle large scale problems
- Shorten the time associated with making a decision
- Improve the reliability of decision processes or outcomes
- Create a strategic or competitive advantage over competing organizations
- Increased ease of upgrading system

The list of benefits and motivations are what companies plan to achieve when implementing the software. On the other hand, it is difficult to measure the effect ERP software does have on the company after implementation, and thereby also makes it hard to know which benefits actually are present after the implementation. There is a known need for additional study on the matter of how to measure the effect. Due to no standardized method, there have been studies regarding measurement of effect in fields ranging from technological, operational, strategic, and accounting (Galy and Sauceda, 2014).

Lastly, another issue to consider, these benefits have mostly looked at ERP software in general. As a consequence, this thesis has not come across any literature that specifically looks into benefits for ETO companies. In general most research within ERP have been done with concern to companies doing mass production. Therefore, there is no definite list of benefits that are known to apply to ETO in the same manner as other types of manufacturing companies.

3.1.3 Identified problems in literature concerning ERP in ETO

The ETO segment of manufacturing industry has specific characteristics that affect ERP implementation and use. As a result there have been different opinions on how well the system can fit the ETO production.

3.1.3.1 Missing functionality within key areas

Aslan et al. (2012) discus how software, with focus on ERP and software integrations, can satisfy the business processes in MTO companies. The article includes ETO in its definition of MTO. By first identifying the most important business processes in ETO, and then evaluating the corresponding ERP software, the authors evaluate the applicability. Their conclusion shows that ERP systems do provide beneficial functionality, but there are some misalignments between key areas, such as decision support in the customer enquiry and the engineering and design phases. However, because of lack of research the authors identify seven areas where more research should be conducted to evolve and increase the knowledge of ERP in ETO.

3.1.3.2 Customization of the ERP-solution

A conference proceeding written by Zach and Olsen (2011) assessed ERP in MTO small and medium enterprises (SMEs). They mainly focus on the implementation phase, and it is this phase that defines what functionality the final solution will consist of. Although this thesis does not focus on implementation, there is still relevant information that can used. In addition, because of few academic articles on ETO in ERP, valuable information can be gathered from literature regarding MTO because the strategies have similarities different from mass production strategies.

Zach and Olsen (2011) agree with Aslan et al. (2012) on the matter of existing literature on the topic. There is a general opinion that ERP systems have limited applicability for MTO and ETO, but the observation is not supported by empirical data. However, they highlight the fact that by looking at specific industries there is a better chance of grouping similar requirements that may be beneficial when conducting new ERP research.

Zach and Olsen (2011) based their research on a case study of an MTO firm that wanted to implement an ERP system. Their drivers were to replace old legacy systems and to become more attractive to their customers. Inhouse representatives had the responsibility of identifying the business processes in the company. These processes were then used to create the ERP system, with use of heavy customization to best fit the company into the software. The company actually decided to neglect the MRP functionality when implementing the ERP system. Without the customization to become more flexible, the system would not have been suitable for the company at hand. Their processes based on the MTO strategy were in need of a flexible system, and unfortunately there did not exist any vendor that could satisfy with off-the-shelf software. The customization was therefore imperative.

On the topic of customization there have been many debates, because it also applies to the mass production companies. Davenport (1998) was of the opinion that the software should not be customized. He argued that the whole idea of implementing an ERP system was to benefit from the best practice processes the ERP software consisted of. Customization also has the tendency of becoming very expensive (Davenport, 1998; Somers and Nelson, 2001), which is not good for smaller enterprises with lower IT budgets. On the matter of ETO companies and ERP systems, there is not enough information to know whether what is best for the company, although from this case it seemed important in order to fit the business into a software.

3.1.3.3 The BOM and MRP functionality

Olsen and Sætre (2007) wrote an article on ERP solutions in niche companies. These niche companies are defined as flexible organizations that customize to satisfy customer need in small market niches. The article looks into four case companies and their use of ERP software. The first case consisted of making one type of product, while the third case focused on information management and shipping of products. These cases were not relevant for this thesis. On the other hand, case number two operated with an MTO strategy where one of three component groups went through a customization stage. Because of the customization, the case also falls under this thesis' definition of ETO, which makes the research applicable. In addition, there is too little information on pure ETO and their ERP solutions to neglect the valuable inputs found on MTO. Case four looks at an ETO company and its solution. After using an average of 90 days in each company, Olsen and Sætre (2007) realized that each company had implemented a mainstream solution, but did not get the system to function as expected.

In case two there were three product groups; *A, B*, and *C*. Group *C* and *B* worked by using regular MRP functionality because of predefined BOM and routing. Group *A* was the customizable group that was the most expensive, where the final product was subjected to customer certification before shipment. Inventory of group *A* therefore had to store items for each classification agency, which was not possible, and because project-oriented production and procurement lead times were unstable, the MRP calculations became unstable. To overcome the problems a separate, customized system was proposed to take care of ordering components based on functionality that was not available in the ERP system. Due to the wish of keeping all information in one system the customized solution was not made. Still, they tried to create the functionality in the ERP software.

Case four was an ETO company that produced one product that was reengineered for every order. During the ERP implementation an ERP vendor was chosen. To cope with the change of product specifications and BOM, the vendor wanted to implement a product variation generator. Instead of showing a BOM and its components, the variation generator let engineers change components based on the relationship between them. What the vendor and customer did not anticipate was the fact that ETO companies have unlimited ways of changing a product. This made it impossible to implement the specifications and variations of components in the variation generator. After using lot of time, resources, and effort the solution was eventually dropped because of the mismatch of business processes.

To summarize, Olsen and Sætre are of the opinion that if a need for a new system presents itself, be careful and use proper expertise and evaluate if ERP can match the business processes of the company. If not, consider other solutions. By other solutions, Olsen and Sætre advertise the fact that companies should not always change into ERP best practice and that for SMEs it is not as expensive and difficult to develop inhouse software. For the ETO company in case four, Olsen and Sætre suggest an Information System (IS) that offered better advantages than a typical automation system like ERP. Because of few orders per year, the IS would keep track of information while decisions are made manually. While MRP functionality needs a BOM to calculate production and procurement, the IS could rather provide historic data from earlier product variants that can assist the engineer in modifying structures for the current customer order. With such a system in place Olsen and Sætre believed it would bring a competitive advantage in the marketplace.

To Olsen and Sætre's knowledge there did not exist an IS as they described as the best solution for their ETO company. Therefore they proposed an inhouse development solution. Off-the-shelf software for applications that can be satisfied company processes should not be included in the in-house development. Clearly, this will lower the work needed to make a fully functioning system. The in-house development takes care of core functionality and "glues" the off-the-shelf software together into one solution.

Another article that conducted case studies on ETO companies and their MRP functionality was Jin and Thomson (2003). All their cases pointed to the need for flexible systems that could handle the many variations of subassemblies conducted on the shop floor, and the variations in productions schedules due to the highly varied volumes and production methods. To cope with purchasing and scheduling, the companies released partial and "phantom" BOMs into the MRP system. On the other hand, the MRP did not cope well enough due to the need for predetermined, fixed data. Because of this, Jin and Thomson (2003) proposed a new framework that included the use of finite capacity scheduling. The finite capacity planning could handle the continuously changing manufacturing load generated by both dynamic dates and varying work content of each product. However, if an MRP should be enough, Jin and Thomson (2003) stressed that it is imperative the software can cope with incomplete BOMs and process plans that can be used to schedule and plan for long lead-time items and keeping track of outsourced parts. As the engineering progresses, the BOM must be updated and the plans recalculated.

Also worth mentioning is that Jin and Thomson (2003) realized that all the companies had difficulty in establishing the true cost of projects. This will damage the company due to the contract nature of the business. In addition, because of the shortcomings of the MRP software, it was harder to increase competitiveness regarding decrease in lead time. The MRP software was also often out of date, due to the rapid changes.

3.1.4 Summary of the research on ERP in ETO

To summarize, literature has found both flaws and solutions to how ETO can benefit from ERP software. Key areas where literature finds flaws in the ERP software regarding ETO use are (Jin and Thomson, 2003; Aslan et al. 2012; Zach and Olsen, 2011):

- Lack important, specific business processes that are special to companies in ETO sector.
- MRP does not provide enough support for managing customer enquiries or replenishment strategy alone. MRP software bases calculation on set lead time for component production, which is not effective for unique product that often are made with ETO strategy.
- MRP can constraint manufacturing flexibility that is needed in ETO. Production planning is therefore hard in dynamic ETO environments.
- Sufficient support for product customization during the engineering and design phase (product configurator only used when repeat orders).
- Flexibility, and thus competitiveness, may be threatened when implementing ERP system. Standardization of business processes may not be profitable for ETO with varied production.
- Production processes are so complex it is hard to fit it into an ERP.

In spite of the negative feedback towards ERP software in ETO companies, there are IT vendors working with ERP software that claim to have constructed a solution that indeed will benefit ETO companies. These companies, such as IFS, have published several white papers and summaries that illustrate their way of integrating the company with the software (IFS a; IFS b; IFS, 2001; IFS, 2012).

Areas within ETO that are covered, which may well be input for the solution to be suggested in this thesis:

- ERP software can be integrated with additional software that can benefit the ETO process. An example is PLM software that can cope with many problems in the design and engineering phase.

- Sharing information across the entire company, this is extremely important in ETO company that produce quote across departments. Get rid of isolated systems and duplication of information.
- Accounting and other “general” modules are the same as for large companies and can be used by ETO companies.

3.1.5 Rephrasing the ERP-problems in ETO to ERP-requirements

When putting the identified problems in a table, this automatically gives the opportunity to rephrase the problems into requirements for what a solution must handle in order to be beneficial for ETO companies. Based on the research from Jin and Thomson (2003), Olsen and Sætre (2007), Aslan et al. (2012), and Zach and Olsen (2011) requirements to take under consideration for an ERP-solution have been suggested in Table 3.

Table 3 - Problems in ERP made to requirements

Problems identified with ERP in ETO	Requirements for the ERP solution
Missing support for some important business processes special for ETO	Identify business processes in ETO and figure out how the solution can fulfill these needs. For example for quotation and design.
BOM for ETO products does not «exist»	Figure out how the system can contain the product even though it is unfinished. Also evaluate how BOM functionality can still be used
MRP can not be used as a replenishment strategy for ETO components	Must evaluate how the MRP (with BOM) functionality can be beneficial for ETO companies. Make a different solution for replenishment that is not based on generated plans.
MRP can constraint manufacturing flexibility, which makes production planning hard	The solution must allow for flexible manufacturing
No sufficient support for customization in design and engineering phase	Solution must support for changes to be made in design and engineering
Standardization of processes may threathen flexibility, and thus competitiveness	Find a balance between standardization and flexibility, in order to enhance competitiveness
Complex production processes does not fit into the ERP system	Analyze the processes and how the ERP system can handle the complexity. If it's not possible consider extra functionality
High customization costs	Make use of the existing functionality to the fullest to minimize cost. Where customization is needed consider if company or system should be adapted.

In order to evaluate how todays ERP-systems can benefits ETO companies, it is necessary to understand the ETO strategy and its special needs. As Zach and Olsen (2011) say, also by looking at specific industries there is a better chance of grouping similar requirements that may be beneficial to an ETO solution. While studying literature of the matter of ETO and manufacturing and supply chain strategies, an inconsistency of the term has been identified. To bring clarification to the ETO term, an extensive research has been done on this matter.

3.2 Clarification of ETO strategy

As it has been established there has been a limited amount of research into the low-volume ETO sector, compared to the high-volume MTS sector. In order to suggest how a vertical solution for the maritime and offshore ETO companies should be designed, the term of ETO must be clarified and established.

3.2.1 The traditional supply chain strategies; MTS, ATO, MTO and ETO

A traditional way to define a strategy is by defining the point in the manufacturing value chain where a product is linked to a specific customer order (Olhager, 2003). This is called the customer order decoupling point (CODP), or sometimes also called the order penetration point (OPP) (Olhager, 2003; Wikner and Rudberg, 2005). Wikner and Rudberg (2005) show in Figure 3 the four typical CODPs; MTS, ATO, MTO and ETO, showing the point in the supply chain where speculation turns to commitment. The locations of the CODP for the respective strategies are at the shipment stage for MTS, at the final assembly stage for ATO, at the stage of procurement and fabrication for MTO, and at the design stage for ETO (Gosling and Naim, 2009). Special for ETO companies is the fact that the engineering and design activities are a part of the customer order lead time in comparison to MTS, ATO and MTO (Bertrand and Muntslag, 1993; Olhager, 2003). Figure 3 also shows the relationship between production lead time (P) and delivery lead time (D). Delivery lead time (D) is defined in APICS as "the time from the receipt of a customer order to the delivery of the product" (APICS, 2013b). Production lead time (P), synonymous with manufacturing lead time, is the total time that is required to manufacture an item (APICS, 2013c). Included are order preparation time, queue time, setup time, run time, move time, inspection time, and put-away time.

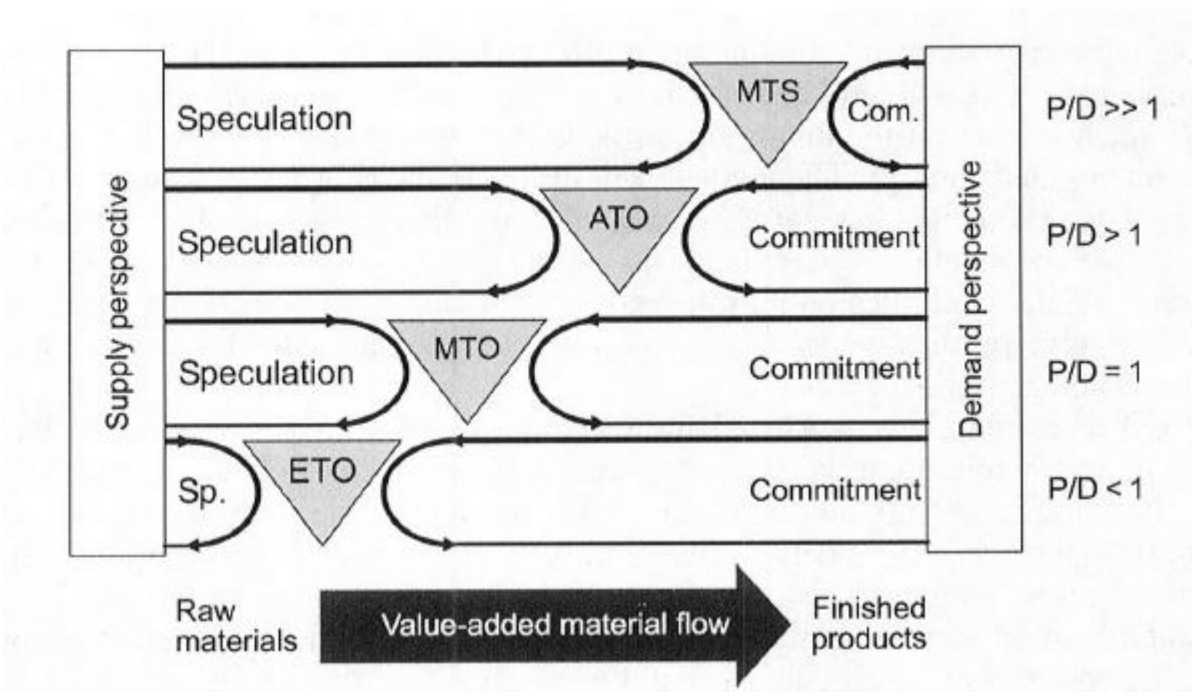


Figure 3 - Four typical CODPs (Wikner and Rudberg, 2005)

For MTS, production time is much larger than the delivery time. The products may take a long time to produce, and are often produced from forecasts or to stock, and are available when the customer wants it. This leaves for a short delivery lead time. In the case of MTO where P/D equals 1, the production lead time will actually be the same as the delivery lead time. When the order comes in, it triggers the start of the production. In the other end is the case of ETO companies. Here, the delivery lead time is larger than the production lead time. This is because the demand lead time for ETO includes the design and planning phase in addition to the production.

3.2.2 Illustration of the inconsistent use of the term ETO

The different strategies mentioned above is a typical approach, however in literature, ETO is defined multiple ways. Different frameworks have been developed in order to capture the essence of what the characteristics of ETO as a manufacturing strategy is. Despite the efforts, the ETO strategy is complex and there still does not exist one, standard definition used for the term. Gosling and Naim (2009) addresses the fact that there is a lack of clarity as to what is the appropriate terminology for describing ETO.

To illustrate this problem, some classify ETO to include both new design and modifications to an existing design (Hicks et al., 2000). Porter et al. (1999) on the other hand differentiates between ETO and Design-to-order (DTO). In their definition, ETO includes engineering and modification of an already existing product design, while DTO includes the entire design phase for a completely new product. An even wider term is when authors discuss MTO, and states that ETO is included in this term (Aslan et al., 2012). All production happens after an order for MTO, ETO and DTO. Amaro (1999) developed a taxonomy for non-MTS companies. His definition of ETO includes a new design from scratch, while MTO consists of modifications of a design including tailored and standardized customization. Table 4 compares the confusing aspect of how the different terms are being used inconsistently. A conclusion might be drawn to say that MTS, ATO, MTO and ETO are not sufficient terms to describe all different manufacturing strategies. There is often a vague line between the different strategies, especially for MTO and ETO as literature has clearly demonstrated.

Table 4 - Matrix illustrating the conflicting definitions from Amaro (1999), Porter (1999), Aslan (2012) and APICS (2013) (Hønsi and Sørbø, 2013)

	Amaro (1999)	**Porter (1999)**	**Aslan (2012)**	**APICS (2013)**
New design from scratch	ETO	DTO	MTO	ETO
Modification of existing design	MTO	ETO	MTO	ETO
Existing design	ATO	MTO	MTO	MTO

3.2.3 Thesis' definition of ETO

This thesis will follow the APICS definition of ETO. APICS (2013a) defines ETO and DTO as synonymous terms for the same case, and defines ETO/DTO as "*Products whose customer specifications require unique engineering design, significant customization, or new purchased materials. Each customer order results in a unique set of part numbers, bills of material, and routings.*" From APICS ETO, the definition will include both when a new design is being made from scratch, and when modifications are being made to an existing design, which both results in a unique product.

3.2.3.1 Need for differentiation of ETO

When studying solely ETO companies there is a need for differentiation between the companies and products as well. An article that agrees on the need for a more detailed differentiation in the design/engineering dimension is Semini et al. (2014). They look into the shipbuilding industry where the ships constructed vary in levels of customization, demand volumes, and other product and market variations. Ships therefore range from highly customized cruise ships to almost completely standard types of tank ships, but all the ships are still in the ETO category.

Another article that recognized the need for differentiation was Wikner and Rudberg (2005). They separated the engineering dimension with the production process and evaluated the CODP as a two dimensional graph. The *production dimension* says something about how much of the production is triggered by the customer order, while the *engineering dimension* says something about how much engineering happens after the order. Wikner and Rudberg (2005) also stated that for the production dimension, ETO is actually a special case of MTO because 100 percent of the production flow is driven by actual customer orders in all cases. All three cases also have the same production CODPs. Furthermore, ETO in the engineering dimension has been divided into three aspects; engineer-to-order, adapt-to-order, and engineer-to-stock. Engineer-to-order in the engineering dimension is when a *new* product is designed and engineered to order. Engineer-to-stock, is when a product is designed before the company has an actual customer order, and can be viewed as the product design being already "in stock". Between these terms is adapt-to-order, and is defined as where engineering modifications are made to an existing product design.

Semini et al. (2014) built their theory on top of Wikner and Rudberg's framework, and rather divided the engineering dimension into Customized Design (CD) and Standardized Design (SD).

The more standardized parts that could be used in an order, the closer the design neared engineer-to-stock and SD. Another article that also extended the Wikner and Rudberg framework, and included a third differentiation dimension, was Mello et al. (2012). They proposed to include procurement as an additional dimension in order to distinguish the different procurement approaches companies can adopt. The values proposed in the procurement dimension are procure-to-stock, procure-to-order, and agree-to-order. Procure-to-stock can procure in advance of an customer order, while procure-to-order will only procure after a customer order is confirmed. Agree-to-order is when a company has pre-selected the suppliers and established a relationship with them. Each order with the supplier will therefore be somewhat similar, but with an additional round of negotiations to incorporate minor adjustments.

Another term used in literature that may be of interest to this thesis is configure-to-order (CTO). Chen-Ritzo et al. (2011) define the term to be an instance of MTO, where products are assembled from several modular components based on customer need. In other words, CTO is based on the customer being able to choose the quantity of each component in the final product. The number of possible combinations can therefore be extremely high. Sabin and Weigel (1998) defined configuration as a design activity where the product is assembled from instances of a fixed set of defined component types, and the components interact with each other in predefined ways. They also point out that the configuration process consists of no new components, and the interface of the existing component types cannot be modified.

3.2.3.2 Introducing an extension of the traditional supply chain strategies

Based on these findings, an extension of the figure from Bertrand and Muntslag (1993) and Olhager (2003) showing the relationship of MTS, ATO, MTO and ETO has been developed in Figure 4. ETO has from Wikner and Rudberg (2005) been separated into EnTO (engineer-to-order) where the entire product is a new design, and AdTO (adapt-to-order) where engineering modifications occur. From the definition of ETS where the design is already in stock, it may resemble CTO and MTO, which also have predefined “design-components”. CTO, even though defined as an instance of MTO, has customization possibilities and will therefore require some kind of “re-engineering”. Therefore, CTO can be placed between ETO and MTO.

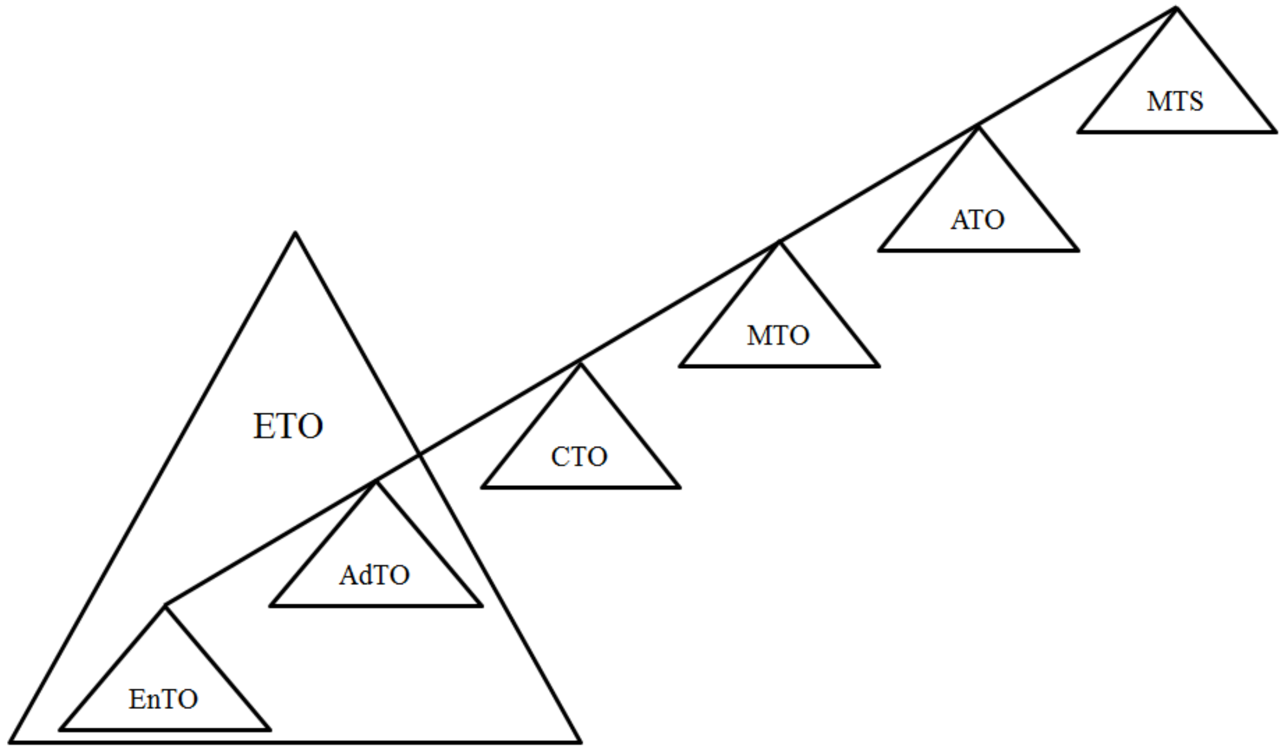


Figure 4 - An extension of the traditional supply chain strategies

The combination of EnTO, AdTO, and CTO will be the degrees of engineering that can take place during a customer order in this thesis. EnTO and AdTO will be sub-classes of APICS' definition of ETO, while CTO will be situated somewhere between MTO and ETO. Since engineering is viewed as a core competency in ETO companies, this thesis has chosen to scope the thesis to focus on the engineering dimension. However, the general solution that will be presented later must also incorporate functionality for procurement and production as these processes are also important. To get a better understanding of ETO the characteristics will be identified in the upcoming chapter.

3.3 Characteristics and important processes in ETO

Now that an agreement of the definition of ETO has been established, the next step is to identify the most important processes and characteristics in ETO companies. This is to be better supported when establishing an ERP solution.

3.3.1 Customization, competitiveness and lead time

ETO makes customer specific products, and their specifications requires unique engineering design, significant customization, and new purchased materials. Each customer order results in a unique set of part numbers, BOM, and routings. Usually, the ability to customize a product is viewed as a competitive factor in a company, however for the ETO sector all products are more or less customized. Customization becomes a requirement for being able to operate in the market, rather than a competitive advantage (Amaro, 1999; Gosling and Naim, 2009). However, the degree of customization will have something to say when competing to win customer orders. For example, if a customer demands total re-engineering of a product, the companies that strictly compete in the AdTO and CTO segment will not be able to comply with requirements. This may lead to loss of bidding rounds, even though they compete in the ETO segment.

However, a factor that is considered competitive in the ETO sector is the ability to estimate lead-times. Combined with cost and the ability to deliver a quality product on time, these factors are considered to be important for competitiveness and for a customer to accept the quotation (Hicks et al., 2000). When lead times are not met, it may affect the total cost of the project or customer satisfaction. Elfving et al. (2005) describes the vicious circle of added lead time, which is illustrated in Figure 5. The longer the time is between design and manufacturing, the larger the probability is for product design changes. In turn, this leads to higher probability of manufacturing changes and further increase of the total lead time.

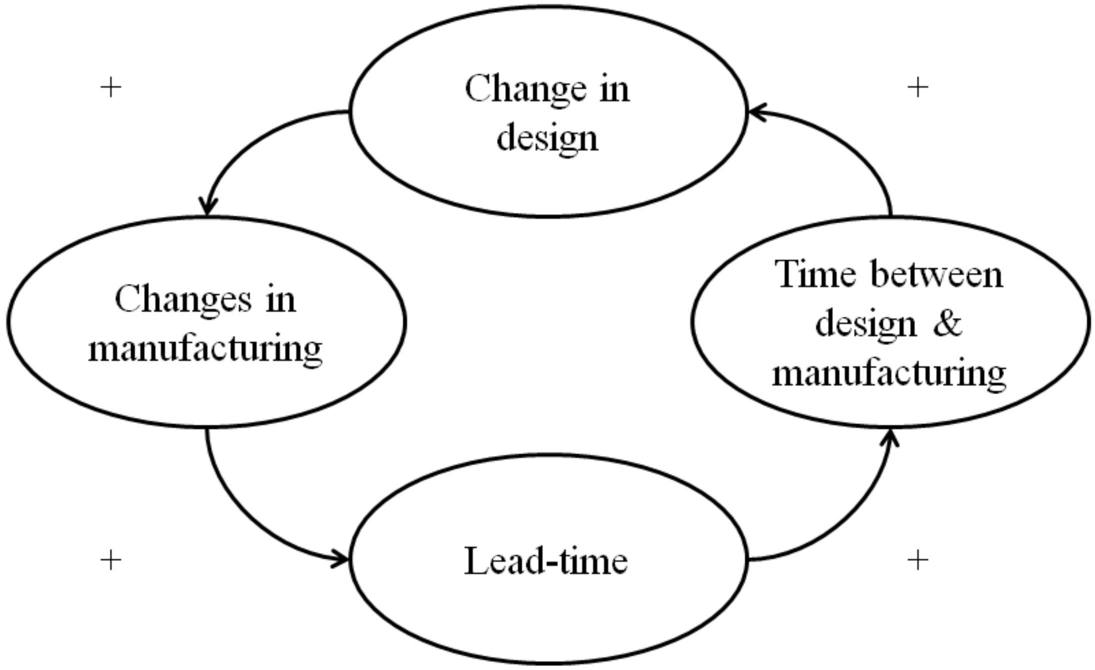


Figure 5 - Vicious circle of added lead time (Elfving et al. 2005)

3.3.2 ETO as the result of a project

Another characteristic is described by Yang (2013). He identifies an ETO product as an ultimate result of a project as it meets the definition of a project being a temporary effort undertaken to create a unique product, service, or result (PMI, 2013). This statement can be supported by research done by Hicks et al. (2000). Research done in collaboration with seven ETO companies identified design and project management as the two processes which were present in all ETO companies. Design and project management were therefore considered to be core competencies for ETO companies, which is illustrated in Figure 6 (Hicks et al., 2000). From the PMBOK Guide (PMI, 2013) one of the outcomes that a project can create is "*a product that can be either a component of another item, an enhancement of an item, or an end item in itself*". This statement is consistent with what an ETO product can be. Also Cameron and Braiden (2004) identifies companies making ETO products as project value stream driven, where they are usually involved in several concurrent projects at any one time.

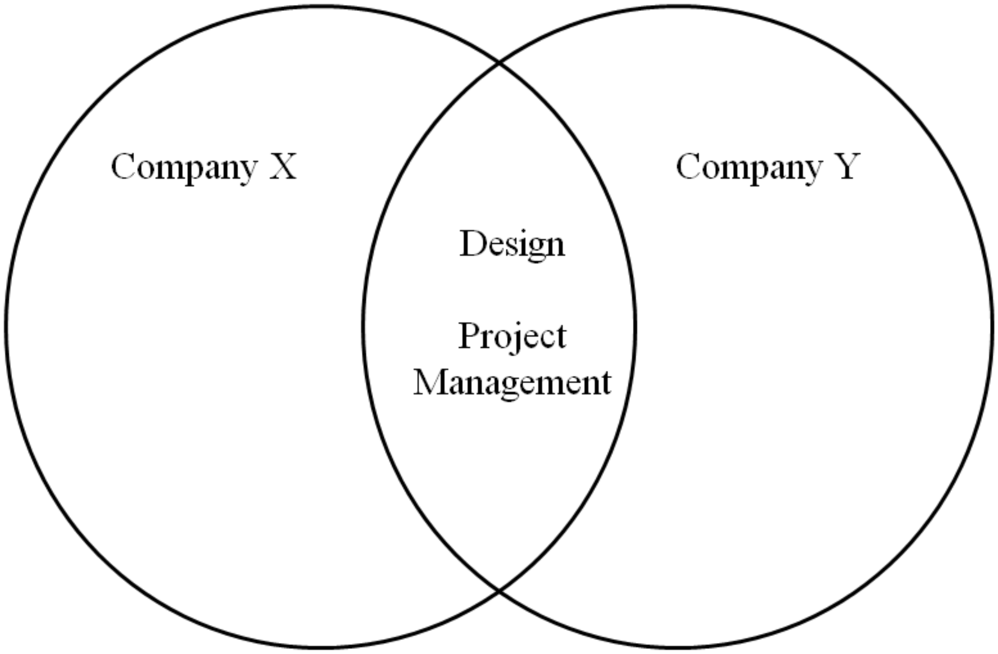


Figure 6 - ETO Core Capabilities

3.3.3 Projects in Maritime and Offshore ETO

As the establishment has been done that production of an ETO product is arranged as a project, projects in ETO are presented**.** In this chapter a typical lifecycle of a project will be discussed to better understand the events that will happen when a company executes a project. This can in turn be used to better get a grip on how the processes can be transferred to an ERP system. This knowledge will also be one of the key knowledge bases as to how the case studies will be conducted to evaluate the different ERP solutions.

3.3.3.1 Complexity in projects

When discussing projects, complexity of the product/project is an issue. While an ETO product is now established as a customized product requiring design and engineering changes and are arranged as a project, there may be big variations of the complexity of the product. One project may consist of several subprojects. Cost of the product/project varies, and so does project lead times. The ETO definition does not say anything about complexity of the ETO production and the product customization. This more or less depends on what product is being developed. ETO companies may differ in terms of degree of customer specificity of the product, the complexity of the products, the lay-out and complexity of the production process, and the characteristics of the market and competitors (Bertrand and Muntslag, 1993). A question that can be asked is; when is a project too complex? When designing a vertical solution for how to handle ETO orders in an ERP system in the maritime and offshore industry, it is necessary to scope it down.

3.3.3.2 Possible differentiation factors in projects

Through the literature study undertaken these factors for differentiation between ETO projects have been identified in this thesis:

- Lead time (weeks, months or years)
- Cost
- Complexity (number of parts, difficult materials, complex structures)
- Size of product (manufacturing inhouse vs. construction onsite)

By analyzing these closer, it can indicate how the relationship between the factors have an effect on each other. As discussed in chapter *3.3.1 Customization, competitiveness and lead time* changes made in design and manufacturing during the project affect lead time (Elfving et al., 2005), and lead time have an impact on cost. Also the complexity of the product and project has an impact on cost and lead time. Size depends on what is the product, but a complex product will often consist of more components, therefore the complexity may affect size, without stating that it always affects size. One may also say that size affects complexity. If the product is too big, it might require its own production/construction site because of transportation challenges, which may lead to more complex processes compared to production happening inhouse. If production is to happen on site this may also affect cost as workers and equipment must be transported to this location.

3.3.4 Differentiation of Maritime and Offshore ETO projects and products

From the reasoning above, an evaluation of the complexity levels for products in the maritime and offshore business versus the size of products in a matrix has been done in Table 5. To categorize complexity as being low, medium, and high is with concern to the number of part represented in a product. A “medium” complex product may consist of several “low” complex products, as for a product of “high” complexity might contain both “medium” and “low” complex products. However instead of categorizing on size, a differentiation on inhouse and onsite production has been used. With ETO being such a broad definition, this matrix will help scope down the ETO projects that will be of relevance when designing the vertical solution.

Table 5 - Projects in maritime and offshore industry compared with concern to complexity and inhouse/onsite production

	Complexity		
	Low	Medium	High
Inhouse	Components Multiphase Meter	Subsea equipment Specialized cranes	Shipbuilding
Onsite		Windmill construction	Platform

This differentiation method opens for the possibility to exclude some of the values in the matrix. This thesis has chosen to exclude all projects produced onsite, along with projects produced inhouse where complexity is very high. In other words, the solution will focus on low and medium complex inhouse products.

3.3.5 Establishment of an ETO Framework

In chapter *3.2.3.2 Introducing an extension of the traditional supply chain strategies* an extension of the traditional supply chain strategies was developed based on findings in literature. For the separation of ETO, it differentiates on the degree of engineering done for every product. The two options within ETO are EnTO and AdTO. CTO is also included, which is when a product is configured from options and rules concerning design that are predefined, but the product may still be unique. The one endpoint of engineering and design is to start from scratch, the other end, as for CTO is that all design already exists, however the customer gets to make choices regarding the design of the product. In reality, phases in between will be gliding as shown in Figure 7.

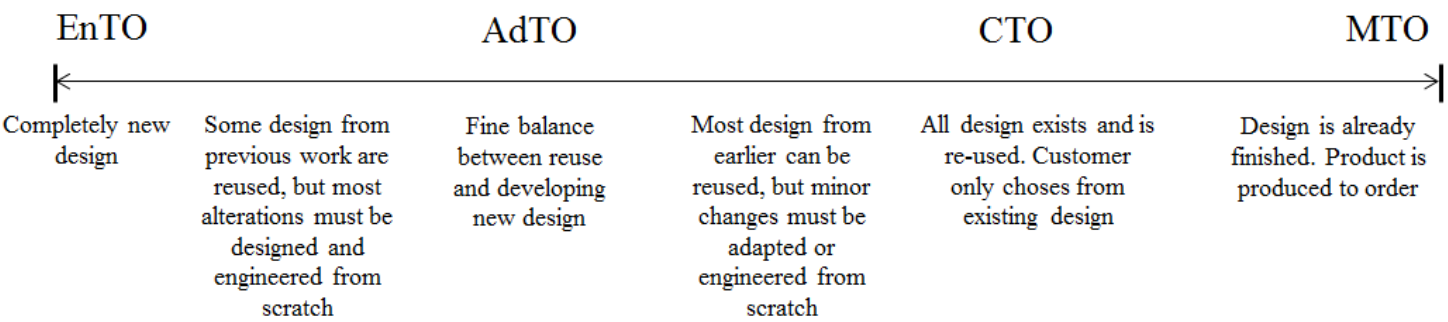


Figure 7 - Gliding phases of the degree of reuse of design and engineering in an ETO product

Using Figure 7 as one axis, combined with the differentiation of ETO products with concern to complexity on the other axis, makes a suggestion for an ETO framework, as shown in Figure 8. As ETO is characterized by being highly customized and complex throughout literature, this framework captures two of the most important characteristics of ETO products. One factor of complexity of a product is number of components, which is what is used for this framework.

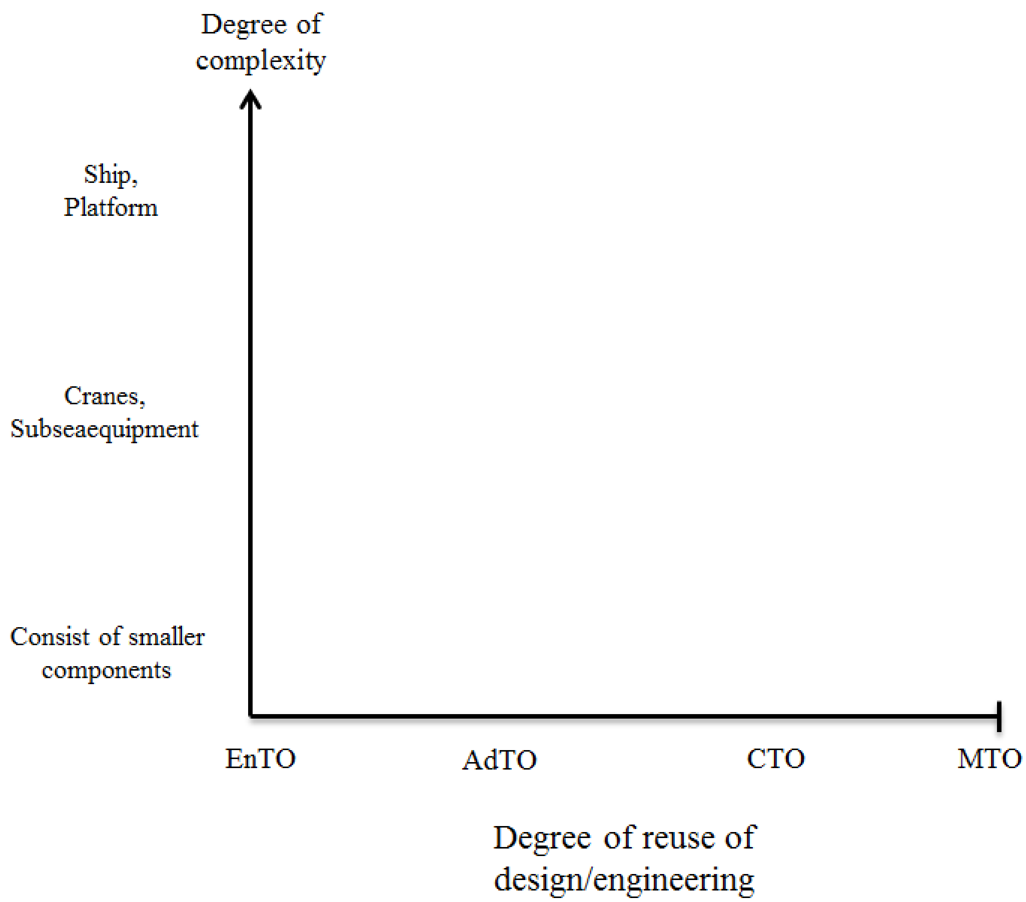


Figure 8 - Framework for ETO products with concern to the degree of re-use of design/engineering and the degree of complexity measured by number of product components

3.3.6 General Project Lifecycle

Even though every project is unique, it follows a certain pattern and predefined life cycle throughout the project's development (Pinto, 2010). These life cycles are generally called conceptualization, planning, execution, and termination (Pinto, 2010). PMI (2013) states that all projects, despite variations in size and complexity, can be mapped to the generic life cycle structure shown in Figure 9. Combining literature of the project life cycle with important business processes will capture the entire phase from quotation to delivery of the product.

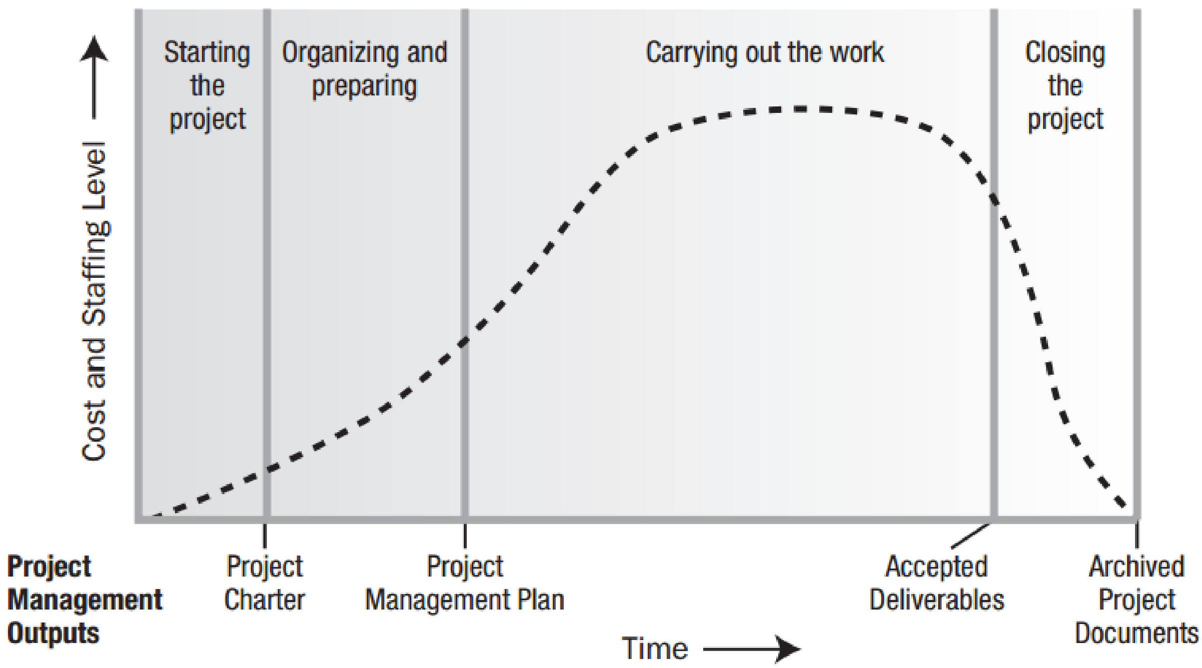


Figure 9 - Typical Cost and Staffing Levels Across a Generic Project Life Cycle Structure (PMI, 2013)

As the figure shows, most of the cost and staffing level is carried out in the phase where the work is carried out (execution). This is after the organizing and preparing (planning) has been done, including setting up a project management plan. Also in the time perspective this phase is longer.

3.3.6.1 Project management processes

Although a project follows this typical life cycle, there are several processes carried out at the same time throughout the project. For example plans change, and planning will therefore be performed while the project is executed. Not to be confused with the generic life cycle in Figure 9, PMI (2013) categorizes traditional project management processes in five *Process Groups*.

- Initiating
- Planning
- Executing
- Monitoring and Controlling
- Closing

Figure 10 shows how these Process Groups are iterative and overlapping during a project (PMI, 2013). Several activities in a project can be carried out at once, where each activity requires management within each process group. For an ETO project these management processes will include how to initiate, plan, execute, monitor and control, and eventually close the ETO business processes that have been identified. This includes for example management of the quotation phase and the design phase among others.

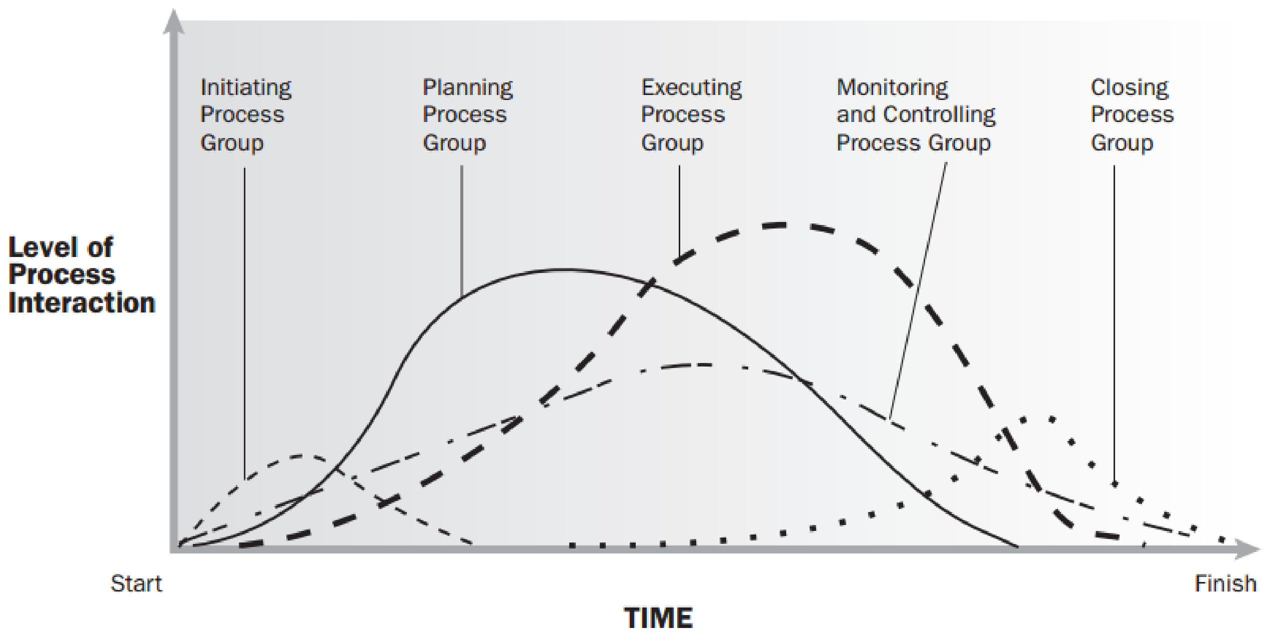


Figure 10 - Process Groups Interact in a Phase or Project (PMI, 2013)

This figure and how it applies to the different processes are described further in the chapter*3.3.7.2 Project Management.*

In other words, even though project management is much about managing changes, it also has somewhat predictable phases, and these phases will be very important for the ERP solution and its functionality. In relation with managing changes, one of the benefits with an ERP system is to keep information and business processes within one system to increase productivity and help decision-making (Botta-Genoulaz and Millet, 2005; Kanellou and Spathis, 2013).

In the upcoming sub-chapters there will be given a description of phases and processes that are important in an ETO project and ETO company. These will be discussed with consideration to the life cycle of the project. Most of the important business processes in ETO were identified in the Project of Fall 2013 (Hønsi and Sørbø, 2013). From identifying critical processes and characteristics, criteria for each of the business processes were developed, which should be supported from an ERP-solution. The business processes that were identified as most important and will be looked into are:

- Quotation
- Project Management
- Design and Engineering
- Procurement
- Production
- Installation/Service/Maintenance

3.3.7 Business processes in ETO companies in offshore and maritime industry

The processes that are presented are the processes that should be supported by the ERP solution.

3.3.7.1 Quotation

First of all, to make products there should exist a customer with a need. The production company then goes through a customer inquiry/quotation stage, which is viewed as a competitive bidding situation, and is the response to an invitation to tender for a particular contract (Amaro et al., 1999; Hicks et al., 2000; Aslan et al., 2012). While the inquiry is the invitation from a possible customer to tender for a particular contract, the quotation is the response from possible companies that wish to be assigned the contract. Hicks et al. (2000) identifies the success of winning a contract to depend upon how the company understands in detail the customers' needs, like technical features, price, delivery, and quality requirements.

In the quotation phase a preliminary development of the conceptual design of the product and definitions of the major components and systems are prepared, and to some extent selection and contact with suppliers in order to get information about cost and lead-times (Hicks et al. 2000).

For companies that manufacture unique, possibly large, complex products the quotation process and production process can be time consuming as it requires special coordination and a certain amount of engineering to be done before there is enough information to be able to calculate costs (Konijnendijk, 1994; Hvam et al., 2006). According to Hvam et al. (2006) cost of production can roughly be divided into engineering costs, actual production costs, and cost of materials. This process is an important part of a project, because it is a contributing factor towards the lead-time of the product. By shortening or making the process more effective, the competitive advantage increases.

The quotation stage is conducted by several departments within the company and requires a lot of resources to accomplish (Hvam et al., 2006). Preparing the quote is viewed as a multi-stage decision process, where decisions with concern to everything from technical specification to delivery terms, price and commercial terms are made under high uncertainty (Bertrand and Muntslag, 1993; Hicks et al, 2000). These aspects must be agreed on in order for a contract to be signed, and therefore communication is very important during this phase to prevent any unnecessary confusion and problems. When price is agreed to at this early stage, it establishes a cost frame for the company for the rest of the project.

In relation with the generic project life cycle in Figure 9, the quotation could be placed in the first phase where the deliverable is a project charter, or the quote itself. After the contract is signed by both parts, the organizing and planning of the entire project can start.

Criterion for the quotation stage (Hønsi and Sørbø, 2013):

- Support for handling the quotation phase in the system, and plan for due date, cost and capacity.

3.3.7.2 Project management

Along with the design, Hicks et al. (2000) identified project management as a core capability in ETO companies, and each order is often arranged as a project. Project management is therefore an important part of ETO companies, in order to manage the entire project from the quotation, design and engineering, procurement, construction and manufacturing, and commissioning, and sometimes also the service and maintenance of the finished product. For an ETO project it will be how to initiate, plan, execute, monitor and control the ETO business processes and eventually the close up.

During the quotation, delivery date and prices are agreed to, and the project manager has the responsibility to see to the delivery of the product on time, and manage the project in order to meet the company goals in terms of cost and profitability. Binding project contracts are signed with the customer. The initiation of the project therefore requires extensive planning on how to address the project further. A part of the initiating and planning often consists of a risk register, work breakdown structure (WBS), project schedule network diagram and project contracts (PMI, 2013).

Multi-phase project processes

There exist different tools and methodologies for project management. A Guide to the Project Management Body of Knowledge (PMBOK Guide) is of one of the most essential tools in the project management profession (PMI, 2013). It contains a globally recognized standard and guide for the profession. The Process Groups mentioned and illustrated in chapter *3.3.6.1 Project management processes* can be furthered presented as in Figure 11, where the planning and execution are an iterative process, with constant monitoring and controlling occurring.

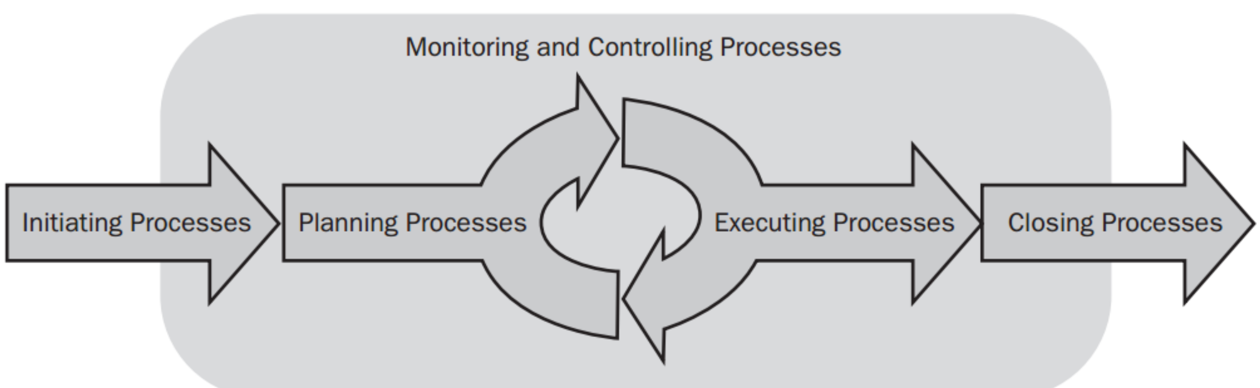


Figure 11- Single Phase Project (PMI, 2013)

However, this figure shows a single phase project which is usually not the case for ETO projects. ETO products are often developed through what is known as concurrent engineering. Concurrent engineering product development processes relies on parallel scheduling of activities throughout the product development cycle (Handfield, 1994). Concurrent engineering will be presented further in the next chapter covering Design and Engineering. Figure 12 therefore shows how the different phases are executed in parallel (PMI, 2013), each requiring management processes in its phase. Planning provides for plans and documents for execution, and as the project progresses plans and documents must be updated. Output from one process often becomes input for another process.

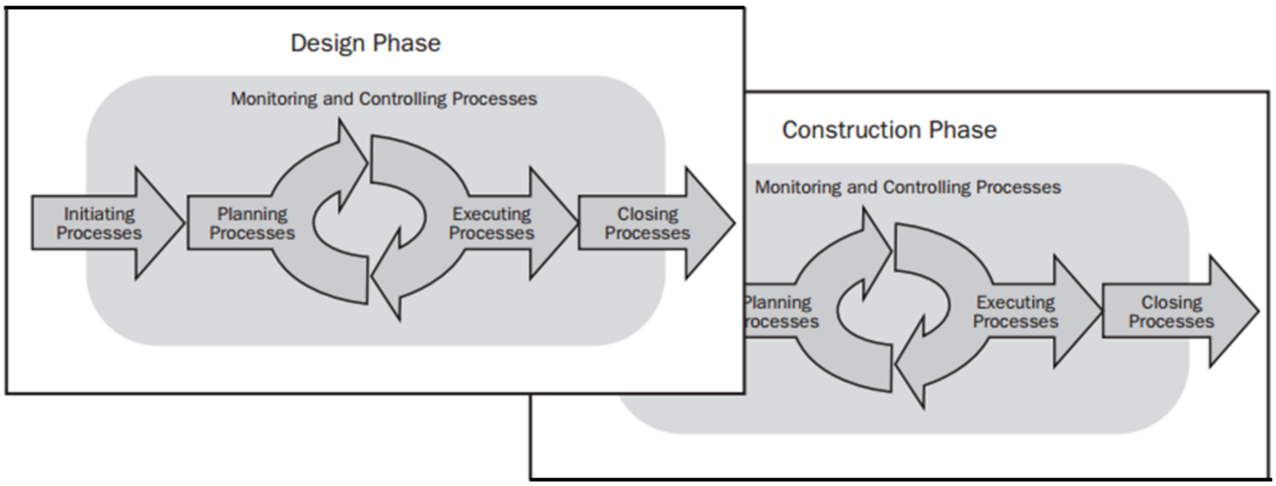


Figure 12 - Example of Project with overlapping phases (PMI, 2013)

Project success factors

Literature on project management identifies several factors that influences project success and therefore can be applied to project and ETO manufacturing (Yang, 2013). These success factors include (Yang, 2013):

- good communication
- suitable and qualified team
- effective change management
- competent project manager
- well allocated resources
- good leadership
- proven technology

- realistic schedule
- risk management
- effective control
- adequate budget
- organizational adaption
- good performance by suppliers/contractors
- acceptance of possible failure
- training provision
- past experience of project management methodology
- environmental influences
- project characteristics

These have been collected from other literature and the research indicates that proven technology, planning tools and non-technical factors may help achieve manufacturing goals in an ETO manufacturing environment (Yang, 2013). A good solution for company should therefore give support for some or several of these factors, so that it can be used as a tool to improve success in a project.

Use of the WBS in a project

The WBS is one of the most vital planning mechanisms in a project, with the intention to divide the project into sub-steps and deliverables in order to establish critical interrelationships among activities and more manageable components (Pinto, 2010; PMI 2013). The WBS provides the foundation for defining work as it relates to project objectives and establishes the structure for managing the work to its completion (PMI, 2013). A good WBS ensures that the project includes all work needed without including any unnecessary work. If unnecessary work is included in the WBS and performed, the customer's time and money will be wasted. In contrast if not all work is included, there is a big chance of the project being delayed, and may lead to cost overruns (PMI, 2013). A faulty WBS, will have an impact on the project, and may cause the project to fail in terms of time and cost.

The WBS is often used as a tool and input for other core processes in project management as shown in Figure 13 (PMI, 2000). As shown in the figure, the WBS is often combined with the making of a time schedule, often portrayed in a Gantt-chart. In addition, identifying work packages and deliverables is valuable information for planning of resources, cost estimations and the making of a budget.

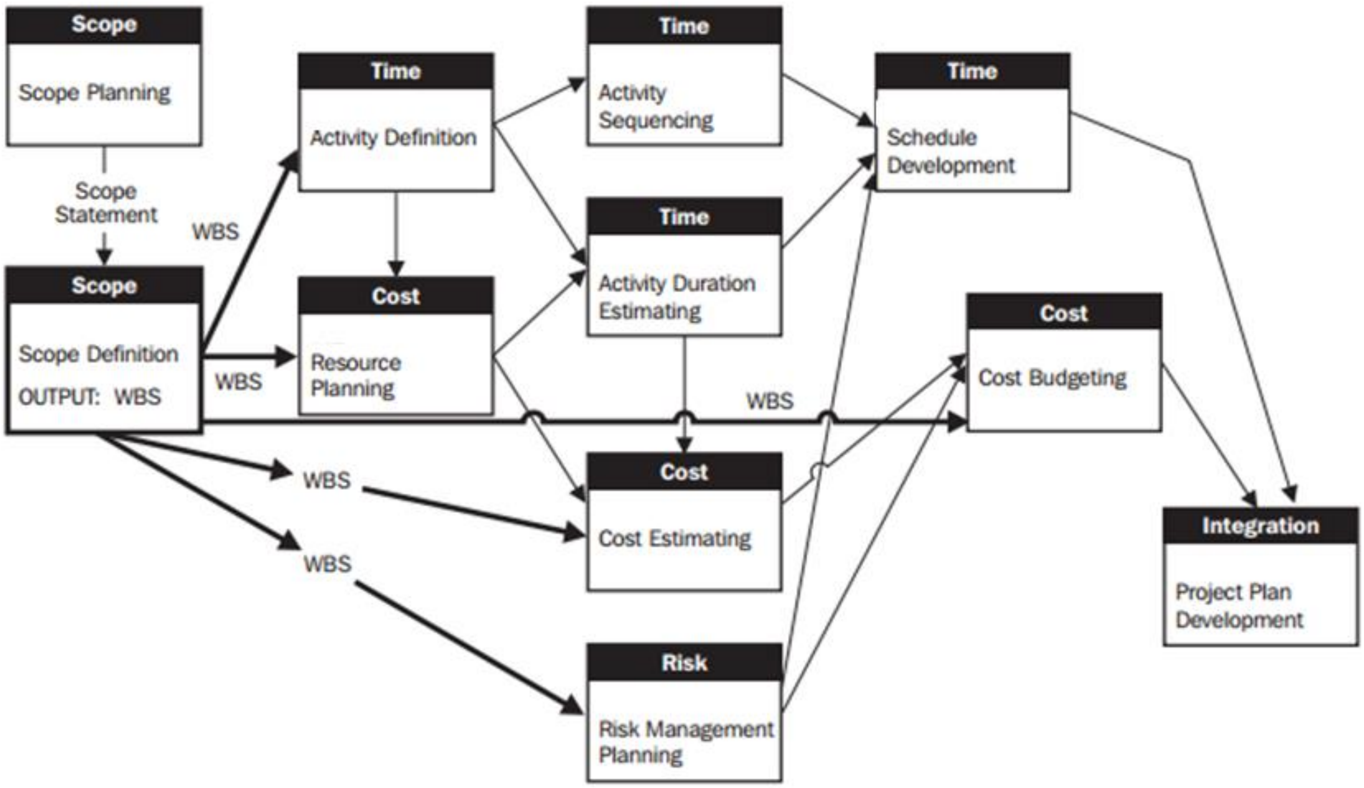


Figure 13 - WBS interactions (PMI, 2000)

This illustration shows what an important tool the WBS is, and how it is used for further planning of a time schedule and a project budget. From the identified project success factors in chapter*3.3.7.2 Project Management* well allocated resources, realistic schedule, risk management, and adequate budget can be directly related to the outputs of the WBS.

Measuring progress and managing changes in a project

Although a project plan is developed, a project is often characterized by many changes along the project lifecycle. As the word cycle implies, the phases in a project are constantly modified in terms of content, cost, and duration as new information is fed back to both the project manager and customer (Lester, 2014). When these changes occur these may affect original plans and budgets, and alterations is often required throughout the project.

There are very few changes that do not affect in some way either the time, cost, or quality aspects of the project (Lester, 2014). These are often viewed as the constraints of the iron triangle pictured in Figure 14, where if one of these factors change it will have an effect on at least one of the other constraints (Kliem, 2002).

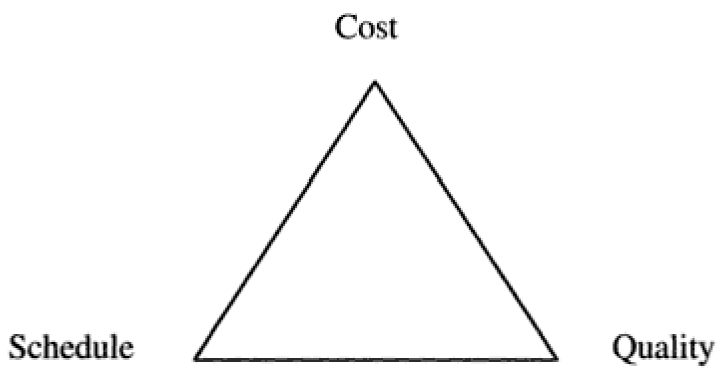


Figure 14 - The iron triangle (Kliem, 2002)

There are different variations of this figure, for example where quality is replaced with scope. In some cases resources and risks are added as main constraints in addition to the four (cost, schedule, quality and scope) (PMI, 2013). However, because of the fact that these factors are all so connected in a project and are affected by changes, the more important it is to record, evaluate and manage all changes (Lester, 2014).

Criteria for the project management and re-use of information/decision support (Hønsi and Sørbø, 2013):

- Have the functionality for project management
- Include functionality for making the WBS
- Support for logging and registration of the WBS activities and deliverables in order to measure the progress
- Generate updated plans, and new cost and lead time estimates as more information of the project and progress is available
- Ability to view information from earlier projects, and reuse information. Especially in the quotation stage, design phase and the production planning. (Criteria applicable for Quotation, Design and engineering, and Production/construction.)

3.3.7.3 Design and engineering

Hicks et al. (2000) identified design and engineering as the core competency in an ETO company along with project management. As ETO stands for Engineering to order, the name itself indicates that the key is to develop the product to fit the customer's needs and requirements. The product and its material and work content is only gradually known throughout the design and engineering phase (Bertrand and Muntslag, 1993).

After winning the contract, the engineering phase is characterized by incomplete and inaccurate information, and progressive availability of data as the product is developed further (Shishank and Dekkers, 2011). Research shows that long lead-times are very often related to the design phase, and in a study by Pandit and Zhu (2007) half of the causes for long lead times were in relationship with the design process. Since other processes like procurement, production planning, and outsourcing decisions are dependent on design (Konijnendijk, 1994; Pandit and Zhu, 2007), design and engineering naturally has a big impact on lead time (Aslan et al., 2012).This problem has been illustrated earlier in the vicious circle of lead-time in Figure 5. Design in itself is an uncertain process, because if the design process takes longer time than what was accounted for in the quotation phase, it will affect the lead time of the project (Bertrand and Muntslag, 1993).

3.3.7.4 Concurrent Engineering

The design and engineering in an ETO project can often be described as concurrent engineering, synonymous to participative design/engineering in APICS (2013d). In concurrent engineering, all functional areas of the company participate simultaneously in the product design and engineering activity, often including both suppliers and customers (APICS, 2013c). As mentioned in chapter *3.3.7.2 Project Management* concurrent engineering relies on parallel scheduling of activities throughout the product development cycle (Handfield, 1994). It means that the manufacturing is often initiated before the final design is complete, and the same goes for procurement.

This way of developing the product should ensure that the final design meets all the needs of the stakeholders and ensure that the product can be quickly brought to the marketplace while maximizing quality and minimizing costs (APICS, 2013c). The design process is usually characterized by feedback and iteration to meet the demands of the product (Salter and Gann, 2003). Challenges with concurrent engineering may also be identified if decisions concerning procurement and manufacturing are done before the entire product is ready. As demonstrated in Figure 15 decisions that are taken at an early point in a project are affected by high risk and uncertainty. When a decision in design triggers other processes it will be too late or expensive to make changes in the design later. However, by including all participants in the design phase, feedback will be given faster and maybe heighten the chance of making the best decisions to satisfy all participants from the beginning. Figure 15 therefore shows the relationship between the degree of risk and uncertainty versus the cost of making changes as the project is carried out. This figure is applicable for other business processes as well.

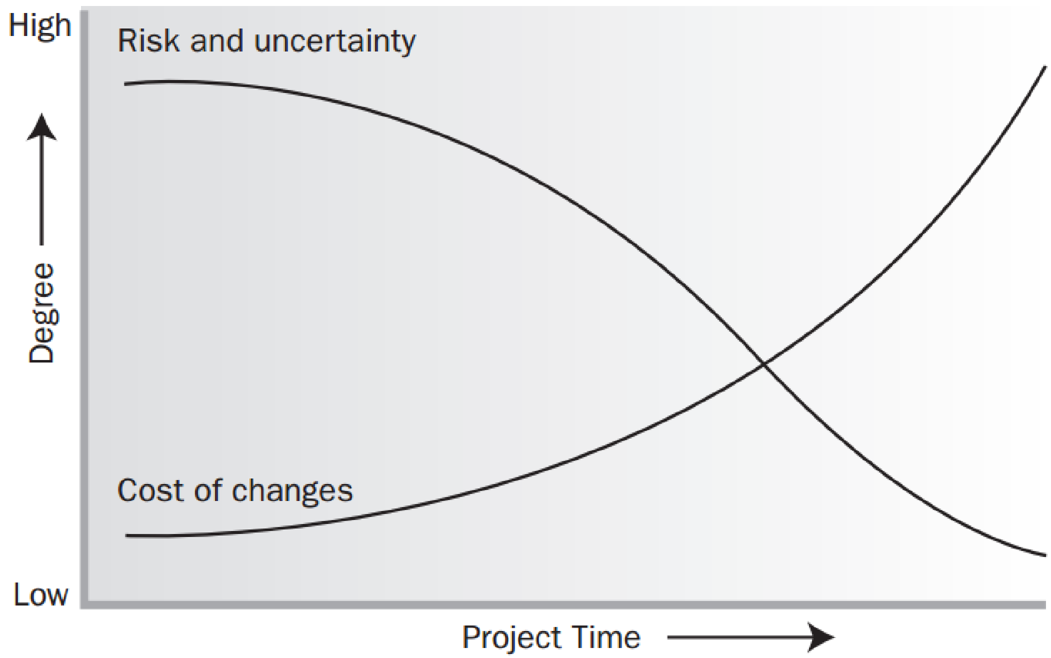


Figure 15 - How risk and uncertainty, and the cost of changes in the project changes over time (PMI, 2013)

Tools for design and engineering

There are various ICT tools and working methods in the design and engineering phase. These include CAD/CAE software, simulation packages, intranets, on-line databases, World Wide Web, video-conferencing and relational databases (Salter and Gann, 2003). Technical literature shows an excitement of how new ICT tools can change the way designers work, communicate and solve problems (Salter and Gann, 2003). However research shows that the design phase still heavily relies on close, personal face-to-face interaction when working in project-based environment (Salter and Gann, 2003). Designers and engineers use a mixed practice combining paper and computer, and still rely heavily on sketching and face-to-face interaction.

The Product Lifecycle Management system, the PLM system, is also relevant. Ming et al. (2008) defined PLM as a system that supports management of portfolio of products, processes and services from initial concept, through design, engineering, launch, production, use, and to final disposal. The PLM system may help create a competitive advantage for manufacturing organizations as it connects products through the value chain and can help create better products in less time, at lower cost, and with fewer defects (Ming et al., 2008).

Criteria for engineering and design, and engineering change management (Hønsi and Sørbø, 2013):

- Integration of PLM system with the ERP system (or some sort of customized product configurator to integrate the design phase with the ERP system)
- ERP system must react and take action when new information is provided through the PLM system
- ERP system must react and take action when new information concerning the project or product is added into the ERP system

3.3.7.5 Procurement

Procurement is closely related to the engineering and design process, and is actually driven by the pace of the engineering development (Jin and Thomson, 2003). The challenges associated with procurement arise mainly from the social, economic or technical difficulty of synergizing various parties along the procurement chain (Pandit and Zhu, 2007). In order to start procuring, the components of the product must be designed, where the procurement effectiveness is dependent on whether the specifications are correct and appropriate (Hicks et al. 2000). When dealing with ETO products, the main problem lies in the fact that because of customization it is hard to estimate lead-time, and thereby delivery dates (Pandit and Zhu, 2007). In addition, there is a risk of expensive rework due to late realization of errors, and then if something cannot be used there is extra material waste (Pandit and Zhu, 2007). Procurement has also been identified as one of the time bottlenecks in ETO production together with quotation and the design stage (Pandit and Zhu, 2007; Gosling and Naim, 2009).

Suppliers and supplier relationships

The level of detail is also important during procurement in ETO companies. If the design is very detailed it gives less flexibility for suppliers (Hicks et al., 2000). This may constrain innovation and result in unnecessary design and procurement activities that can lead to increase in cost and lead-time (Hicks et al., 2000). According to Hicks et al. (2000) the procurement happens in different stages of the product development. First, customers specify requirements that might only be done by certain suppliers. Second, during the quotation stage some components are specified and cannot be changed later in the project. Procurement may therefore become more challenging due to the low number of suppliers available. Because of the ETO strategy some companies may also have low volume sales, and when they need to procure certain components from suppliers, the power in the relationship may lie at the supplier because the order may not be significant to them (Hicks et al., 2000). Third, the detailed design phase, takes parts with long lead-time into consideration. When components are customized and information are not reused it increases procurement uncertainty and risk (Hicks et al., 2000).

It is obvious that procurement can be dependent on suppliers. In other words, it has become increasingly important to improve supplier relationships, and especially supplier involvement. This may contribute to product quality, project development time, and project cost (Yang, 2013). Hicks et al. (2000) also identified multiple activities to enhance the procurement stage in ETO companies. They were to increase knowledge sharing, limit customization using modular configurations and standard items, and conduct proactive procurement. Proactive procurement is defined as participation in the development of specifications with consideration to potential vendor capabilities and performance (Hicks et al., 2000).

3.3.7.6 Production

Production is a complex process for ETO companies because product information is largely unknown at the acceptance of an order, and it continuously changes until product specification are finalized (Jin and Thomson, 2003). In ETO companies, in order to meet delivery times, production is often started before the final product is finalized, making the production even more complex.

Customization of the production processes

Because of the ETO strategy the production process has to be customized for each order (Gosling and Naim, 2009), and specific skills and craftsmanship are therefore usually required to execute the manufacturing (Konijnendijk, 1994). As with procurement, the production is therefore also dependent on the engineering development (Jin and Thomson, 2003). In addition to limited information on the product, the uniqueness of each customer order makes the production challenging due to the coordination of requirements and the production process (Konijnendijk, 1994). As a consequence, the customization of a product makes it hard to determine the exact workload of a project, as well as production.

Inhouse and outsourcing

The amount of production of a product done by a company is called vertical integration. There are two “extremes”, where in one end the company does all production inhouse, while the other outsources all production and only manages administrative tasks inhouse (Hicks et al., 2000). This is true for all companies, independent of strategy. While vertical integration is the degree of production conducted by a company, the strategies used during production in ETO requires different manufacturing environment than other strategies (Yang, 2013). To find an optimum level of vertical integration ETO companies strive to find a balance between reconciling customer delivery times with available capacity, reducing costs, the availability of capital for investment in equipment, potential utilization of plant, and internal/external capabilities and flexibility (Hicks et al., 2000).

Because of business strategy certain parts of production will not be outsourced to keep important technology inhouse (Konijnendijk, 1994). On the other hand, standard components used in the final product can be outsourced, and can be better planned for with consideration to lead-time.

Planning of production schedules

Other difficulties during production arise when there occurs conflicts between project and manufacturing schedules (Pandit and Zhu, 2007). For example, projects with unrealistic production schedules are often the reason for delays (Yang, 2013). The team members are forced to work hard towards completion, which might require sacrifices like quality of the product (Yang, 2013). This also affects the uncertainty and increases the risk of the project. For ETO products the final phase of production is most often testing and commissioning, and this stage cannot begin before all other activities are performed (Konijnendijk, 1994).

In other words, production in ETO is hard to control, and when the workload increases the lead-time increases. Furthermore, ETO companies must know what production to outsource and what must be done inhouse (Konijnendijk, 1994). In addition, use of advanced manufacturing technologies is recognized as an important element in building a competitive manufacturing system that can deliver the product variety that customers demand (Yang, 2013). This includes IT to increase responsiveness and create performance improvements in the production process (Yang, 2013).

Criteria for production and manufacturing (Hønsi and Sørbø, 2013):

- ERP system should include a solution that makes it possible to initiate production even though the complete product/master BOM is not finalized yet
- ERP system should support product routing with consideration to job shop, and allow for flexibility in production
- Should be able to register when a job/operation has been performed

3.3.7.7 Installation/service/maintenance

From the discussion of ETO projects it was established that ETO companies within the maritime and offshore industry often deliver customized and complex products meant for, among others, ships and offshore platforms. Identified in the Project Paper (Hønsi and Sørbø, 2013), these ETO companies within this industry are often involved with installation, service, and maintenance of their products. Also Cameron and Braiden (2004) recognized that ETO companies are often involved in commissioning and through-life support including decommissioning and cleanup.

For companies that are involved with service and maintenance of their products, it is necessary to keep a track record of each product. Both location-wise and in order to determine if the product is working as it should and what operations should be performed (CGI, 2013a). By keeping track of this type of information it may reveal patterns of maintenance and service operations.

Criteria special for offshore and maritime industry (Hønsi and Sørbø, 2013):

- The solution should be able to store information of where the products placed, can be met with an installation register
- Should support the arrangements of the shipment of the product, can be met with a shipment module

Criteria special for offshore and maritime industry if they perform service and maintenance (Hønsi and Sørbø, 2013):

- The solution should contain a service and/or maintenance module to plan and register service operations of a product
- The service and/or maintenance module should provide information of previous service operations that have been performed on the product
- The ERP solution should support for special agreements made on price and service operations, can be met with a contract module

3.3.8 ETO Summary

Through the thesis so far the important business processes in ETO to be supported by the ERP-solution have been identified. Further it has been established that these processes are executed as a part of a project. That also means project management is a process that will be carried out throughout the project. With focus on project management, the solution should manage the quotation, design and engineering, procurement, production, and the installation and service. Each of these processes has their complications which set some requirements.

Through all the business processes lack of product information, uncertain lead times and their relation with cost of late changes are constantly mentioned. Managing progress in terms of cost and schedule may therefore be seen as extra important.

With inspiration from IFS's executive summary on the project enterprise (IFS b) Figure 16 is proposed as a framework for ETO processes that should be focused on in an ERP solution.

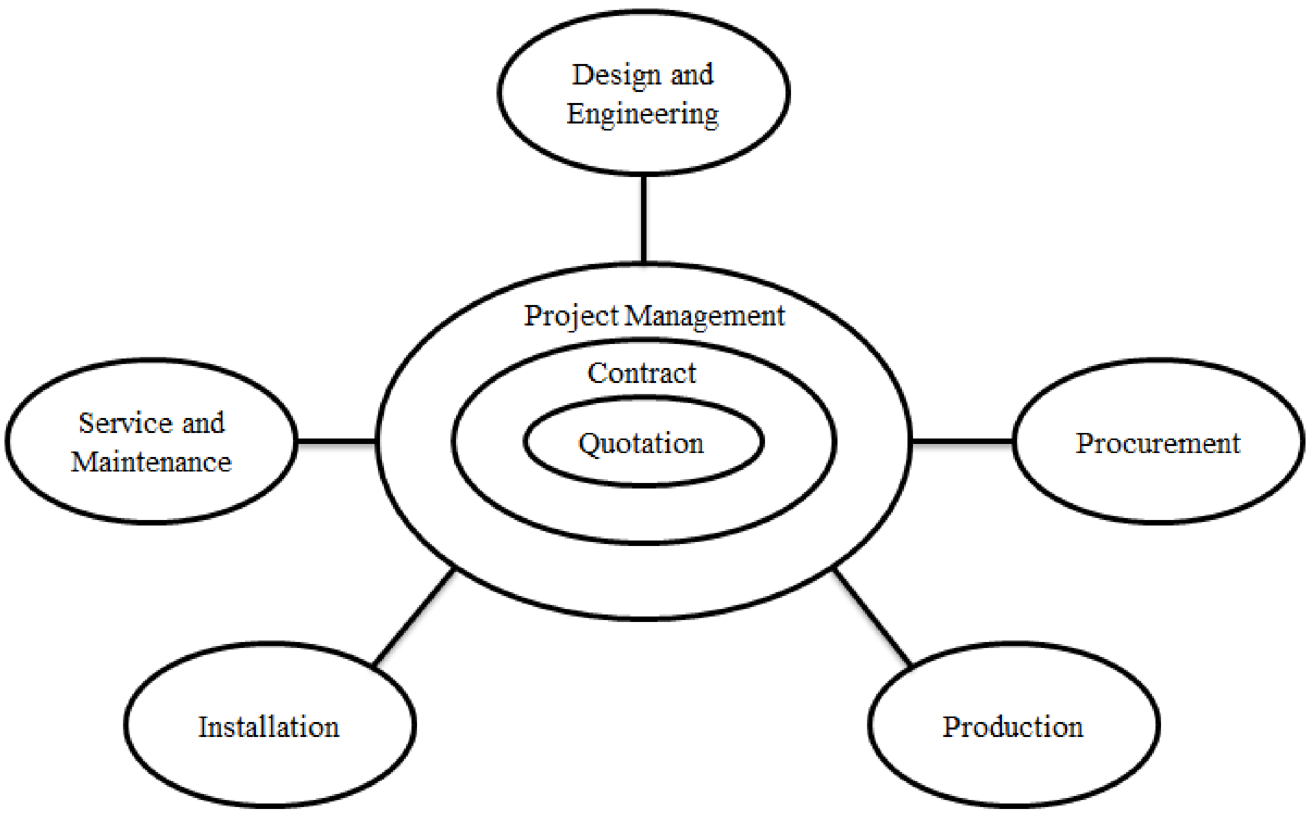


Figure 16 - ETO Business Processes important in ERP Solution

3.4 Relevant/important functionality in AX

3.4.1 Introduction to Microsoft Dynamics AX

AX is Microsoft's core business management solution, and is designed to meet the requirements of mid-sized companies and large multinational organizations (Luszczak, 2013). As illustrated in Figure 17, Microsoft was the 5th biggest ERP provider in 2012, with 5% market share. In comparison, SAP was the biggest provider with a 25% market share (Columbus, 2013).

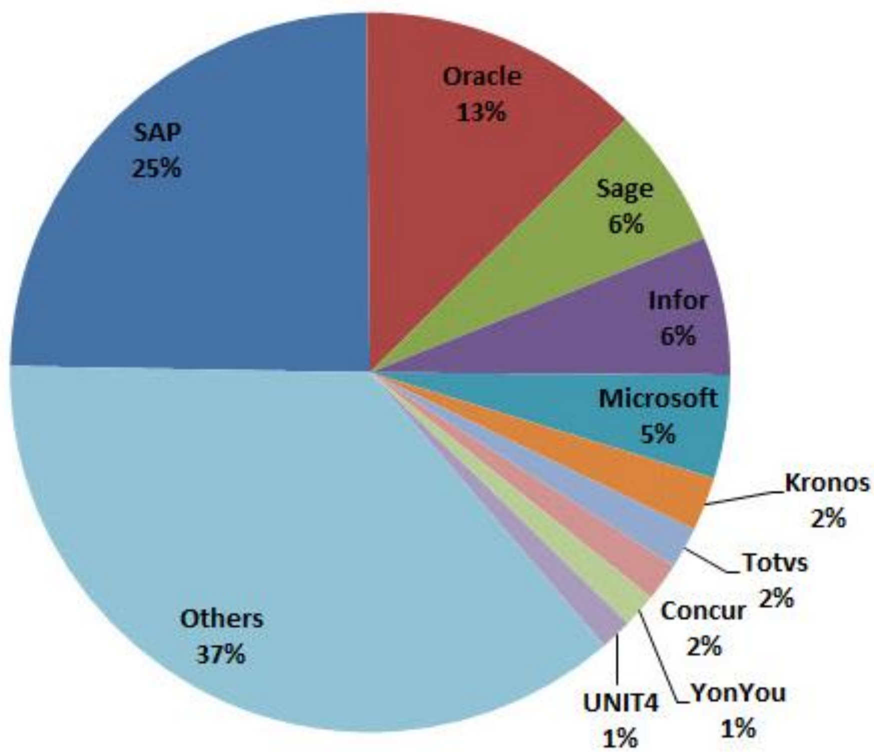


Figure 17 - Worldwide ERP software market share from 2012 analysis by Gartner (Columbus, 2013)

Microsoft is one of the most valuable brands in the world, only beaten by Apple (Forbes, 2013). The fact that AX is a Microsoft product is therefore regarded as the anchor point of AX (Ehrenberg, 2011). AX is a combination of extensive Microsoft research, development, and innovation investment to business customers wrapped in a unified solution. Describing AX in three words, the system is said to be powerful, agile and simple (Ehrenberg, 2011).

While ERP has been an evolution from MRP, ERP systems have had an evolution of their own, including Microsoft Dynamics AX. There have been published several versions of the system, and the system is constantly developed further.

3.4.2 The history of Microsoft Dynamics AX

AX was originally developed under the name Axapta by a Danish software company called Damgaard A/S (Luszczak, 2013). First version 1.0 of Axapta was released in 1998. The company was acquired by Microsoft in 2002, who rebranded Axapta to Dynamics AX in 2006 (Luszczak, 2013). When Microsoft released their version in 2006 functional enhancements was done, in addition to a new interface, showing a complete redesign with a Microsoft Office look and feel. Throughout the years Microsoft has released several new versions. The solution in this thesis will be based on the newest available version when evaluating the functionality of the system. Information of the different versions have been gathered and presented in the list below (Luszczak, 2013; Microsoft, 2014i):

- 2006 - Dynamics AX Version 4.0:
  New: Functional enhancements and interface with Office-look
- 2008- Dynamics AX 2009:
  New: Role centers, workflow functionality and improved interface. Functional enhancements including multisite foundation and additional modules to ensure an end-to-end support for the supply chain requirements of global organizations.
- 2011 - Dynamics AX 2012:
  New: User interface, role-based security, accounting framework with segmented account structures, enhanced use of shared data structures. More suitable for large multinational enterprises with facilitation for collaboration across legal entities and operating units within the application.
- 2012 - Dynamics AX 2012 Feature Pack:
  New: industry features for retail and process manufacturing

- 2012 - Dynamics AX 2012 R2:
  New: Data partitions, functionality for additional countries and support for the latest Microsoft platform including Windows 8
- 2014 - Dynamics AX 2012 R3:
  New: Enhancements and new functionality with focus on industry, apps and mobility, lifecycle services, and cloud.

As can be seen for every new version, functionality is added and changes are made to the system. One may assume that the system develops along with the company needs. Every new edition should be an enhancement from the previous one. However, every new version leads to the fact that companies with previous version become somewhat outdated.

3.4.3 Some basic functionality of Microsoft Dynamics AX

AX is built with industry-specific capabilities to be combined with core ERP capabilities. Figure 18 shows the different industry specific capabilities together with the core ERP capabilities, and key functionality for each of these (Microsoft, 2011a).

Figure 18 - Industry Specific Capabilities in AX

While all this functionality exists in the system, not all functionality is used by every company. For the ETO offshore and maritime companies the Services and Manufacturing of the industry-specific capabilities might be more important than Retail, Distribution and Public sector. Out of the core ERP capabilities Project Management and Accounting is interesting as the solution will focus on how to manage the project and production through the system. Financial management and Procurement and Sourcing for example will be as important for an ETO company as many other companies operating with other strategies. The company chooses what functionality to be used in order to meet their daily processes.

3.4.4 Relevant/important functionality in Microsoft Dynamics AX

To develop a generic vertical solution in AX the first step is to evaluate the functionality that already exists. Second, if the solution does not perform as expected, or meet the requirements for ETO processes, new functionality should be assessed. To evaluate the functionality with special focus on the maritime and offshore project lifecycle some functionality is especially important. Based on the important characteristics of ETO companies, their projects and business processes, relevant and important functionality that exists in AX have been identified through this chapter.

This chapter will look shortly at functionality that exists for the important business processes that have been identified throughout chapter*3.3.7 Business processes in ETO companies in offshore and maritime industry*. The quotation and project management are presented in one chapter as the quotation functionality lies within the Project Management and Accounting module.

3.4.4.1 Quotation and Project Management in Microsoft Dynamics AX

When evaluating ETO and making project management the core, the Project Management and Accounting module will play an important role in the general solution. One of the findings made by the authors in previous work (Hønsi and Sørbø, 2013), was to move the traditional focus from the MRP-functionality in an ERP system, over to how to perform project management throughout the lifecycle of an ETO project.

Microsoft documentation states that the module Project Management and Accounting can be used to plan, create, manage, control and complete projects in an organization (Microsoft, 2014a). Important tasks of this module are (Microsoft, 2014a):

- create a project contract
- create a project
- create a project quotation
- manage project forecasts
- create and submit an original project budget
- create and post invoice proposals

In Figure 19 Microsoft shows how the module supports the different business processes when running a project (Microsoft, 2014a). When initiating a project the quotation is done first, followed by making a contract if the quote is accepted. Then the creation of the project is initiated. In order to plan the project a WBS is created along with forecasts and budgets. The WBS was presented in chapter *Use of the WBS in a project* as an important project management tool. In addition, workers can be assigned their respective roles. From chapter*3.3.7.2 Project Management*, these are all processes that are mentioned in literature as a part of the initiation and planning of a project.

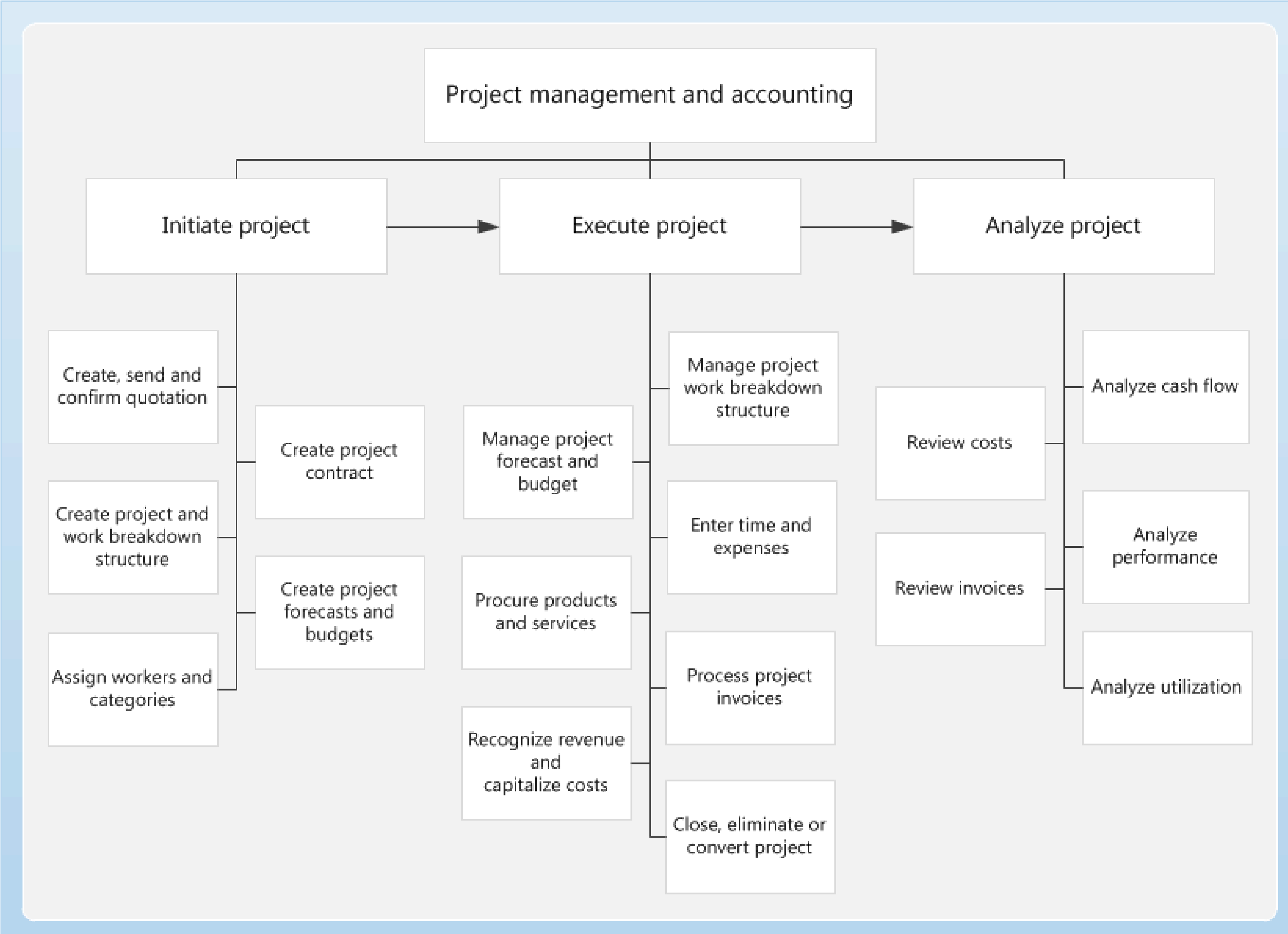


Figure 19 - Business Processes performed through the Project Management and Accounting module (Microsoft, 2014a)

As Figure 19 clearly shows, the phases are divided into initiation, execution and analysis of the project. The initiation is all about getting the project into the system and builds the foundation for further controlling. Execution is about controlling the project, both in terms of progress and cost. Extracted from Figure 19, important execution and controlling tasks in AX are (Microsoft, 2014a):

- Manage project WBS
- Manage forecast and budgets
- Enter time and expenses
- Procure products and services
- Process project invoice

- Recognize revenue and capital cost
- Close, eliminate or convert project

Lastly an important part of the project is analyzing the project, which can be used for further improvement. This figure can be seen as resembling with the generic lifecycle of a project in chapter*3.3.6 General Project Lifecycle*.

Quotation

The quotation is the initial step in the project. AX has various tools that can support this process. When doing quotations in AX, items and services that are quoted need information such as basic contact information, special trade agreements/discounts, taxes, and surcharges to be entered into the system (Microsoft, 2012b). AX also allows for activities and tasks to be selected at the quotation stage, which allows for already making the WBS (Microsoft, 2012b).

Further the ability to monitor, review and control the pipeline of the project quotation is suggested as an important part of the project management that AX provides tools for (Microsoft, 2011c). Analyzing the pipeline of the project can be supported by tools in AX such as correct reference data definitions; for example quotation types, quotation origin, and prognosis and probability. These tools can further be used to categorize the reasons for why a quotation was won or lost and determine the possible value of the quotation (Microsoft, 2011c).

Creation of the project

Projects in AX must be assigned as a certain type. Customer-focused projects, which are the case for ETO projects, must be chosen on a time and materials or fixed-price basis, as shown in Figure 20. In time and material projects, the customer is billed for all costs that are incurred on a project. These include costs for hours, expenses, items, and fees (Microsoft, 2011b). In a fixed-price project, the invoices consist of on-account transactions. Projects are invoiced according to a billing schedule that is based on the project contract. Throughout the project, revenue can be calculated and posted, and often they can benefit from using the values of work in progress to calculate degree of completion (Microsoft, 2011b).

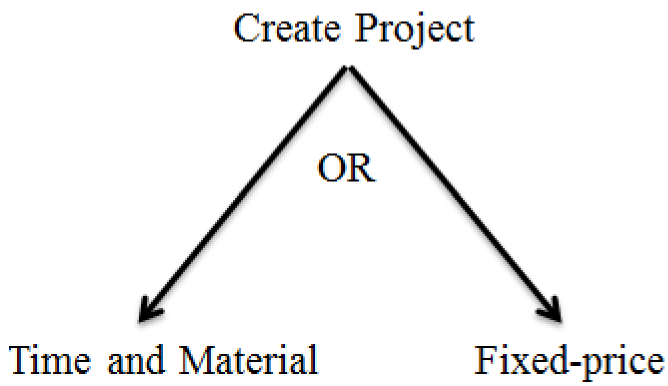


Figure 20 - Types of Project Based on Cost

Usually for an ETO project, prices are agreed to in the quotation phase which makes it a fixed-price project, and from there the company strives to deliver the product within budget to meet the requirements for desired profit.

Use of templates and wizards in AX:

AX allows for companies to make templates to be used when feeding data into the system. The system also allows for copies to be made from other projects, and then modified to fit the current one. The template-functionality has been identified for use in making quotations, project, WBS, and budgets (Microsoft, 2012a; Microsoft, 2012b; Microsoft, 2014b). Templates are used to ease the input process by using schemes that are already somewhat filled, and information is then being re-used and the process is more simplified. For example; templates in quotation allow for the users to create records more quickly, and help save time when creating similar quotations to those which have been done in the past. The usage of template allows for setting up projects more efficiently.

The wizards help transfer the data within the system, for example from quotation to creation of project (Microsoft, 2013b). When a quotation has been processed through AX, the system allows for functionality in order to transfer the quotation directly to a project with the help of the "project wizard" (Microsoft, 2013b). When creating a new project a project copy wizard can be used to copy a source project and customize it (Microsoft, 2012a).

The WBS in Microsoft Dynamics AX

The importance of a good WBS was emphasized in chapter *Use of WBS in a project*, and complications of planning an ETO project due to lack of information about the final product also affects the situation a great deal. In AX, the hierarchy of activities is identified by making the WBS and it also represents the sequence of tasks for a project (Microsoft, 2014b). In the WBS, tasks can be scheduled, education and experience required for the task can be specified, qualified workers can be assigned and estimated cost and revenue for a task can be entered. In order for the sequencing of tasks, dependability can be specified, where one task may require another task to be completed (Microsoft, 2014b). An example may be that the start of a design task depends on a specified planning task to be finished. The starting date for the dependent task can then be automatically set to the day after the predecessor task ends, instead of a specified date.

Following details for each task can be added in the WBS (Microsoft, 2014c)

- The sequence of tasks in a hierarchy
- Other tasks, if any, that must be completed before a task can be started
- The starting date, ending date, and duration of a task
- The number of hours required for a task
- Any required worker skills and education
- The workers who are assigned to a task
- Estimated revenue and costs

Budget and cost

As the name of the module Project Management and Accounting indicates, the module has a big focus on accounting and project costs. To efficiently manage costs in a project is important, especially when dealing with fixed price projects. When the revenue is final it is important that the project is controlled correctly in order to meet the profit goal.

The module allows for creating and monitoring project budgets for cost control. The purpose of the Project Budget functionality in AX is to help ensure that the project is well controlled and funded on time by providing functionality for viewing all aspects of the cost data.

A budget is created for the estimated costs and related revenue amounts for the project. Budget amounts can be entered manually or be copied from a forecast model or from another project. After the project budget is created it is submitted for approval (Microsoft, 2013c).

A project budget control is set up and enabled individually for each project. When transactions are entered, the balance amounts in the remaining budget are reduced. This creates an audit trail for each event, which makes it easier to track revisions (Microsoft, 2011d). Timesheets and expense reports can be entered into the system by employees and contractors to record project-related time and expenses (Microsoft, 2014a). Also indirect costs can be assigned along with definitions of calculations for the indirect cost amounts and be allocated to a project. Indirect costs are calculated based on the worker hours that are added to a project.

Integration between project management and other modules:

The information in a project evolves as the product design or manufacturing progresses through the life-cycle of engineering, detailed design, procurement, fabrication, testing, delivery, installation, usage, maintenance and disposal (Pandit and Zhu, 2007). One thing that can be accomplished through the use of an ERP system is with concern to collecting and sharing of information across the company. In terms of ETO, information about the ETO product needs to be shared between all participants of the project, which includes engineers, designers, estimators, suppliers, fabricators, contractors, architects, owners and their supporting information system (Pandit and Zhu, 2007).

As mentioned by Pandit and Zhu (2007), information in the project must be shared between all participants. The full solution should therefore be integrated in such a way to fulfill these requirements. Project Management and Accounting can be integrated with the following modules (Microsoft, 2014a):

- Accounts payable
- Accounts receivable
- General ledger
- Budgeting
- Cost accounting
- Fixed assets

- Cash and bank management
- Travel and expense
- Compliance and internal controls
- Human resources
- Set up procurement and sales category defaults for projects
- Product information management
- Master planning
- Production control
- Inventory and warehouse management
- Sales and marketing
- Service management

Integration with Microsoft Project

The Project Management and Accounting module allows for easy integration with Microsoft Project (MS Project). The project management and accounting module can be integrated with Microsoft Project Server for more flexible project planning (Microsoft, 2014a), which may be a wish for ETO companies.

By combining the capabilities in the Project Management and Accounting module in AX with MS Project, it can help the company gain more visibility into the projects and project resources, and manage them more effectively (Microsoft, 2013a). The integration allows for corresponding hierarchies that makes it possible for information about projects, subprojects, and activities to flow between the two programs (Microsoft, 2013a).

3.4.4.2 Design and Engineering in AX

AX does not provide any functionality for the design and engineering. In order to integrate the design and engineering process with AX, it is possible to integrate AX with a PLM system.

For the integration, products in the PLM system would be integrated with the BOM of the product located in the Product Information Management module. In the product information module, products are firstly defined and then released. For the data to stay correct it must be maintained (Microsoft, 2014e).

3.4.4.3 Procurement in AX

AX has the module Procurement and Sourcing to handle procurement. Purchasing policies can be created to control this process. Main functionality of the purchasing processes in the module is to identify suppliers, onboard suppliers as new vendors through an approval process, maintain vendor information, create agreements with the vendors, order items and/or services, maintain purchase orders and agreements, and confirm receipt of products (Microsoft, 2014d). After the transactions for the vendor are processed through Accounts payable, the spending and vendor performance can be analyzed (Microsoft, 2014d). This functionality is illustrated more in detail in Figure 21 (Microsoft, 2014d).

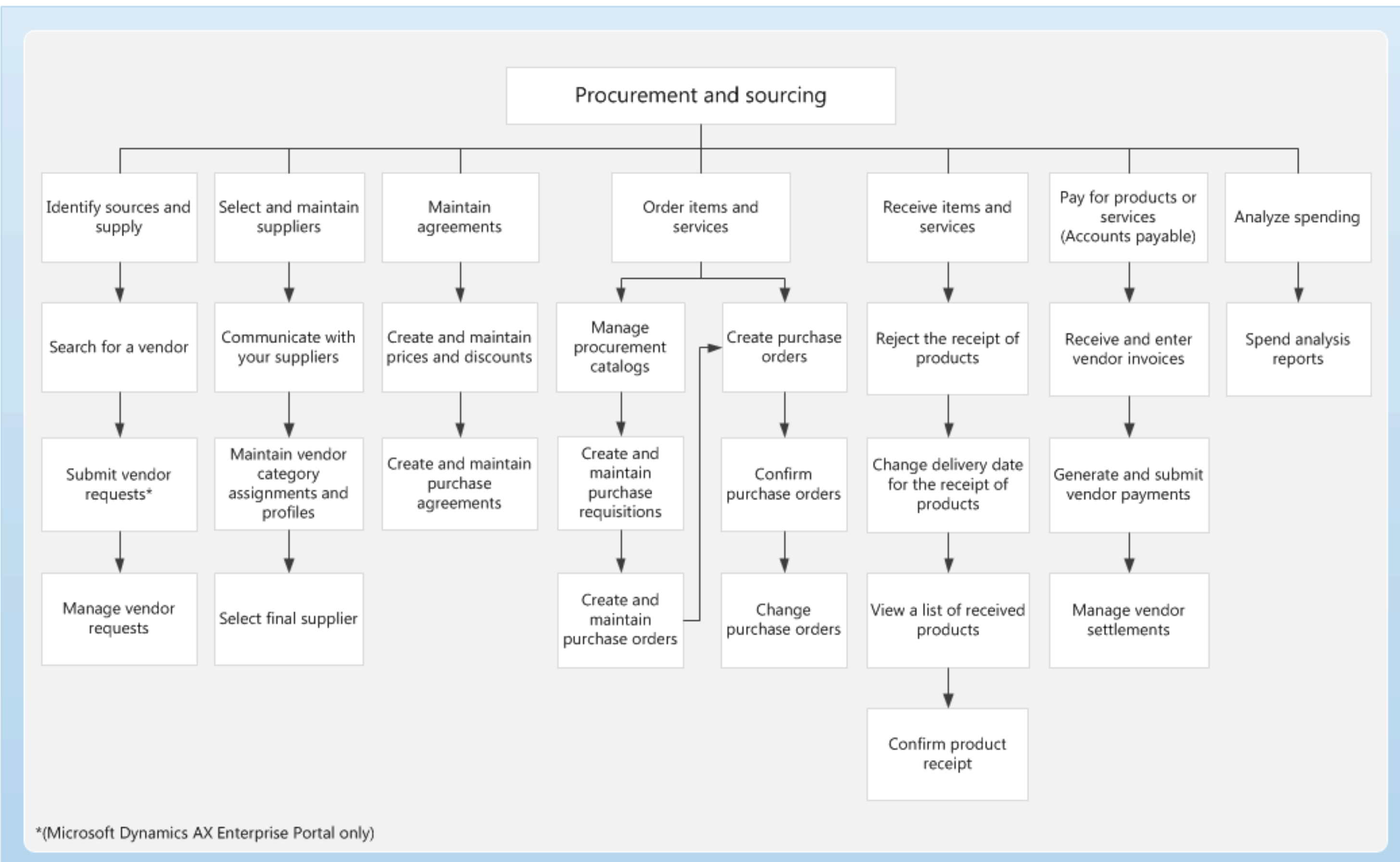


Figure 21 - Procurement and sourcing business process in AX (Microsoft, 2014d)

The procurement and sourcing module is also integrated with the master planning module, which has functionality for forecast and master scheduling (Microsoft, 2014d). The master scheduling uses the MRP, material requirements planning, and calculates net requirements for items in order to fulfill the demand. It provides a capable to promise calculation and available to promise calculation based on the plans in AX (Microsoft, 2014d). This is a tool for doing procurement, as it provides for an overview of what items is necessary to procure. The planning may also be optimized by processing action messages and future messages that are generated during master scheduling (Microsoft, 2014d). This information can be used to modify planned orders. A more detailed view of master planning can be viewed in Figure 22.

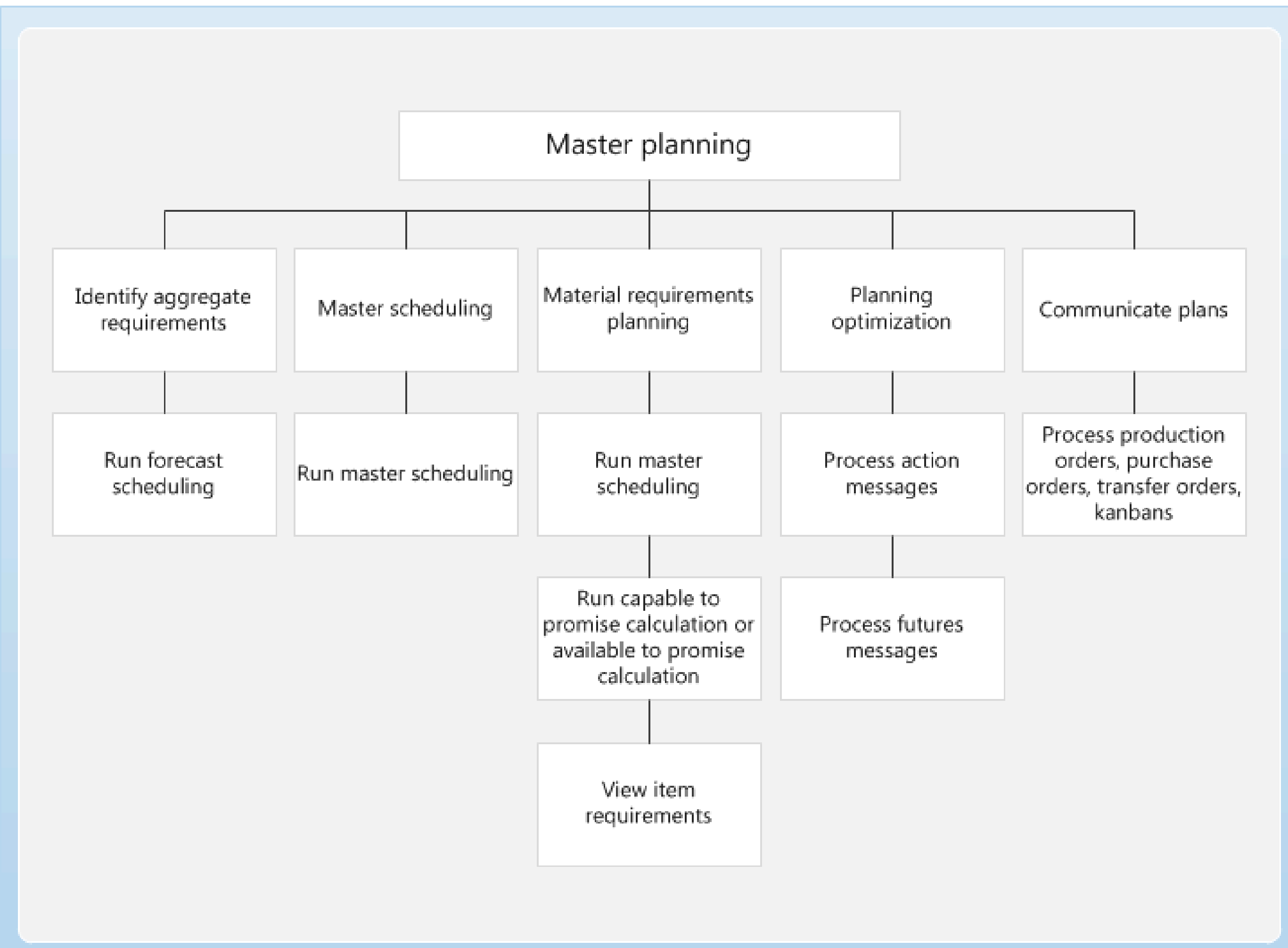


Figure 22 - Master Planning in AX (Microsoft, 2014d)

The procurement and sourcing module is also integrated with inventory management, so that when a receipt is confirmed, the inventory status will be updated (Microsoft, 2014d). It is of course integrated with the product information management module, where the information of the products is stored, in addition to the Accounts payable module and General Ledger module for cost purposes (Microsoft, 2014d).

3.4.4.4 Production in AX

AX has its own Production control module, with the key functionality of Material and capacity planning, resource management, job scheduling and sequencing, product configuration, and shop floor management (Microsoft, 2011a). The module can be used for managing and tracking production activities. Figure 23 tries to illustrate the different tasks that are executed during production control (Microsoft, 2014f).

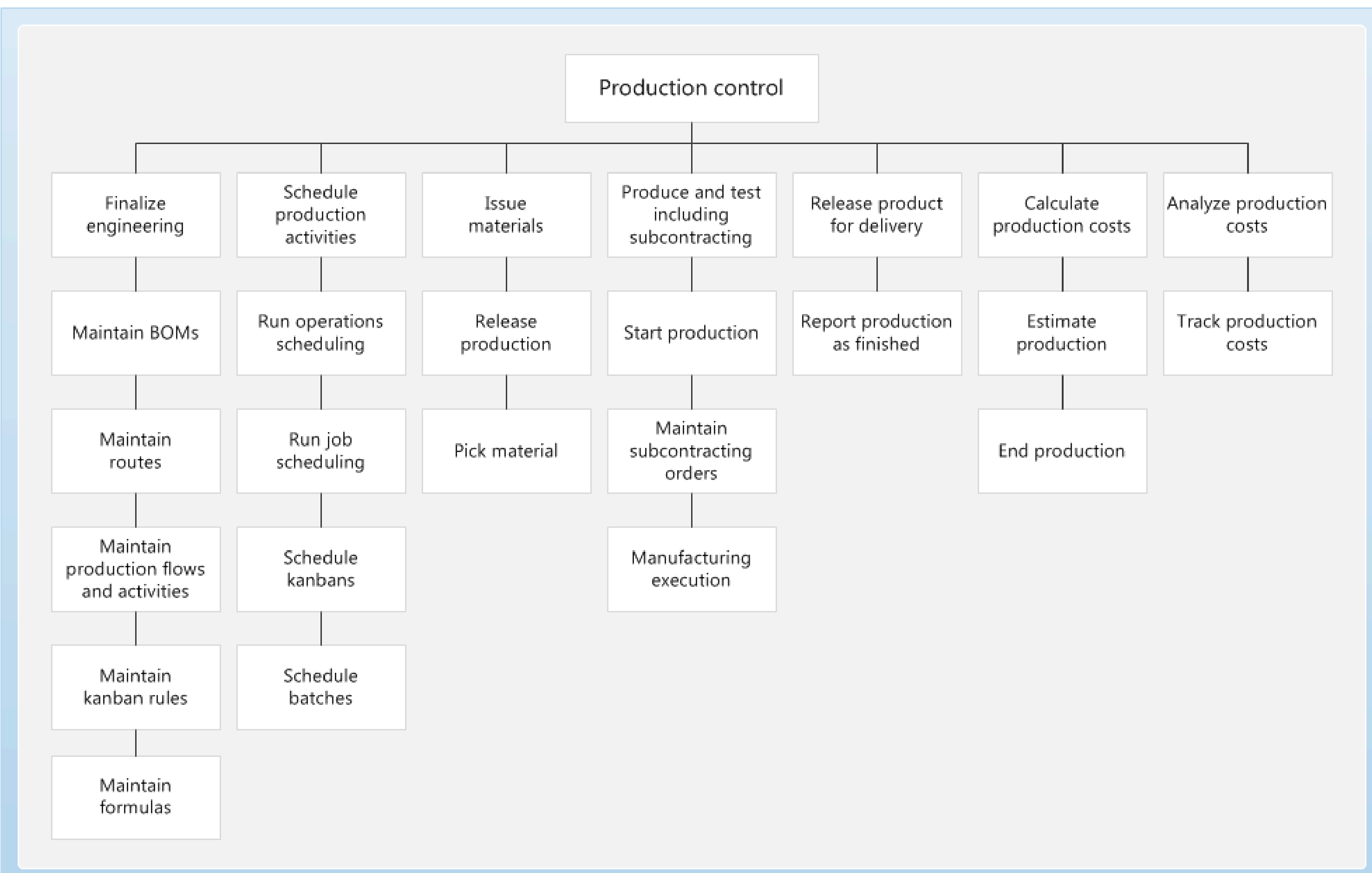


Figure 23 - Production control in AX (Microsoft, 2014f)

As can be viewed from Figure 23 one of the tasks is to finalize engineering. This is done in order to finalize the BOM, routing, production flow and activities. When these are set, scheduling of activities and jobs can be done, so that material and route consumption can be tracked when the production is later initiated. During production, feedback can be registered into AX by using manufacturing execution functionality (Microsoft, 2014f), also when the production has started costs can be posted against the order (Microsoft, 2014g).

AX documentation describes the production life cycle, where the production follows specific steps that are needed to complete the manufacture of an item. Every step in the life cycle requires certain types of information in order to complete the process. Therefore, in order to support the information flow that is required to complete the item, the production control module is integrated with the modules; Product information management, Procurement and sourcing, Inventory management, Master planning, and Cost accounting (Microsoft, 2014f; Microsoft, 2014g). The production life cycle in AX is as following; create - estimate - schedule - release - start - report as finished - ended. For each step that is completed, the production order changes status (Microsoft, 2014g).

The fact that finalization of engineering is required, as shown in Figure 23, contradicts with how ETO does production. ETO companies are often involved with concurrent engineering where design and engineering, procurement, and production are being initiated in parallel. The production is then initiated before the BOM is ready, which may lead to complications with concern to the production functionality in AX.

3.4.4.5 Installation/service/maintenance

AX has a Service Management module with the key functionality of service orders, agreements and contracts, calls and dispatching, repair management, service subscriptions and to manage and analyze the delivery of services to customers (Microsoft, 2011a; Microsoft, 2014h). Service agreements can be used to define resources used in a typical service visit, and to view how these resources are invoiced to the customer (Microsoft, 2014h).

A service order is created in order to manage information about visits to a customer site. It includes information as (Microsoft, 2014h):

- The hours of work that the service technician will perform
- The type of service or repair
- The item to repair, including details about the symptoms and diagnosis
- Any expenses and fees related to the service or repair

When an order is received service stages can be used to monitor progress and specify rules that control what actions are enabled in each stage. Reporting tools can help monitor service order margins and subscription transactions, and print work descriptions and work receipts (Microsoft, 2014h). A more detailed view of the business processes for service and maintenance with its integrations, is illustrated in Figure 24 (Microsoft, 2014h)

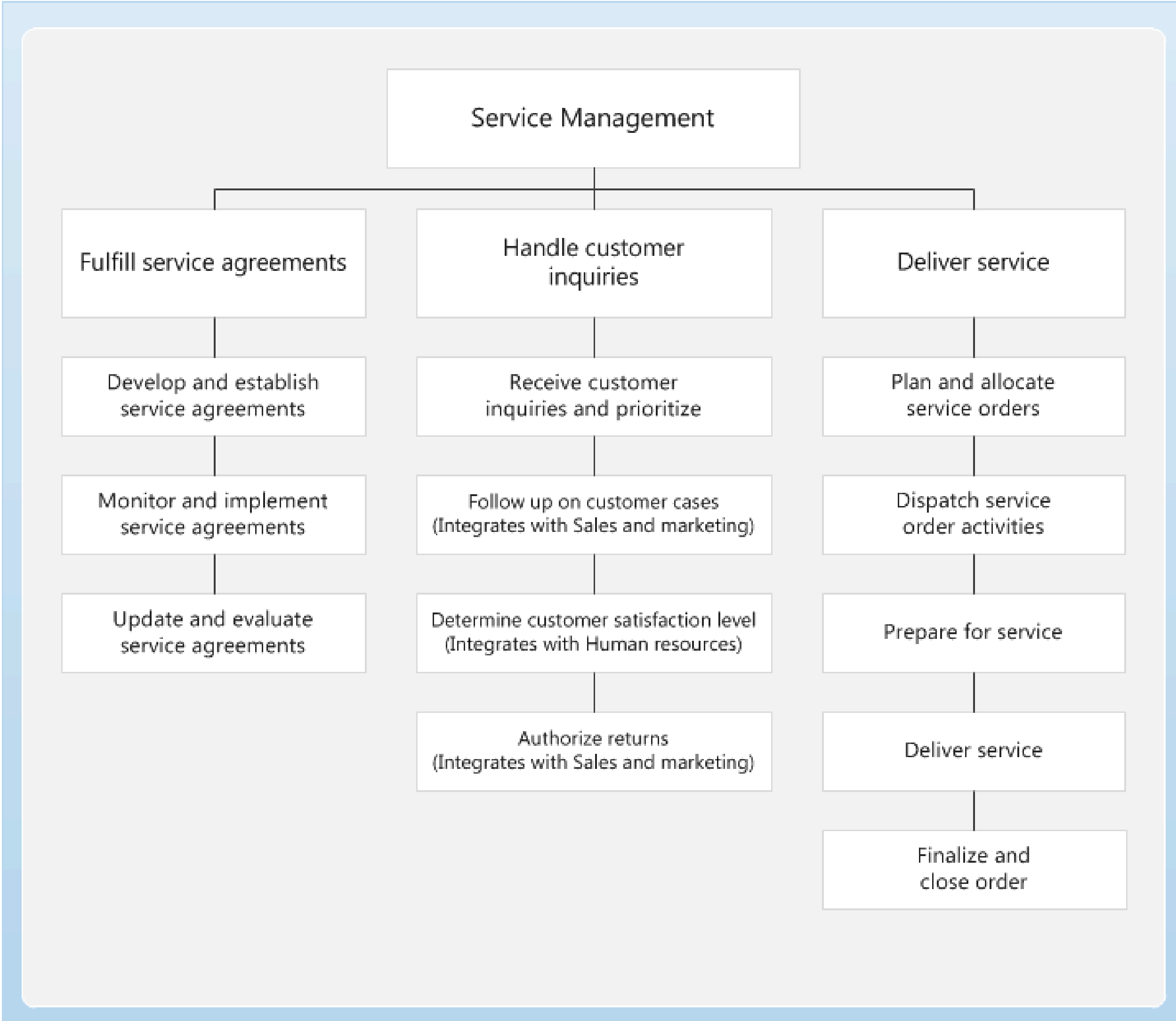


Figure 24 - Service in AX (Microsoft, 2014h)

3.4.5 Summary of functionality in AX

There does exist some functionality in AX for most of the important ETO business processes. ERP systems in general and AX are comprehensive systems covering multiple parts of the business. However unforeseen problems often arise during implementation. More information is needed in order to say that these processes can be solved sufficiently through AX. There is no module in AX designed specifically for covering ETO needs. In order to solve ETO requirements in AX, ETO must instead be viewed as a project, for which AX has functionality for managing. As integration with MS Project is suggested for more flexible planning, a solution could be to integrate with MS Project, as ETO production is a complex process that requires flexibility.

One case of misalignment between ETO and AX has been identified. Full functionality in the production module cannot be exploited as it requires the BOM to be finalized in order to add the routing for the production.

3.5 Findings Literature Study

In conclusion, the findings from this literature study consist of:

- General benefits from ERP in *3.1.2 Identified benefits in literature*
- Problems from current situation of ERP in ETO transformed into table of requirements from *3.1.5 Rephrasing the ERP-problems in ETO to ERP-requirements* in Table 3
- New differentiation of ETO introduced in *3.2.3.1 Need for differentiation of ETO* and Figure 4
- Creation of a new framework based on customization vs. complexity for products in the maritime and offshore ETO industry in *3.3.5 Establishment of an ETO Framework* and Figure 8
- Define business processes in ETO project that must be focused on during design of the general vertical solution in *3.3.7 Business processes in ETO companies in offshore and maritime industry*.
- Business processes used to explore existing functionality in AX in chapter *3.4 Relevant/important functionality in AX*. Some weaknesses have been identified, but empirical study is needed to evaluate if system is sufficient.

Based on this research and its findings, as well as the criteria from the Project Paper (Hønsi and Sørbø, 2013), a survey that will be used in the case studies has been generated, which can be found in Appendix C. Survey and Interview Questions.

4 Case Studies

This thesis has conducted three interviews and surveys. This will be the basis for the case study and the results. First of all there will be given a short introduction of each company. Then the empirical results will be presented. In order to evaluate the information gathered, the information from each company will first be presented with consideration to certain topics that the thesis is focusing on.

The topics that will be presented during the individual case company assessments are:

- Product evaluation
- Project dimensions
- Project execution and software solution

4.1 Background on Case Companies

4.1.1 OneSubsea

OneSubsea is a joint venture, where 60% of the company is owned by Cameron and 40% is owned by Schlumberger (Pump Industry, 2013). The mix of two global companies lets OneSubsea tap into valuable knowledge from both angles. Cameron is known for fields such as flow control, process technologies, manufacturing and aftermarket capabilities, while Schlumberger is known for their petro-technical leadership, reservoir and production technology, and R&D capabilities (OneSubsea, 2013a). Thus, OneSubsea deliver products and services to the subsea oil and gas market, where they offer a change in reservoir recovery through integration and optimization of the entire production system over the life of a field (OneSubsea, 2013a).

4.1.2 TTS Offshore Handling Equipment AS (TTS)

TTS Group ASA is a global enterprise that designs, develops and supplies equipment solutions and services for the marine and offshore industries. TTS Group ASA is one of the top three largest suppliers in its specialized market segments (TTS, 2014a). The companies are described as an all-round group that provides solid foundation that enables them to assemble complete project teams with expertise in the fields required.

TTS Offshore Handling Equipment, from now on called TTS, is part of this group, and is responsible for engineering and production of a complete range of lifting equipment for offshore vessels (TTS, 2014b). The lifting equipment will always be made specific to the vessel type it is supposed to be installed on, and therefore operate with an ETO strategy. Over the years TTS has developed better and safer solutions for subsea load handling in rough and deep waters (TTS, 2014b).

4.1.3 Kongsberg Maritime

Kongsberg Maritime is a Norwegian company that focuses on market segments such as merchant marine, offshore, subsea, and marine information technology (Kongsberg Maritime, 2014b). Their base is in Norway, but the company has offices around the world (Kongsberg Maritime, 2014a). Kongsberg Maritime was established by Kongsberg Våpenfabrikk in 1995 as a separate business area. Kongsberg Våpenfabrikk is one of the oldest industrial factories in Norway, and was established in 1814. Kongsberg Våpenfabrikk is today known as Kongsberg Gruppen and KONGSBERG (Kongsberg Maritime, 2014a).

Kongsberg Maritime's products range from delivering systems for dynamic positioning and navigation, marine automation, safety management, cargo handling, subsea survey and construction, maritime simulation and training, and satellite positioning (Kongsberg Maritime, 2014b). Kongsberg Maritime also provide services such as training, product rental, engineering, recycling, and retrofit/refit (Kongsberg Maritime, 2014c). Key markets are defined as countries with large offshore, shipyard and energy exploration & production industries (Kongsberg Maritime, 2014b).

4.2 Empirical Results

4.2.1 OneSubsea

OneSubsea's software solution is based on the use of three software programs that are integrated into one large system that is used throughout the company. The software used is the PLM software Teamcenter, the project planning software Primavera, and the ERP system AX 2009 (Breivik, 2014).

4.2.1.1 Products

This case study has revolved around OneSubsea's production of three main product groups. Each product group is manufactured by OneSubsea, but some of their work-packages/ components are outsourced (Breivik, 2014). The main and most advanced technology is done inhouse to keep the core competency inside the business. The product groups all have different degree of customization, where two of the groups definitively fit the ETO strategy. The third group is classified as AdTO. Therefore, all products are only manufactured when customer orders are placed (Breivik, 2014).

The AdTO product group is multiphase meters, which is a product that can be placed inside a pipe to measure certain values. An example of a measurable value; "how much oil or gas flows through a cross section in the pipe at any given time" (Breivik, 2014). These products are smaller in size and cost less to manufacture than the other groups, but on the other hand they are sold in higher quantity. Because of the AdTO strategy and the lower complexity of the product, the orders are managed by forecasting.

The mid-sized product group is called "Swivel". The Swivel ensures that all fluids, controls, and power are transferred safely from the geostationary components (wells, flowlines, manifolds, risers) to the rotating vessel and its processing plant, under all environmental conditions (OneSubsea, 2013b). These products and projects are larger in size than the multiphase meters, but they are smaller than the last group of products (Breivik, 2014).

The last and largest group of products is customizable multiphase subsea pumps. These are the most complex products that handle pumping of oil and gas (Breivik, 2014). Multiphase pumps handle water, oil, and gas mixtures with high gas volume fractions (OneSubsea, 2013c). The pump regulates the pressure to get the fluids to go where it is supposed to go, either up or stay down in the well/pipe (OneSubsea, 2013c). A pump project is delivered as a pump system, and may consist of several pumps in one delivery (Breivik, 2014). A pump project might consist of 5 pumps to be delivered at different dates, combined with other extra equipment such as umbilical, cable profiles, spare parts, and installation equipment.

4.2.1.2 Projects Dimensions

Each product will have different project values. In Table 6 below there are certain variables defining the different OneSubsea projects.

Table 6- OneSubsea project dimensions (Breivik, 2014)

	Swivel Systems	**Multiphase Meters**	**Pump Systems**
Sale Sum (million kr)	Closer to pump than multiphase meters	1-3	1000-1500
Work Hours (thousand hours)	Closer to pump than multiphase meters	2-2,5	120-220
Years per Project	Closer to pump than multiphase meters	NA	2-2,5
Projects	1-2 parallel projects. The projects are in different lifecycle phases.	150 sold per year (1-20 multiphase meters sold per project)	4-5 parallel projects. The projects are in different lifecycle phases.

The table is not complete, but it gives a pointer of the dimensions of the projects. The pump is the largest and most complex project compared to the other products. Although, the Swivel variables are not very descriptive it was made clear in the interview that they were a "degree/grade" below the pump-size of projects, while multiphase meters were the smallest in size, but the largest in quantity.

Regarding the ETO strategy for the projects and products, OneSubsea uses a combination of EnTO and AdTO strategy. There is a wish to evolve more towards standardization and the use of

AdTO strategy to cut cost and lead time. During the interview there was made an interesting comment on the degree of customization. Right now the oil and gas industry's use of money reflects the degree of customization of products they buy. Because the industry has the ability to spend large amounts of money, the customization will be high and product price will be high. On the other hand, a trend that might appear is the need to cut costs in the offshore and maritime sector. When cutting costs a result may be that customers of OneSubsea will need to buy cheaper and more standardized products. This trend will affect OneSubsea, and help push production towards AdTO. However, because of the current customization situation there is not a fast pace towards standardization.

4.2.1.3 Project Execution and Software Solution

The integrated solution was designed to take over all existing tools used in the company. The implementation project was, and still is, very large and complex. On the other hand, OneSubsea valued the benefits of one integrated solution. The implementation has rolled out functionality over time, where most of it is now in use. Because of the complexity and size of the system, all parts of the system is not used in an optimal manner yet. The correct and intended use of the software takes time to realize, but with good leadership and defining the right methods for the system the company intends to standardize processes and get full use of the functionality that the software offers. There has also been initialized reporting of "lesson learned" from each project, where valuable experience is transferred to new projects. This is done manually through meetings.

Quotation

Quotation is conducted in Primavera. AX did not satisfy the need for the quotation process OneSubsea operates with. Breivik said (2014) there may often be piles of documents attached to one project, and Primavera can handle this complexity better.

During the quotation, Primavera does support planning of due date, cost, and capacity. Whenever a new project is quoted the users starts with a template WBS that is used for cost estimates, which then is made into a project.

Project Management

Primavera is OneSubsea's main project management tool. Breivik mentioned that the reason for choosing the software was because of it being popular in the industry, as well as it is more advanced in its functionality than both AX and MS Project. Because Primavera is favored in the industry, OneSubsea can easily exchange information with its customers.

Everything regarding project management is done in Primavera; planning, budgeting, cost control, master data, etc. AX is integrated with Primavera, but only as a one-way integration. Primavera is a "closed box", and cannot be changed and modified as AX can (Breivik, 2014). Therefore, AX is in charge of the integration. By manually telling AX to integrate, AX initiates a project and gets the information from the corresponding project in Primavera to fill in information. Usually, AX is updated when most of the project information is present. If there is a change in Primavera, AX must be integrated once more to update its values.

Each project has a WBS with its work packages defined in Primavera. Each level down can represent subprojects within the larger project, whereas the top level represents the final system of products to be delivered to the customer. The BOM is also very important in all projects.

Design & Engineering

During the design and engineering phase the PLM software Teamcenter is used and all engineering tasks are conducted here. All information, documentation, and specifications on the products are stored in Teamcenter, and thereby also the BOM.

The integration between AX and Teamcenter is updated every night, automatically. Then all changes done during the day are propagated to AX and its corresponding values.

Procurement

Procurement of materials and components is handled by AX. The multiphase meters are the most standard product and therefore managed by forecasting. This functionality is present in AX, but not taken into use just yet. The procedure used today is manual forecast based on variations of the multiphase meter product. It is the engineering department that makes the different meters, while the management makes the forecasting decisions based on resources and capacity. The differently designed meters have fictional BOMs and the components are then ordered based on the master plan. All forecasting is done in Primavera, and is done once a month. Because the frequency of forecasting is low, there is no integration made for this functionality as it was not considered a valuable investment.

The other products are managed by MRP, and orders are suggested based on it, but the orders are manually overlooked and changed/approved. According to Pål Breivik, this functionality is critical for keeping track of all parts and components. It would be too much work and a complex process if it was to be done manually. The biggest challenges during production is to estimate lead-times correctly due to uncertainty in the design. In addition, it is hard to decide how many of what components must be included in the procurement orders, as the BOM is not yet entirely complete, which is also because of the design being unfinished. When setting dates, these dates have to be flexible. Changes should also be discovered quickly as they occur.

By effectively conducting procurement there is a wish to not have any capital tied up in inventory longer than necessary. The estimation of lead-time is challenging, mainly because of concurrent engineering. Some components/products also change design after orders have been placed at suppliers, which is a risk OneSubsea is aware of and have to accept.

Production

Even though the BOM is not complete, the solution does support initiation of production of components. Today, OneSubsea does not use routing and detailed production in AX, but this is something they wish to explore further. Currently Primavera is used for scheduling, and it is here details of the production are registered. Smaller activities are organized from the larger project and are posted on a board where the employees conduct the production. This is a leanboard-system. Although, the production orders are in AX, the reporting of finished components/products is done in both AX and Primavera.

OneSubsea also operates with the strategy “free issue”. This is a way of contracting work to suppliers, where the customer, here OneSubsea, provides the necessary material and specifications for what is to be done. The outsourced production does not incorporate anything regarding the core technology of OneSubsea, as they want to keep their competitive advantage inside the company and not create new competitors.

As previously mentioned, because of the risk of components changing after an order has been placed, OneSubsea has taken use of a method. This method is called conditional release. Each component or product is released for production, but there are constraints set on it. AX has functionality for registering conditions. The customer must accept the design and constraints before delivery of the product. The risk taken by manufacturing before the entire BOM is finished has to take place because the supply chain must be defined to reach the deadlines of the timetable and lead-time estimates.

Installation and Service/Maintenance

When products are completed during projects, the products are shipped to the customer. As a service OneSubsea offers monitoring of products, and service and maintenance on them. To keep track of all the products the solution has an installation register, which is closely tied to service/maintenance functionality. Together this forms a module in AX that is built on top of the project management module. This module is therefore a combination of installation and service/maintenance module, and was bought as an independent module from a Danish company and integrated into AX.

When service and maintenance is needed offshore, a work order is initiated in AX based on an object in the installation register. The object is a product. The work order is used to keep track of costs, spare parts needed and used, work hours, comments on service done, etc. This is the standard onsite maintenance and service OneSubsea offers. On the other hand, the company also has an aftermarket department that uses a separate system to keep track of the monitoring of information gathered from the products running offshore. This system is not integrated with AX in any way. This solution offers a web-portal for customers, where data from offshore are displayed in reports.

Other

When production is complete the product needs to be shipped to customers. Each project may contain multiple, independent products that may be complete at different times. Each product may also be needed by the customer at different times. As a result, OneSubsea has taken into use a module in AX called the shipment module. This module is also built on top of the project management module, same as for the installation and service/maintenance module. The shipment module has functionality for building deliveries based on item-list of finished products. As a result, there are multiple ways of shipping parts to customer.

Another topic that was discussed during the semi-structured interview was change management. This includes change management for time and cost of a project, as well as change management of the engineering of the product. Change management of time and cost is managed by personnel responsible for their part of the project. If changes occur, the information is communicated to the correct person who changes the values in Primavera. These are often project managers, or sub-project managers. For the engineering of the product, concurrent engineering leads to change in design during large parts of the projects in OneSubsea. As a result, the use of revisions and acceptance of revisions is used. These revisions take inventory, processes, and other variables into consideration. All changes are done in Teamcenter, and then updated in AX, to prevent employees working in two systems.

Lastly, on the matter of what was the most challenging aspect of implementing an integrated software solution was getting the employees to work in a normal, routine, and correct way with the system (Breivik, 2014). Because all previous systems were changed, the methods and processes in the company had to change. Also, the company has grown from a small company, to a greater size, which brings along more customer, larger contracts, more products, and bigger responsibility for the supply chain.

4.2.2 TTS

TTS is a company that is part of a larger group of companies, and therefore has a specific area of expertise in a wider network of businesses. TTS has the responsibility for engineering, manufacturing, and delivery of products, as well as responding to calls regarding the equipment during the warranty period. After the warranty period is over, normal service and maintenance is carried out by a different TTS Group company.

TTS's software solution is a combination of integrated and non-integrated software, consisting of the ERP software AX 2009, the project management software MS Project, and the visual drawing studio autodesk VAULT. The software called EME is also used by the sales department when conducting quotes, which has a small integration with AX. The solution is very specialized and tweaked to best fit TTS and their daily routines. The TTS Group is currently trying to implement the software into all TTS Group companies.

4.2.2.1 Products

TTS's main product is customizable, offshore cranes. The total customer order can consist of cranes, different extra equipment, and spare parts. A project containing a crane is rarely done more than once, and the products therefore will always need to be changed for each customer order. Each crane also needs to be installed on a rig/vessel.

Some of the cranes include a technology for keeping the hook steady in all weather conditions. These types of cranes take longer time to produce than cranes that do not contain the technology. This technology is called "hiv kompansert kran" in Norwegian, and can be translated to "heave compensated crane". Examples of extra equipment can consist of grippers and pipe handling equipment. The gripper is used to lift pipes, which cannot be lifted by regular hooks on the crane. The extra equipment is not considered as standard equipment.

4.2.2.2 Project Dimensions

Each customer order is defined as a project, where each project can contain one or multiple cranes, as well as extra equipment. Because each project is very different from each other there are very contrasting estimates on the dimensions of the projects conducted in TTS. Below in Table 7 are the values that were acquired from the semi-structured interview with Kjartan Ringseth. As the values show, the cost of a crane project can vary a lot, while the project duration is mostly the same. At the time of the interview there were 16-17 different parallel projects in different phases, like engineering or commissioning, that TTS were responsible for.

Table 7 - Project Dimensions TTS

	Sales Sum		Project duration (months)	Parallel projects in different phases
	Low (million NOK)	High (million NOK)		
Crane Project	10	120	15-16	16-17

Regarding the strategy for the projects, TTS currently place itself in the EnTO dimension. However, as OneSubsea, TTS also want to move more from an EnTO strategy to AdTO. This is currently quite difficult because each customer order is too contrasting, and the need for customization hinders the standardization of products. Also, the systems used by engineering have not been considered satisfactory for the AdTO strategy.

When asked what TTS though about trends in the offshore and maritime industry, they reply on the same note as OneSubsea. The oil and gas industry has to use increasing amounts of resources to get oil and gas up from the ground. This will in turn affect other parts of the industry because cost need to go down other areas to make the mining profitable.

4.2.2.3 Project Execution and Software Solution

As previously mentioned, the software used by TTS is a group of independent software solutions with little integration.

Quotation

The quotation stage is not handled by AX at all. The sales department uses EME when conducting quotes, which has simple integrations with AX. This integration transfers information on what type of products are to be included in each customer order/project.

AX was considered too simple to handle the quotation process.

Project Management

Project management of a customer order is handled in MS Project. The first step in a TTS project is to create a generic WBS that all projects follow. The WBS includes main parts and activities of a crane that are present in most products, but not any customizable parts. The WBS is structured with levels in a hierarchy, where the top level represents the final, total customer order and all its products. The second level illustrates the different products the customer order consists of, and levels below are different sub-projects within each product. In other words, all products are connected to the WBS. The structure also captures information on parts, hours, and activities.

Although MS Project is used, there is no integration between it and AX. As a consequence, the WBS has to be created twice and manually updated for each customized part and change made to the WBS. All registration of finished components is also only registered in MS Project, whereas AX does not keep track of how far the production has gotten. When registering finished components in MS Project, the TTS team on the project operates by milestones, where they recognize how far they have gotten, percentage-wise, when certain work packages are done.

Sometimes there are additional orders that are added to an original customer order. These orders are quoted, and then added to the generic structure of the original WBS in AX and MS Project.

A benefit TTS wanted from implementing AX was to increase information management. TTS uses AX to view previous project information that helps make better predictions on new projects with similar characteristics. An example is looking at the cost of a project that contained X number of hydraulic elements in a component, and then use it to estimate cost in a new project that will contain the same or similar amount of hydraulic elements.

Lastly, regarding other project management software, TTS evaluated the use of Primavera. According to Kjartan Ringseth, there has been, and still are, enquiries made for acquiring it by employees working closely with project management. However, when evaluated for TTS it was not a complete match. MS Project is therefore still the software in use for project management.

Design & Engineering

The design and engineering of products is conducted in VAULT autodesk. Vault does have integration with AX, where AX gets all product information from Vault. Vault is therefore solely responsible for BOM, documentation, specifications, and design and engineering of components. The components are transferred to AX and then tied to the WBS.

The use of previous projects is very hard, because the customer requirements are very contrasting. An example mentioned during the interview was a crane that is currently being designed for Statoil. The crane is so special and tweaked with requirements, that Kjartan claimed that no part could ever be reused for other new products. These cases take very long time to engineer, because the designers have to start from scratch. Although customization is the case now, there is a wish to standardize more of design and engineering in the future. Nonetheless, it is very dependent on customer requirements, and the trend is now still based on wanting new products for each customer order.

Procurement

TTS stores information on products and components in Vault. AX then uses the information on the BOM for procurement purposes. When there is a need for components, a team sits down and maps the demand, then register it in AX, note down the requested receive date, and lastly generate a plan based on estimated lead-times. The demand is therefore manually calculated and entered into AX, which generates a procurement plan. The components are ordered on specific dates to prevent any components being stuck in inventory. Keeping inventory on specialized parts ties up capital, which TTS wants to avoid.

However, some of the components have longer lead-times, and must be procured earlier for the project to finish on the scheduled date. To avoid delays, TTS has a list of components that are known for their long lead-times. New projects use the list to establish what components are critical and have to be engineering first. When done, the purchasers are put on the task of negotiating with supplier and procuring the component, often before the remaining components are designed.

Another important aspect of procurement, that is very special for TTS, is the shipment module. This module is very customized for TTS, and is used to keep track of all project components. Because TTS uses suppliers all over the world, and work on a predefined time schedule, it is imperative that there is some way of keeping track of status on components. It is therefore considered the “company logistics” function. The shipment module also generates documentation that has to be shipped with components. This functionality was engineered for TTS because manual retrieving of documentation would take a lot of time. An example is when sending components to China, where there are very strict regulations on what information must be presented at the border regarding the components. The functionality is therefore critical for TTS.

Production

The off-the-shelf production module, offered by AX vendors, was considered by TTS to be more favorable to mass production companies than for ETO production strategy. As a result, AX does not handle any production for TTS. On the other hand, production of components is registered in MS Project and as previously described, certain milestones determines the progression of the project. The reporting of finished production is done by people responsible for the project/ sub-project.

If components contain faults or break during testing and production, deviation projects are initiated. These projects are coupled with the original project. They only register faulty components, while the original project shows which components are needed to finish the crane. The separation is done to get statistical information on components. If a type of component often breaks, there is reason to either improve it or change the supplier to improve the statistics.

4.2.2.4 Installation and Service/Maintenance

Because TTS is a part of a larger group of businesses, another business in the group offers service and maintenance on TTS Group products. Therefore, TTS does not conduct service and maintenance on their products. On the other hand, there does exist a warranty period after the delivery of the product. Then TTS does have responsibility to respond to calls regarding the cranes and extra equipment. If this happens, warranty projects are generated. These projects register work connected to the warranty period. Information such as man-hours, spare parts used, and comments are registered in the project. The warranty projects are given the same name as the original project, but with the letter “w” in front of the name to indicate the connection between the projects.

Other than during the warranty period, TTS does not have to keep perfect track of the product, and therefore does not need an installation register. However, TTS does conduct a commissioning phase. This is when employees of TTS go onsite and test the finished product to check if all requirements are met and that the crane is functioning properly. There exist different analysis that can be done, like HAT and FAT. These analyses are part of the generic WBS project structure, and are conducted for all finished products.

FAT is “factory acceptance test”. The product is tested after assembly of all components to see if all components function as they should. HAT is “harbor acceptance test”. This is often testing of the heave compensation technology. The test checks if a load lifted by the crane is kept still during different weather conditions. The crane has to adjust itself to for example waves and wind. This functionality is very important when placing large subsea components on the seabed.

Other

Shortcomings that were disclosed during the interview were based on one major issue, namely the integration of software. What was mainly the problem was the lack of coordination between planning and execution. Because MS Project and AX are not integrated, there is currently no integration between planning and execution. AX contains a lot of valuable and useful data that can be used during planning, but TTS cannot exploit it during planning as much as if there existed integration. Also, functionality for reporting in AX is missing, and is currently not optimal today. In conclusion, there is a gap between planning, execution and reporting.

4.2.3 Kongsberg Maritime

Kongsberg Maritime have been using the ERP software Microsoft Dynamics AX 4.0, but the company is currently in the process of updating the software to AX 2012. The answers in this chapter are therefore firstly based on the current situation. If otherwise, the distinction will be made clear between the two versions during the presentation of the empirical results. In addition to AX, Kongsberg Maritime uses the project planning software MS Project and the PLM software Teamcenter. There are also other administrative software with functionality like managing HR and payment of employees that have simple, one-way integrations with AX.

Because of busy schedules, Kongsberg Maritime could not participate in the interview, but they were able to answer the survey and a few emails regarding follow-up questions. On the other hand, an interview with a CGI employee was conducted (Johansen, 2014). This resulted in good information on the AX software, but some information regarding the ETO production and products is still missing. This is obvious during the presentation of the following chapters *4.2.3.1 Products* and *4.2.3.2 Project Dimensions*.

4.2.3.1 Products

Kongsberg Maritime deliver products to the offshore and maritime industry, but elaborate information on the matter was not available during the CGI interview. Although, products mentioned were sensors and navigation and positioning systems. The sensors are considered to be of CTO/MTO production strategy, while the navigation and positioning systems are ETO. There was given a rough estimate that approximately 70% of Kongsberg Maritime's production was ETO.

From online studies, it is clear that Kongsberg Maritime has a large product portfolio (Kongsberg Maritime, 2014d).

4.2.3.2 Project Dimensions

The project dimensions were not discussed during the interview.

Although the products and project were not discussed in detail the survey showed that the ETO production in Kongsberg Maritime was a combination of all three strategies. Kongsberg Maritime therefore conducts EnTO, AdTO, and CTO production. Although all strategies are used, the company wants to move more into the CTO segment to simplify processes such as quotation and reduce the risk that is present when conducting ETO production.

4.2.3.3 Project Execution and Software Solution

As previously explained, the current ERP software is Microsoft Dynamics AX 4.0, and it is integrated with MS Project and Teamcenter. The integration with MS Project is a two-way integration, while the integration with Teamcenter is a one-way integration. The solution is used by the entire company, and therefore covers more than just ETO production.

Quotation

As for the other case companies, Kongsberg Maritime did not handle the ETO quotation in AX. The functionality was considered too simple for the ETO strategy and other software is used instead. Among the software used for quotation, excel was mentioned.

On the other hand, for the products that have predefined design, the quotation module in AX is used. The quotation module is also used for smaller projects and service on delivered projects. The reason for using the AX module for these cases is because of known price on the products. This makes the quotation phase a lot easier and predictable.

With concern to ETO, the module in AX is not adequate for quotation. Because of the variations for each customer order’s final product there does not exist any type of list of prices. On the other hand, in the software used by the company there does exist calculation systems and functionality that uses input from criteria and previous experience to generate quotations. Among other things, the quotation functionality generates a plan with start and end date of the project, what products are required, and costs of the project.

Project Management

Kongsberg Maritime uses the project management module in AX and MS Project, which are integrated in a two-way integration. This implies that when values are updated in one system, they can automatically be updated in the other. The propagation of information must be triggered, as well as accepted, manually. The acceptance of changes made by other systems is Kongsberg Maritime's change management protocol in order to prevent incorrect information to spread to the entire systems. The MS Project-AX integration is customized for Kongsberg Maritime. Although there is a two-way integration, there does still exist certain information that can only be found in one of the systems. In other words, the systems have separate uses and functionality, but do share values, like the WBS. Generally, areas covered in MS Project are activity planning and determining resources for each activity, while AX covers the execution and logging of the activities.

In the current version of AX, projects are initiated before a quotation has been conducted. Each project is therefore connected with a quotation. If Kongsberg Maritime is awarded the contract additional work and manufacturing is conducted, if not, the project is finished. In AX 2012 there has been some experimenting with quotation wizards in hope of making the quotations first, and then transferring the quotation into a project. Then, projects are only created when a contract has been awarded to the company.

The WBS in a project is generated in MS Project. When generating a new WBS there exists functionality for use of templates that promotes the reuse of information. There also exists functionality named "Actual Hours", which registers all working hours spent on an activity package in the WBS. This information will then be used to calculate how well the project is going compared to the estimations from the quotation and planning phases. Thus, this functionality lets Kongsberg Maritime be able to always know the project progress.

Design & Engineering

The software Teamcenter is the PLM system used at Kongsberg Maritime. It is also integrated with AX, but with a one-way integration. As a result, Teamcenter is the main software for registering all products and the information on them, while AX uses the integration to update its information based on Teamcenter. Teamcenter is therefore the root to product information and BOMs.

The integration is automatic, and AX updates its information with predefined time intervals. It is also possible to manually activate AX to update its information from Teamcenter if something is needed before the given automatic update. Teamcenter also uses revision control in order to keep track of changes made to products. Each change will increase the revision number by one, which will also be updated in AX.

Procurement

In the email sent by the Kongsberg Maritime employee, he explained that there are always challenges regarding procurement for their ETO production, and especially for long lead-time components. The long lead-time components are procured early in projects based on prognoses. When asked if the risk is large, the employee answered that there does exist risk when procuring before design is complete, but the risk is not too large.

Other components are procured by using regular MPS and MRP functionality.

Production

When designing the products, Kongsberg Maritime use default and standard products that can help start manufacturing of certain components before the final design is complete. By doing so, production does not have to wait for final design and lead time can be shortened.

Installation and Service/Maintenance

Kongsberg Maritime does have an installation register that is a separate module in AX. This module is customized to fit Kongsberg Maritime’s business processes, and was considered a critical modification when the software was implemented.

Service and maintenance is done on products after delivery by Kongsberg Maritime. However, there does not exist a module in AX for the registration of these services. In standard AX 2012 there does exist functionality for service and maintenance, but it was considered too complex and cumbersome to take into use. AX 2012 operates by creating three separate, different orders for one service done on a product. These orders are sales order, return order, and replacement order.

Kongsberg Maritime instead operates the service and maintenance registration with other functionality that exists in AX, rather than having a module for it.

Other

The software used by Kongsberg Maritime has been customized to fit their business processes. This was done because the processes could not be solved by standard ERP software. The largest changes were the ones made to the installation register and the project module. The installation module was critical in for Kongsberg Maritime's business.

Kongsberg Maritime solution also includes a shipment module that has been customized to fit their business processes better than the standard AX module. The standard module was too rigid, while the customized module can collect and set variables without affecting other parts of the system. A keyword Kongsberg Maritime used for the module was that it had to be "flexible".

The information gathered on the installation and shipment module was acquired from the CGI interview. When asked if any of these modules could fit into other offshore and marine companies the employee responded that it was possible. This was mostly true for the shipment module because it is the most generic of the modules, while the installation register is probably too customized to fit Kongsberg Maritime's organization.

4.5 Survey Results

The survey results in Table 8 are based on the total software solution used in the company. This includes AX and the software that is integrated with it. It will also include software that is not integrated with AX, but it is considered a part of the total project software package. To register if extra functionality is integrated with AX there is an extra column in the table named "Integrated with AX". If there is no answer in this column, the functionality is either in AX or the question is not applicable for that specific question.

Table 8 - Survey Results

Category	Question	OneSubsea		Kongsberg		TTS	
		Total Solution	**Integrated with AX?**	**Total Solution**	**Integrated with AX?**	**Total Solution**	**Integrated with AX?**
Project management	1. Does the solution have functionality for Project Management	Yes	Yes	Yes	Yes	Yes	No
	2. Does the solution have functionality for making Work-Breakdown-Structure (WBS)?	Yes	Yes	Yes	Yes	Yes	No, two independent copies of WBS
	3. Does the solution have functionality for logging and registration of WBS activities and deliverables in order to measure progress?	Yes	Yes	Yes	Yes	Yes	No
	4. Does the solution have functionality for generating updated plans, cost, and lead time estimates as more information of the project and progress is available?	Yes	Yes	Yes	Yes	Yes	No
Reuse of information/ decision support	5. Does the solution have functionality for viewing information from earlier projects?	Yes		Yes		Yes	
	6. Does the solution have functionality for reusing information in other projects?	Yes		Yes		Yes	
Quotation	7. Does the solution support quotation?	Yes	Yes	Yes	No	Yes	Separate system with minor integration used by sales department
	8. Does the quotation functionality include planning for due date, cost and capacity?	Yes	Yes	Yes	Yes	NA	
Engineering and design	9. Does the software support integration with PLM systems or other design software?	Yes	Yes	Yes	Yes	Yes	Yes
Change management	10. Does the ERP system update dependent variable when changes are made in the integrated software?	Yes	Yes PLM, but manually tell Primavera/AX to update	Yes	Yes, but manually trigger software to update	No	
	11. If the ERP system updates the defined integrated variables, does the ERP system then update/notify all other	No		No		No	

	dependent variables in other modules that are affected by the change?						
Production and manufacturing	12. Is it possible for the ERP system to initiate production even though the complete product/master BOM is not finalized?	Yes		Yes		Yes	
	13. Does the ERP system support product routing with consideration to job shop, and allow for flexibility in production?	No		Yes		No	
	14. Does the solution register when an activity/finished product has been performed/completed?	Yes	Yes	Yes	Yes	Yes	No
Offshore and maritime industry	15. Does the system support functionality for an installation register?	Yes		Yes		No	
	16. Does the system support functionality for shipment of products in form of a shipment module?	Yes		Yes		No	Has an "company logistic" shipment module before product completion
Service and Maintenance	17. Does the company offer service and maintenance of the products after delivery?	Yes		Yes		Yes	In warranty period
	18. If yes; does the solution contain a service and/or maintenance module to plan and register service operations of a product?	Yes		No		No	
	19. Does the service and/or maintenance module provide information of previous service operations that have been performed on the product?	Yes		NA		NA	

5 Discussion

5.1 Case Evaluation

The case evaluation will base its discussion on the empirical results gathered in the interviews, as well as the survey results. The data will also be evaluated with consideration to the literature study findings.

5.1.1 Products and Production Strategy

The products that the companies manufacture vary in both size and complexity, although all companies do produce with an ETO strategy. The framework that was created in chapter *3.3.5 Establishment of an ETO Framework* has been used in Figure 25 to illustrate where the products are located based on the product information given in the case study.

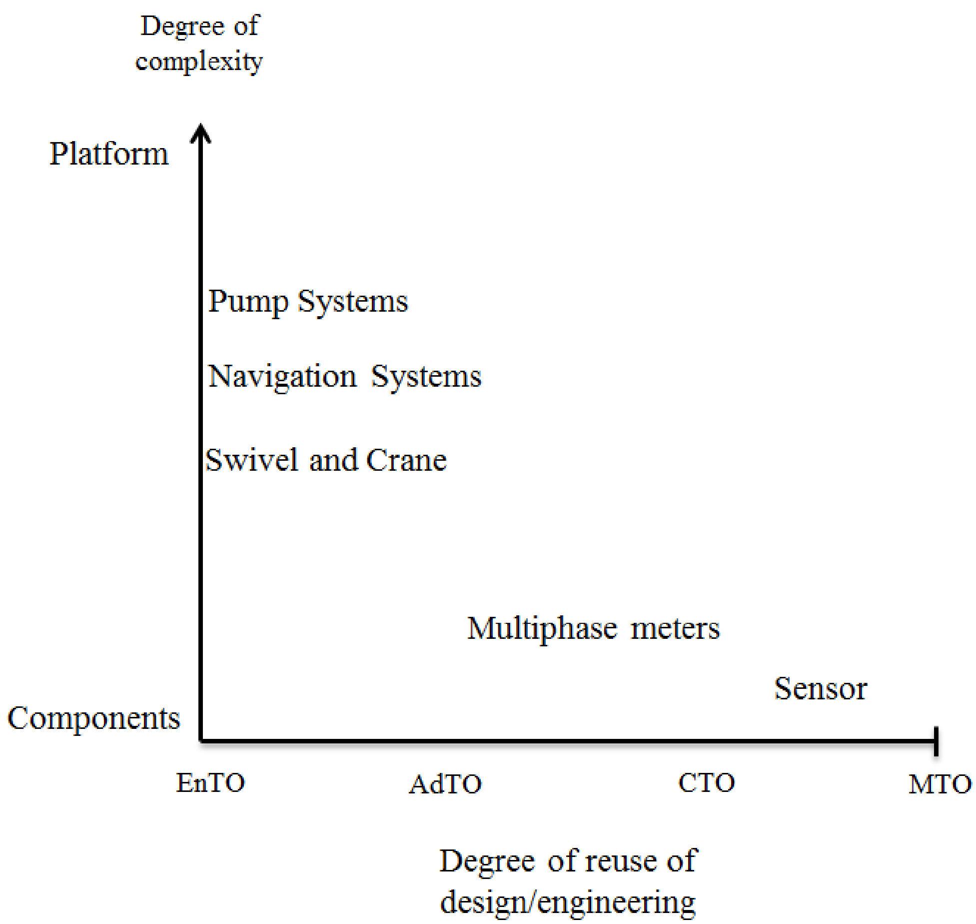


Figure 25- Case Study Products Placed in Framework

On the x-axis, regarding the differentiation of degree of reuse of design and engineering, all companies used a mixture of the different types of strategies, namely EnTO, AdTO, and CTO. An observation made during the interviews was that all companies considering their production as EnTO expressed a wish of wanting to move their strategy towards AdTO or CTO. OneSubsea and TTS both use an overweight of EnTO and wants to move towards AdTO, while Kongsberg Maritime uses a mixture of all strategies, but wants to move all production towards CTO.

Because of ETO strategy the competitive advantage is based on delivery time, quality of product, and being able to comply with customer requirements. The companies therefore defend the notion of moving towards AdTO and CTO because a decrease in reengineering of customer orders will cut risk, costs, and lead-time, which in turn will increase competitiveness and profitability. From the framework developed in chapter *3.3.5 Establishment of an ETO Framework*, a further conceptual framework has been developed in Figure 26 of where the companies want to be in terms of reengineering. The companies all express a wish to move further to the right in terms of this figure.

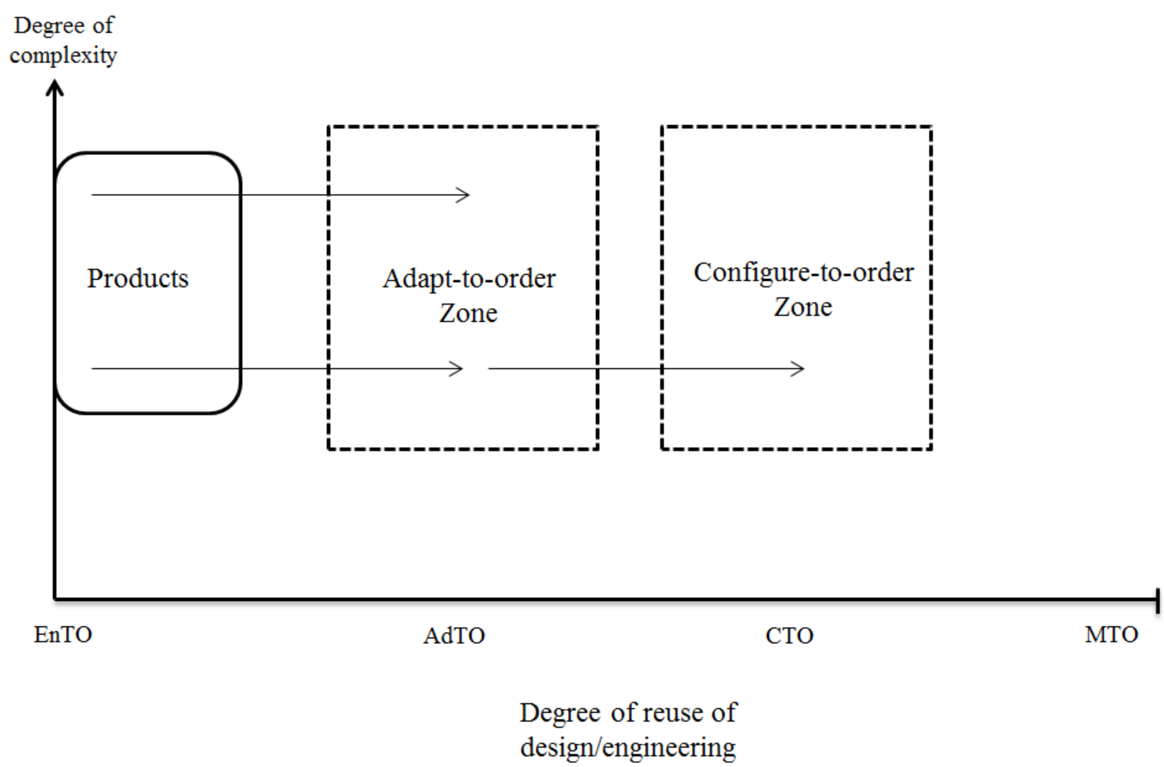


Figure 26 - Moving the between zones of degree of reengineering

In order to reuse information about design and engineering, the question is how to manage information in a way that right information can easily be accessed and re-used when it is relevant for a new customer order or during quotation.

5.1.1.1 Case companies have mixed strategies

In addition to the ETO strategy, the companies also manufacture components and final products that use more of a CTO and MTO strategy. Examples from the case studies where the company also have CTO and MTO orders, is in OneSubsea when making the multiphase meters and in Kongsberg Maritime when manufacturing sensors. For these products minor changes are made to the products, or they produce an existing design that is purely MTO. As a consequence, it is important to keep in mind that the generic vertical solution for companies that are viewed as ETO has to not only take into consideration ETO, but also other strategies that might be present in versatile companies with ETO production. Hence, the system has to be flexible.

5.1.2 Total Software Solution

When evaluating the total solution, the software systems used by the companies includes additional software on top of AX. AX is therefore not considered to be a complete solution by itself in these ETO companies. From the case study it seems that the software needs assistance in areas such as project management, quotation, and product information/visualization (engineering and design). This is mostly due to lack of functionality and flexibility in AX required by the complex ETO strategy.

5.1.2.1 Customization of AX

Furthermore, all companies chose to customize the ERP software to some extent. Both TTS and Kongsberg Maritime made it clear that the customization was imperative to make the solution work in their business environment. Among others, changes were made to the shipment module, service module, and the project management module. Along with customization, there are new modules to satisfy industry specific requirements. This was the installation register.

5.1.2.1 Integration with support systems

Regarding the integration between the software that was present in the different systems there were both similar and contrasting methods for solving the coupling. The integration that was the same for all cases was between the PLM software and AX. The PLM software has a one-way integration with AX, where a one-way integration lets only one of the two software use information from the other. In other words, in the case of the PLM system Teamcenter; AX can gather information from Teamcenter, but Teamcenter cannot access information in AX. The way the companies have solved the use of the PLM software is that the PLM system is the master of the product information data. AX then gets information from the PLM system on BOM and other documentation/specifications on products.

A different integration was between Primavera and AX in OneSubsea's solution. This integration is also only one-way, as with the PLM software and AX. This implies that changes in AX information does not propagate to Primavera. As OneSubsea have solved the software implementation, Primavera is not dependent on AX and its information because it is the only and main project management tool. As the PLM system works as the master of the BOM, Primavera here becomes the master of the project information.

The other two cases used MS Project as their project management software in the total solution, but in two very different ways. It is only Kongsberg Maritime that has implemented integration with AX, while TTS uses MS Project as an "island solution" without any connection to AX and other software. Kongsberg Maritime also uses a two-way integration between the project management software and AX. When not having the programs integrated, one will miss the benefits described in chapter *3.4.4.2 Integration with Microsoft Project* about the AX and MS Project integration. The integration allows for flow of information and flexibility. For example, the "actual hours" functionality shows how the integration can be used in an optimal manner to keep a real-time and up-to-date overview of project progress. Also both budgeted and actual costs for hour and expense transactions and the revenue can be viewed in MS Project, and transfer the project work for billing and revenue back into projects that are maintained in AX (Microsoft, 2013a).

The lack of integration in TTS is evaluated as not optimal because the systems have information that would benefit the ETO processes if they were shared, like the WBS and resource planning. TTS solves the lack of integration by making two copies of the WBS. It takes both more time and resources to make two, identical WBSs, as well as keeping them both updated. In reality they are doing the same job twice. However, the fact that AX, and also MS Project allows for the use of templates makes the duplication easier, but there is always information that is specific for each project that has to be recorded.

Below, Table 9 illustrates the business processes and the software used in each company to satisfy the process is presented.

Table 9 - Business Processes and Software Used

	OneSubsea		**TTS**		**Kongsberg**	
Functionality	**Used in AX**	**Alternative Software**	**Used in AX**	**Alternative Software**	**Used in AX**	**Alternative Software**
Quotation	No	Primavera	No	EME	No	Excel and other software
Project Management	No	Primavera	No	MS Project	Yes, integrated systems	MS Project
Design and Engineering	No	Teamcenter	No	Vault	No	Teamcenter
Procurement	Yes		Yes		Yes	
Production	No	No	No	No	No	No
Installation Register	Yes		No	No	Yes	
Service and Maintenance	Yes		Yes (warranty projects)		Yes	
Shipment	Yes		Yes (before completion)		No	No

5.1.2.2 Satisfaction of Criteria

OneSubsea

From the survey it is clear that the total software solution of OneSubsea has implemented satisfies all but two criteria from the Project Paper for an ETO strategy. The first criterion that is not satisfied is the functionality for warning users to update information in AX when changes have been updated from Teamcenter or Primavera. To be more specific, once AX has updated dependent variables from e.g. Teamcenter, there are extended, additional variables in AX that are dependent on the information. An example is if a component's BOM is changed in Teamcenter, then the changes are updated in the BOM in AX. A problem would occur if there existed a procurement order on that specific component, because the order also needs to know that the BOM changed. The second criterion that was not satisfied was the support of flexible production and routing in AX.

Among the critical functionality for ETO that the solution satisfies is support for project management and quotation, integration and sharing of information, as well as the software supporting production beginning before the design is complete. Another important factor of this solution is that OneSubsea chose to replace all other software with this solution. A benefit of one joint system is removing redundant information because the information is based on one source, as well as it decreases the chance of out-of-date information.

TTS

TTS's solution does not satisfy all criteria wanted from an ETO ERP system, and it is missing important functionality such as integration between execution and planning, and functionality for quotation within or integrated with the ERP system.

TTS does not have an installation register or a service and maintenance module. This is because after the delivery of the project a sister company does the service that is involved. However, an installation register could still be useful since there exists a "grey area" of two years where TTS are responsible for the warranty of the products.

Another functionality that is missing is support for shipment of the finished products; this is handled outside the solution. TTS does have a shipment module, but it is designed for use other than final shipment. The shipment module is customized to keep track, status, and documentation of components around the world during production.

This case is the company that satisfies the least amount of criteria in the survey. However, the special shipment module is very interesting. This module/functionality might be something to consider during the generic software evaluation because ETO production does use a lot of outsourcing and may need support for keeping status and location of components all over the world.

Kongsberg Maritime

Kongsberg Maritime also did not satisfy all criteria. The total software solution is missing functionality for change management in the same way OneSubsea did. Kongsberg Maritime also does offer service and maintenance, but they do not have a proper service and maintenance module. To have a service and maintenance module and integrate it with the installation register similar to the one OneSubsea has could be a possible solution. Lastly, Kongsberg Maritime lacks integration between quotation and the rest of the solution.

5.1.3 Project Execution

Each case company has their way of conducting projects. Each project process identified will be analyzed based on the case interviews and the survey. This will result in recommendations to what may, and may not, be relevant for the generic vertical solution. The cases are the most important source of information during the work for developing a generic vertical solution, as this brings empirical results to be evaluated. From literature there is stated that there is a lack of empirical research on ERP in ETO.

5.1.3.1 Quotation

Quotation functionality in AX seems to be insufficient

When looking at functionality for quotation in AX in chapter*3.4.4.1 Quotation*, it does not immediately come across as insufficient. When taking a closer look at the functionality for quotation, all case interviews and surveys point to AX not satisfying the needs of the process in an ETO environment. It was said that functionality was too simple to handle the different rounds of negotiations and the documentation gathered from each round. All companies had other processes that took care of this phase of the project. OneSubsea's use of Primavera was the only case where the quotation was handled by a single software, as well as being integrated with AX. Kongsberg Maritime used multiple software, while TTS had a separate sales-department conducting quotes in a separate software.

When stating that the quotation functionality was insufficient, Kongsberg Maritime actually did use the quotation functionality, but only for their MTO products. This was for products with a complete BOM and a price list. However, they were not able to do their ETO quotations in AX.

Primavera was the only software that could handle the quotation process, as well as integrate with AX. MS Project does not include functionality for quotation, and companies using the software must therefore find other solutions for the processes. Because of the ETO strategy, the quotation process has been identified by Gosling and Naim (2009) as one of the time-bottlenecks in the project lifecycle due to the need of defining preliminary requirements/design and estimating costs. Therefore it is essential to have the correct prerequisites for conducting the quotation ideally to decrease total project lead-time.

All in all, the quotation process in AX is shown as not being able to satisfy the ETO needs, and other systems or support functionality must be evaluated when making an attempt towards a general solution. Quotation is time consuming and both literature (Gosling and Naim, 2009) and the cases show that the process has the potential to be improved.

5.1.3.2 Project Management

Project Management in AX needs additional support

In chapter *3.4.4.1 Quotation and Project Management in Microsoft Dynamics AX*, there can be found a lot of functionality in the existing module. However, as mentioned, MS Project is suggested in Microsoft's own product material for a more flexible project planning. As a requirement for ETO being a flexible solution, this may suggest that the project management module AX might not be flexible enough for ETO.

Through the case studies the module in AX for project management is not considered to be functional enough to handle the ETO processes by itself. All companies have therefore installed additional project management software. By doing so all cases satisfy the criteria for including functionality such as project management, creating and updating WBS, and reporting progress.

OneSubsea uses Primavera as the project management "module" of the total solution. It was chosen because of its popularity in the industry, as well as for its increased functionality compared to the standard module in AX. The popularity helps OneSubsea simplify the process of exchanging information with clients that use the same software. During the interview, it was suggested that many of the biggest actors in the offshore and maritime industry used Primavera and demanded their suppliers to have their reports printed from Primavera as well.

TTS and Kongsberg Maritime use the project management software MS Project. MS Project should provide for a more flexible planning, as described in chapter *Integration with Microsoft Project*. As previously explained, TTS's project management and execution software is not integrated with each other. Because MS Project and AX do not exchange information, they are forced to compromise where the integration could make processes more efficient and beneficial. In a project management aspect, this increases the chance of information being wrong because a change in one system will not be propagated to the other. Therefore, more resources have to be used to double check information and record the changes twice. The missing integration between the project management system and AX is therefore viewed as a weak link.

Regarding Primavera, TTS deliberated the fit during the implementation process, but it was found not satisfying towards the business processes TTS conducts. There were no specifications made as to which processes that were not satisfied. Considering Primavera for project management had been a wish from the project department i TTS.

Review and reuse of project information

A positive element of the TTS system is its support for reuse of information by generating generic project structure in the WBS. Templates, as mentioned in chapter *Use of templates and wizards in AX*, exist in both MS Project and AX. In addition, there is a search function that pulls up previous projects based on chosen criteria. This would be an important functionality for ETO because even though the customer orders vary each time there still exists information on elements and components that may be reused.

Regarding TTS and its wish to increase the unification of execution and planning software, the company should evaluate the two-way integration Kongsberg Maritime has implemented. Kongsberg Maritime even uses the same type of software as TTS, where the integration is between AX and MS Project. AX is also constructed in such a way that it is easy to integrate with MS Project. This way information must only be added once into their preferred system.

In terms of procurement and production TTS explained the use of a list of long lead-time critical components. Having the list of components allows for an easy identification of what components are known to be critical. In order to keep deadlines, the company knows they have to start each project with these components if they are present in the current customer order. This might be an idea for ETO specific functionality for ERP software.

As a result, for the general solution there does seem to be a need for implementing additional project management software. Furthermore, the case studies show that the companies that have integrated AX with the project management software are more satisfied with the outcome. When evaluating the difference between what software of MS Project and Primavera is considered more appropriate for an ETO company, the companies evaluating the software have to analyze how it fits into their business procedures. The difference between the possibility of a two-way integration with MS Project and the existing facilitation in AX versus Primavera's possibly increased quotation functionality and alleged popularity in the industry must be considered.

5.1.3.3 Design and Engineering

PLM

As there is no functionality for design and engineering in AX, all cases integrated AX with PLM systems. Both OneSubsea and Kongsberg Maritime use Teamcenter, while TTS uses software called Vault. As previously explained, all of the software is integrated with AX by a one-way integration, where only AX can get information from the PLM software.

The requirement from the criteria that comprises the PLM software integration is the ability to automatically update AX. All the PLM systems fortunately run automatic updates within predetermined time intervals, for example every day at midnight. Because changes are not made to often during ETO projects that can drag on for up to 1-2 years, there is no need for "on the second” rapid updates, and OneSubsea is therefore content with updates done once a day. By chance there was an important update that had to be integrated at once, it is possible to manually task AX with updating variables from Teamcenter. This aspect of the solution seems to work as intended, where AX uses Teamcenter for BOM and product information. Teamcenter therefore works similarly as Primavera, it is the only and main source of information for design and products. A PLM system is therefore crucial to the vertical solution for ETO companies.

Concurrent Engineering

For design and engineering process, an important aspect for ETO is that the software has to handle concurrent engineering. The aspects and challenges of concurrent engineering are explained in chapter *3.3.7.4 Concurrent Engineering.*

. By the use of revision control in the PLM system integrated with AX, there is a working process of including and implementing the changes in design for components into the final product. Another tool to support the process is the use of long lead-time component lists that are given priority once in the design phase. There is unfortunately always a risk that the components that are procured or produced first are subjected to change. This is a risk that all case companies are aware of, and have to accept. This is a part of the business, and the risk is not too large compared to increasing the lead-time and waiting for the design. The long lead-time list is discussed further under Procurement.

OneSubsea also devised a method for coping with the risk affiliated with concurrent engineering and design, namely conditional release. Designs are released to procurement or production, but with conditions on the specific part. The customer therefore has to approve the criteria and conditions before the parts are procured or the production can start. This is a way of controlling the concurrent engineering and reducing the risk of doing procurement and production.

Addressing some of the challenges with concurrent engineering by the use of conditional release can be a clever way to reduce risk during the project. This way the customer is involved, and has approved the current design. The customer makes a commitment, and procurement or production can be initiated from this.

5.1.3.4 Procurement

Importance of MRP

For procurement the case studies showed that the MRP functionality is still very important for the companies, even with an ETO strategy. The procurement module is not used to plan production based on forecasting. It is mainly used as a way of keeping track of and planning the production/procurement based on estimating lead-times and material requirement for components in projects/customer orders. This functionality is described in chapter *3.4.4.4 Procurement in AX* as the existing functionality in AX. OneSubsea characterized MRP as critical to their manufacturing process. By using MRP and estimation of lead-time, the companies proactively try to not keep any inventory for longer time than absolutely necessary. By keeping the inventory at a minimum, capital is not tied up in physical products that can turn obsolete in the rapidly changing environment.

Long Lead-Time Items

Like TTS explained, ETO companies has knowledge on what type of general components have the longest lead-times, which is taken into consideration both during the design and procurement phase. Today, TTS uses a manual list to check which components have long lead-times in order to start development of the critical supply chain early in the project. The list of critical components is something each ETO company should keep, and could also be an idea for functionality that can be implemented into the software solution. It is critical to address these items early on in order to deliver the product on time. Having this list integrated with or classified in AX could support the identification and handling of these items.

However, there are known problems when wanting to implement management of long lead-time component functionality into AX. The problems are based on what activity the long lead-time items will be connected with in the WBS. The items can either get a separate activity called "long lead-time items", or they can be connected to the WBS as part of the product structure. Because of the ETO strategy the product structure is not defined at the initiation of the project, but there is some knowledge and educated guesswork on what long lead-time components will be included in the total BOM. This is the advantage of connecting with a separate activity. Although the design is not complete, engineers can start designing/procuring the items. On the other hand, the downfall is that the components will be registered in the structure a second time as the BOM structure progresses. This may lead to double procurement of the long lead-time items. However, if only registered in the product structure, the lead-time will increase because procurement must wait until the product structure includes long lead-time items. The solution could be to have the separate activity combined with functionality that sees to that the long lead-time items are only counted once.

Company Logistics Module (Shipment Module)

A finding during the TTS case was the use of the customized shipment module. It is not used the way this thesis' criteria defines the finished product shipment module/functionality, but rather as a logistics module for tracking components that are outsourced all over the world. In the offshore and marine business, free issue outsourcing is common. Customers then supply the supplier with material and production plans, and the supplier executes the instructions. The use of the shipment module therefore has a status on the components, and also generates documentation that is needed when traveling across borders. The use of such logistics functionality could therefore also be something to consider during evaluation of the general solution.

5.1.3.5 Production

From previous chapters, it is obvious that production starts before the design is complete, and that the software systems in place support these events. The survey also agrees on the matter. However, when looking at the survey and criteria, it is only TTS and OneSubsea that answer "Yes" to having a system that supports flexible production. This is considered an important aspect of the ETO strategy because it is not only the product that needs to be designed, but also the production process.

During the production process, all three software systems handle reporting of completion. This is important with consideration to progress reports. Also during the production process, TTS registers faults on components. They are registered in special deviation projects, where information on the faults can be used to improve both parts and production processes. The functionality for deviation projects is also used on outsourced components. The information generated in the projects can be used to evaluate if a supplier delivers satisfactory products.

Registration of deviation, and perhaps being able to recognize patterns, is important to consider in the vertical solution.

In chapter *5.1.3.4 Procurement*, the use of conditional release in OneSubsea was explained. The method is used to reduce the risk of producing something that could later change, as well as starting early with production to reduce lead-time. This is definitely important in production as well.

5.1.3.6 Installation Register and Service/Maintenance

Out of the three cases, OneSubsea and Kongsberg Maritime had functionality for an installation register in their software solution. Both companies had a module in AX for it. OneSubsea's module is made on top of the project management module in order to benefit from the functionality there, as well as it being coupled with service and maintenance. TTS does not have installation register functionality in the solution, which keeps track of the finished products, because this is done by another part of the TTS Group ASA. The company did however provide a warranty on their projects for two years after completion and could therefore have benefitted from an installation register that keeps an overview of the delivered products. AX does not have any existing functionality for an installation register, and this functionality must be added/customized to the solution.

Furthermore, TTS and Kongsberg Maritime do not have customized service modules in their solutions. As mentioned in chapter*3.4.4.6 Installation/Service/Maintenance*, AX has a standard module for service in the system, but none of the case companies recognized the module as an adequate solution. The module is therefore not being taken into use by any of the companies. This indicates that the service module in AX is not good enough. While TTS only does warranty service that connects the service orders to the original project, Kongsberg Maritime conducts service, but does not have a separate module for the functionality. The case studies do however show that they all do some form of service either related to warranty or maintenance of their products.

In conclusion, it seems that when companies do conduct service it is important to both have functionality for installation register and registration of service and maintenance activities. As many ETO companies conduct service, the generic solution should also be able to support these processes.

5.1.3.7 Shipment

The shipment module in OneSubsea has functionality that is a form of logistics module, like TTS's shipment module for components during the production. OneSubsea's shipment module takes care of logistics "after completion", where it keeps track of and organizes shipments of components to the customer.

From the case study there has been identified a need for shipment functionality in some format, whether it is during production or after. Because the functionality could be used for all production companies in the ETO offshore and maritime industry, there can be benefits generated in form of increased logistic capability by implementing a solution that included both inhouse and after production shipment.

5.2 Findings

During the analysis of the current situation of ERP solutions in the ETO industry today, specific findings can be highlighted. The findings are also evaluated with consideration to the literature study. This information is what will be most important in the generic vertical solution in the upcoming chapter. The findings are listed in Table 10 below.

Table 10 - Findings Case Study

Topic	Finding
ETO	• Wish to move more towards AdTO or CTO engineering • ETO company also conduct non-ETO production, must also be handled by system
Quotation	• AX not sufficient because it cannot handle the documentation generated from different rounds in negotiation process • Primavera only single software capable of handling quotation • MS Project does not handle quotation and the total solution therefore needs more software to cover the entire project process.
Project Management	• AX not sufficient, include additional software that can be integrated with AX
Design and Engineering	• Must integrate with PLM system • Ususally no need for «on the second» updates from PLM to AX, therefore automatic updates once a day is enough. • Manual initiation of update is available if changes need to be updated at once.
Concurrent Engineering	• List of long lead-time items used to get started on critical components first • Revision control used to implement new parts into the total design • Conditional release used to set constraints on parts set for production, where the parts are only produced once the constraints are set by engineers or customers
Procurement	• MRP functionality still critical for procurement of parts, but more as a planning tool for components per customer order
Production	• Include deviation projects to keep statistics on components and their quality
Installation Register and Service/Maintenance	• Installation register should be present in generic solution • Service functionality should be present in generic solution
Integrated Software	• Evaluate business processes and software fit. Some software may fit better than other
Shipment	• Use of shipment logistics both during and after production

5.3 Generic Vertical Solution

To refresh the phenomenon of the thesis, the task at hand is to figure out how an ERP system can best fit into an ETO company in the offshore and maritime industry. The thesis also chose to scope down the ETO sector into medium sized projects that are conducted inhouse, as well as to focus on the ERP software Microsoft Dynamics AX. The research questions for this thesis have been formulated as follows:

- Q1:
  - How can Microsoft Dynamics AX solve the requirements of ETO project oriented production in the offshore/maritime industry?
- Q2:
  - How have these offshore/maritime companies solved the special requirements for ERP solutions today? (Case study)
- Q3:
  - What benefits can a company expect from implementing such a solution using Microsoft Dynamics AX?

Q2 has been answered in great detail both during chapter *4.2 Empirical Results*, as well as during the discussion in chapter *5.1 Case Evaluation*. The results and discussion ended up in a table of findings which highlight the aspects of an ERP system that is affected by the ETO offshore and marine industry requirements. As Q2 has been answered, Q1 and Q3 are still left. In order to answer Q1 the findings in Q2 are important. The table of findings can be transformed into a table of requirements that will be the basis of the AX general solution. The requirements will be based on what this thesis considers to be the "best" functionality of the three case studies combined. When the requirements have been identified, a simple model of what an AX solution could look like will be presented. This will answer Q1. Looking at benefits that come with some of the different functionality in AX from the case studies, and combining these with ERP benefits identified in literature, Q3 will be answered.

5.3.1 Business processes and Software

Based on the research conducted, the general solution should have functionality that satisfies these business processes:

- Quotation
- Project Management
- Design & Engineering
- Procurement
- Production
- Service and Maintenance
- Installation Register
- Shipment

The findings in chapter *5.2 Findings* can be transformed into these requirements presented in Table 11:

Table 11 - Requirements for General Solution

Topic	General solution requirements
ETO	• Total solution must be integrated to keep information up-to-date, consistant, and not redundant. • Total solution should be able to handle processes that are not classified as ETO
Quotation	• Total solution must include extra functionality for more advanced ETO quotation than AX can deliver • The quotation software must handle documentation management aspects
Project Management	• Solution should contain extra project management functionality/software in addition to AX in order to better benefit the project lifecycles in an ETO environment
Design and Engineering	• Total solution must integrate with PLM system • Information must be automatically updated from PLM system to AX within a predetermined time interval • Manual initiation of update must be available if changes need to be updated at once
Concurrent Engineering	• Solution must support revision control in order to implement new parts into the total design in a controlled manner • Solution must support conditional release in order to reduce risk of changes being made to design after procurment process has been initiated
Procurement	• Procurement should support functionality for long lead-time items in order to get started on critical components early on in a project • Procurement must support use of MRP for planning component manufacturing even though BOM is not finished
Production	• Solution should support deviation projects to raise awareness on quality
Installation Register and Service/Maintenance	• Software solution must support installation register functionality • Software solution must support service and maintenance functionality
Shipment	• Solution must support shipment of complete products in a customer orer • Solution should support shipment and logistics of components during manufacturing and procurement • Shipment before completion of product should keep track of status on component, documentation on component, and location of component

Because of the ETO strategy there have been identified certain software that should be included in a total ICT solution in addition to AX.

- PLM system
- Quotation support
- Project Management software

Fulfilling the needs for engineering and design with a PLM system, can be easily done by implementing this one system. Which PLM system is not evaluated, but it must provide for product data and creation of the BOM in AX by transferring data. The two different PLM systems in the case studies both provided for this functionality and are therefore regarded as sufficient in this matter. The general solution suggested in this thesis will therefore not suggest any specific PLM system, as long as they can be integrated in this manner.

When it comes to evaluating software for quotation and project management, in the case studies there can either be one support system for both business processes, or there can be different software for each process. In the vertical solution there will be presented a solution for both a combined and a separate alternative. The reason for this is that Primavera is very expensive software, and even though the company is able to integrate these two processes with this solution, they may not consider it cost beneficial. Some companies however will evaluate Primavera as beneficial and worth the cost because of the benefits of having the same project management tool as the big actors in the industry, in addition to the more advanced functionality in this software.

The other option is where project management and quotation are handled separately is the integration with MS Project, for more flexible functionality in project management, and the documentation management software SharePoint, for supporting quotation. The reason for choosing SharePoint is to offer a solution for documentation management that can integrate with AX in order to satisfy requirements for an ETO AX solution. SharePoint is characterized as a place where companies can share and organize information, people, and projects in one system (Microsoft, 2014j). In addition, these systems are both Microsoft products that allows for an easy and preferred integration. This leaves a vertical solution for the maritime and offshore industry built on the same principles but with two options for the individual company to consider.

5.3.2 Vertical solution - option 1 with Primavera

Figure 27 shows an illustration of how AX can be integrated with one way integrations between Primavera and a PLM system, where the integration is illustrated by arrows. The business procedures identified have been satisfied, as well as critical functionality and requirements relevant for ETO companies in the offshore and Maritime industry.

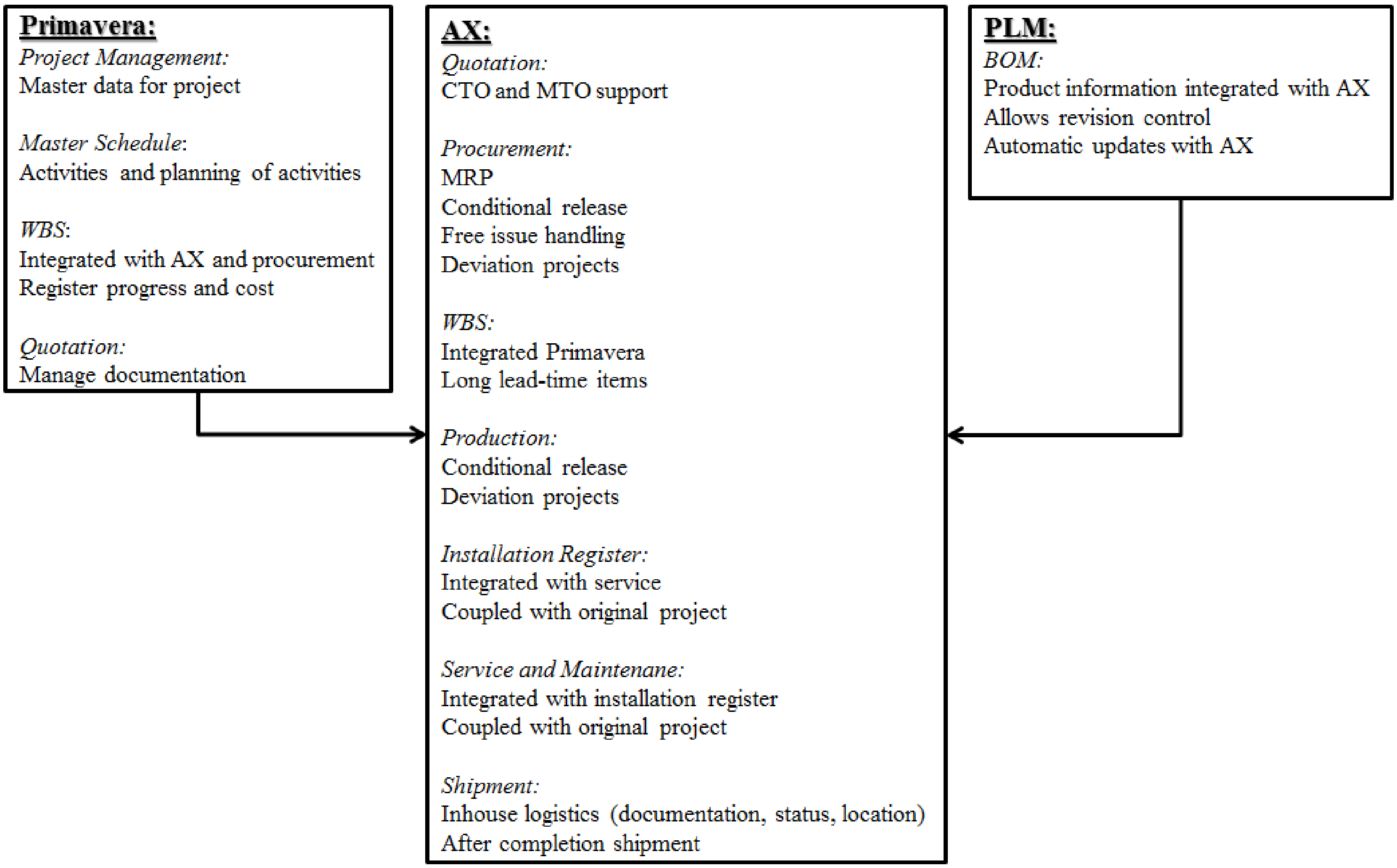


Figure 27 - Vertical Solution 1 with Primavera

5.3.3 Vertical solution - option 2 with MS Project and SharePoint

Figure 28 below illustrates the integrated AX solution that uses MS Project as the project management software and SharePoint as the documentation management software. The integrations are illustrated with arrows, and in this case there are two arrows that have a two-way integration.

SharePoint will support the quotation by establishing a site for quotations, where all documentation for every project can be shared and categorized. This will provide for an uncluttered way of sharing information when handling the quotations manually, and easy access to earlier quotations. As mentioned in chapter *4.4.4.1 Quotation* on AX, one functionality for quotation is to do an evaluation and register why every quotation was won or lost. This should be done also when quotations are carried with the support of SharePoint.

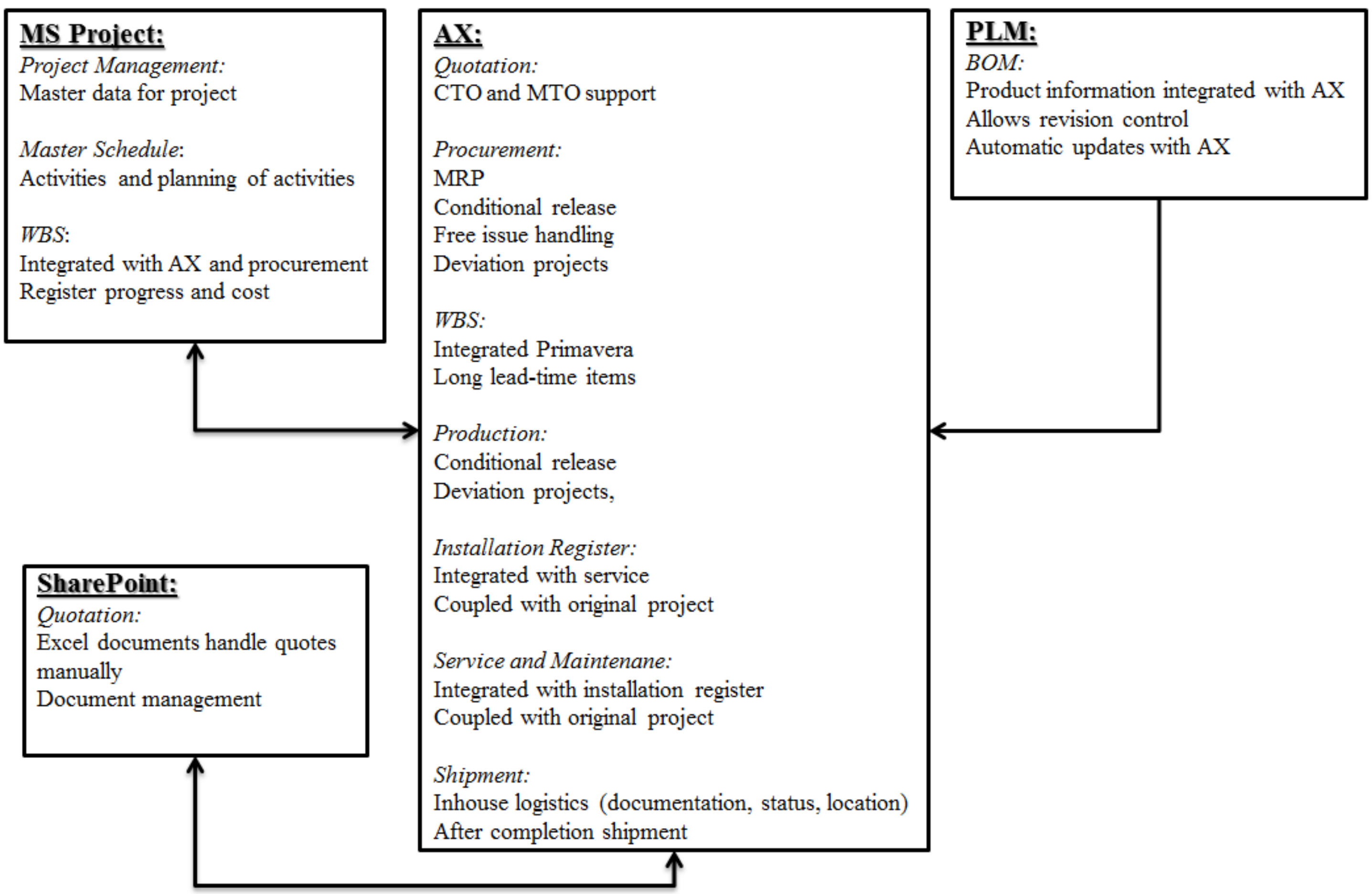


Figure 28 - General Solution 2 with MS Project and SharePoint

5.4 Benefits of General Solution with consideration to ETO ERP solution

From the findings these specific benefits aimed at the maritime and offshore industry can be identified:

Quotation:

- Reduce quotation time and effectively manage time-bottleneck in the project process by including quotation software that is integrated with total solution
- Better handling of the quotation process in ETO environment by increased documentation management
- Effectively manage quotation for other manufacturing strategies by including standard AX functionality in addition to ETO quotation software

Project Management:

- Increase project management capabilities in form of a software integration to effectively and better support the need for conducting ETO customer orders as projects
- Decrease redundant information, as well as keeping updated and consistent information, by using integrated software between project management and AX
- Increase project management flexibility by integrating with additional software

Design and Engineering:

- Move degree of reengineering towards AdTO and CTO, as well as keeping the customization ability, by reuse of information and use of templates in software as shown in Figure 26
- Reuse of information will decrease the time it takes to generate BOM, which in turn reduces total lead-time of the project
- Decrease total lead-time by use of long lead-time item functionality for a quick start of the most critical components in the design and engineering phase of the customer order
- Decrease redundant information, as well as keep updated and consistent information, by automatic updates between PLM system and AX

- Support of ETO design and integration of new designed components by use of revision control

Procurement:

- Decrease risk of changes in design after procurement has been initiated by the use of conditional release, as well as promote concurrent engineering

Production:

- Increase quality awareness by use of deviation projects

Installation register and Service/Maintenance:

- Effectively follow up unique products as well as keep service history on the products and location

Shipment:

- Increase flexibility by use of shipment module that can help organize deliveries that best suits the customer
- Increase inhouse logistics by use of shipment module that keeps status and additional information on components

In addition to these benefits that are very important to the industry and the ETO aspect, some of the earlier identified benefits in chapter *3.1.2 Identified benefits in literature* can also be mentioned in this setting.

- Shorten the time associated with making a decision and increase the reliability of the decision processes - by reusing information from previous projects, this can definitely become one of the most important benefits.
- Optimize supply chain and inventory - by using the ERP system and its planning and overview technology there is a better chance of starting with supply chain activities at the right time and thereby keep inventory as low as possible

- Increase business flexibility - important in an ETO environment and can be achieved by integrating AX with project management software as MS Project
- Decentralize information processing by making it real-time
- Achieve balance between decentralization and control among functions to avoid redundancy, ensure synergy, and manage performance indicators

6 Conclusion and Future Work

The research in this Master Thesis has consisted of a literature study continued from a previous Project Paper study, and a case study to gather empirical data. The literature study decided on a definition for ETO as there has been identified an inconsistency to the ETO-term. Further, sub-classes for the ETO strategy were introduced differentiating between for the degree of reengineering done in each customer order; EnTO and AdTO. Based on the engineering differentiation in ETO a framework was created to illustrate the coordination between customization/degree of reengineering on the x-axis and complexity on the y-axis. This framework has been used to categorize the products in the case companies.

Literature has highlighted the lack of empirical data and research on ERP in ETO companies, which made the case study highly necessary. The literature study and the research from the Project Paper resulted in a survey and semi-structured interview questions to be used on a set of case companies. The case companies operated in an ETO maritime and offshore environment, and they were all using the ERP software AX. By focusing on one industry the thesis took advantage of grouping similar requirements that offshore and maritime companies generate.

The results of the survey and interviews were used to evaluate and analyze the current solutions in an empirical manner. The discussion resulted in a table that highlighted the industry and manufacturing specific requirements identified from the three cases. The results show that AX is not a sufficient system in itself, but can be integrated with other software to incorporate the functionality it is lacking. Consequently, because of the heavy focus on project management, AX has to integrate with extra software to gain more flexible project management functionality. The module in AX is not satisfactory.

A process that AX could not handle because of the complex ETO products was the quotation. Because it has been identified as a time-bottleneck in project execution, it is important that the vertical solution supports this business process. MRP and procurement are still identified as important functionalities existing in AX, using the BOM to calculate the component needs. For ETO products it is used even though the BOM is not finalized. Rough estimates can be used for calculating needs even though all details are not clear. Conditional release within production and procurement is identified to be a functionality that promotes concurrent engineering and reduces risk.

Another problem identified was the lack of integration between software critical to the ETO processes. This integration is especially important for the additional support for project management. When a company has to generate and update duplicate information in multiple systems, the company has to use more resources on the process to do what integrated solutions would have done automatically.

Integrating the software, and connecting the information is the best prerequisite for storing information that can be useful in upcoming projects. The importance of reuse of information was illustrated in a developed framework, where the degree of reengineering will move from EnTO to AdTO to CTO because reuse of components design can be incorporated in similar upcoming customer orders. This generates a huge benefit in decreasing another time-bottleneck, namely the engineering and design phase.

The thesis ended up with two options for a vertical solution based on the requirements identified during the empirical study. Industry- and ETO-ERP benefits were also identified, and show that the ERP system can benefit ETO companies. The benefits can be achieved with extra support for design and engineering, more flexible project management and quotation, and some customized functionality for service and maintenance management and installation register. Because the thesis focused on the use of Microsoft Dynamics AX, the contribution to research is therefore how this specific solution in Microsoft can best fit into ETO companies within the industry. However, the empirical results do tell something about the general ERP requirements from the industry. Anyway, the research conducted is a contribution to the academic empirical study of ERP systems in ETO companies, which is sorely needed.

Due to the focus on AX, the thesis has not looked into other vendors and how they solve the requirements that have been identified during thesis work. Further study can therefore be to conduct the same/similar procedures as this thesis, but using different ERP software to explore empirically if other systems can handle the difficult ETO environment better than AX. There could also be made a more thorough research on what types of modules and software integrations are available for AX, in order to improve the general solution presented in this thesis. Lastly, it could also be beneficial to focus research on a single business process in ETO companies, for example it would be possible to do an in-depth research on the information handling and process for only quotation in ETO and how it can be supported.

7 References

PUMP INDUSTRY, 2013. Cameron and Schlumberger seal OneSubsea JV. *Pump Industry Analyst,* 2013**,** 1.

AMARO, G., KINGSMAN, B. & HENDRY, L. 1999. Competitive advantage, customisation and a new taxonomy for non make-to-stock companies. *International Journal of Operations and Production Management,* 19**,** 349-371.

APICS. 2013a. *APICS Dictionary - Engineer-to-order* [Online]. Available: http://www.apics.org/dictionary/dictionary-information?ID=1409.0 [Accessed 13.12. 2013].

APICS. 2013b. *APICS Dictionary - Delivery lead time* [Online]. Available: http://www.apics.org/dictionary/dictionary-information?ID=1102.0 [Accessed 04.04.2013].

APICS. 2013c. *APICS Dictionary - Manufacturing lead time* [Online]. Available: http://www.apics.org/dictionary/dictionary-information?ID=2442 [Accessed 04.04.2013].

ASLAN, B., STEVENSON, M. & HENDRY, L. C. 2012. Enterprise Resource Planning systems: An assessment of applicability to Make-To-Order companies. *Computers in Industry,* 63**,** 692-705.

BENTO, F. & COSTA, C. J. 2013. ERP measure success model; a new perspective. *Proceedings of the 2013 International Conference on Information Systems and Design of Communication.* Lisboa, Portugal: ACM.

BERTRAND, J. W. M. & MUNTSLAG, D. R. 1993. Production control in engineer-to-order firms. *International Journal of Production Economics,* 30–31**,** 3-22.

BOTTA-GENOULAZ, V. & MILLET, P.-A. 2005. A classification for better use of ERP systems. *Computers in Industry,* 56**,** 573-587.

BREIVIK, P. 2014. OneSubsea Case Study. *In:* HØNSI, M, SØRBØ,G. K. (ed.).

CAMERON, N. S. & BRAIDEN, P. M. 2004. Using business process re-engineering for the development of production efficiency in companies making engineered to order products. *International Journal of Production Economics,* 89**,** 261-273.

CGI. 2013a. *ERP-tjenester Verktøy for virksomhetsstyring* [Online]. Available: http://www.cginorge.no/system-integration/enterprise-resource-planning [Accessed 09.12. 2013].

CGI. 2013b. *Om CGI - et overblikk* [Online]. CGI. Available: http://www.cginorge.no/company-overview [Accessed 09.12. 2013].

CHEN-RITZO, C.-H., ERVOLINA, T., HARRISON, T. P. & GUPTA, B. 2011. Component rationing for available-to-promise scheduling in configure-to-order systems. *European Journal of Operational Research,* 211**,** 57-65.

COLUMBUS, L. 2013. *2013 ERP Market Share Update: SAP Solidifies Market Leadership* [Online]. Forbes. Available: http://www.forbes.com/sites/louiscolumbus/2013/05/12/2013-erp-market-share-update-sap-solidifies-market-leadership/ [Accessed 17.04. 2014].

DAVENPORT, T. H. 1998. Putting the Enterprise into the Enterprise System. *Harvard Business Review*. Harvard Business School Publishing Corporation.

DAVENPORT, T. H., HARRIS, J. G. & CANTRELL, S. 2004. Enterprise systems and ongoing process change. *Business Process Management,* 19**,** 16-26.

EHRENBERG, M. 2011. Microsoft Dynamics AX 2012 - A new generation in ERP. Available: http://download.microsoft.com/download/8/7/6/876FA255-57F8-447C-98B9-FA5D5BC2C3B1/Microsoft_Dynamics_AX_2012-NewGenerationinERP.pdf [Accessed 17.04.14].

ELFVING, J. A., TOMMELEIN, I. D. & BALLARD, G. 2005. Consequences of competitive bidding in project-based production. *Journal of Purchasing and Supply Management,* 11**,** 173-181.

FORBES. 2013. *The World's Most Valuable Brands* [Online]. Available: http://www.forbes.com/powerful-brands/list/ [Accessed 17.04. 2014].

GALY, E. & SAUCEDA, M. J. 2014. Post-implementation practices of ERP systems and their relationship to financial performance. *Information & Management,* 51**,** 310-319.

GOSLING, J. & NAIM, M. M. 2009. Engineer-to-order supply chain management: A literature review and research agenda. *International Journal of Production Economics,* 122**,** 741-754.

HALLDÓRSSON, Á. & AASTRUP, J. 2003. Quality criteria for qualitative inquiries in logistics. *European Journal of Operational Research,* 144**,** 321-332.

HANDFIELD, R. B. 1994. Effects of concurrent engineering on make-to-order products. *Engineering Management, IEEE Transactions on,* 41**,** 384-393.

HICKS, C., MCGOVERN, T. & EARL, C. F. 2000. Supply chain management: A strategic issue in engineer to order manufacturing. *International Journal of Production Economics,* 65**,** 179-190.

HOLSAPPLE, C. W. & SENA, M. P. 2005. ERP plans and decision-support benefits. *Decision Support Systems,* 38**,** 575-590.

HVAM, L., PAPE, S. & NIELSEN, M. K. 2006. Improving the quotation process with product configuration. *Computers in Industry,* 57**,** 607-621.

HVOLBY, H.-H. & STEGER-JENSEN, K. 2010. Technical and industrial issues of Advanced Planning and Scheduling (APS) systems. *Computers in Industry,* 61**,** 845-851.

HØNSI, M. & SØRBØ, G. K. 2013. *ICT-enabled production model in an ETO environment*

IFS a. *Streamline Crossfunctional ETO Manufacturing Processes with IFS' Engineer to Order Solution* [Online]. Available: http://www.ifsworld.com/nb-no/download/resources/pdfs/executive-summaries/engineer-to-order/executive-summary-eto.pdf. [Accessed 19.05. 2014].

IFS b. *IFS Application offers the complete solution for today's project enterprise* [Online]. Available: http://www.ifsworld.com/nb-no/download/resources/pdfs/executive-summaries/project-enterprise-solution/executive-summary-project-enterprise.pdf. [Accessed 07.06.2014]

IFS 2001. Engineering Project Delivery. *IFS Application for Engineering & Project Delivery*.

IFS. 2012. *Product Lifecycle Management* [Online]. Available: http://www.ifsworld.com/nb-no/download/resources/pdfs/brochures/project-enabled-manufacturing/brochure-plm-product-lifecycle-management.pdf [Accessed 19.05. 2014].

JIN, G. & THOMSON, V. 2003. A new framework for MRP systems to be effective in engineered-to-order environments. *Robotics and Computer-Integrated Manufacturing,* 19**,** 533-541.

JOHANSEN, Ø. K. 2014. CGI Kongsberg Maritime Case. *In:* HØNSI, M. & SØRBØ, G. K. (eds.).

KANELLOU, A. & SPATHIS, C. 2013. Accounting benefits and satisfaction in an ERP environment. *International Journal of Accounting Information Systems,* 14**,** 209-234.

KLIEM, RALPH L. 2002. *The Project Manager's Emergency Kit*, Taylor & Francis.

KOH, S. C. L. & SAAD, S. M. 2006. Managing uncertainty in ERP-controlled manufacturing environments in SMEs. *International Journal of Production Economics,* 101**,** 109-127.

KONGSBERG MARITIME. 2014a. *Kongsberg Maritime History* [Online]. Available: http://www.km.kongsberg.com/ks/web/nokbg0237.nsf/AllWeb/03E4EADBA358FC78C1256A55004648C0?OpenDocument [Accessed 10.04. 2014].

KONGSBERG MARITIME. 2014b *Kongsberg Maritime in brief* [Online]. Available: http://www.km.kongsberg.com/ks/web/nokbg0237.nsf/AllWeb/0B29D39758C415B0C1256DF700560834?OpenDocument [Accessed 06.03.2014].

KONGSBERG MARITIME. 2014c. *Products* [Online]. Available: http://www.km.kongsberg.com/ks/web/nokbg0237.nsf/AllWeb/5DA9836E54D225B6C12575EC003FC3B5?OpenDocument [Accessed 06.03.2014].

KONGSBERG MARITIME, 2014d. *Products A to Z* [Online]. Available: http://www.km.kongsberg.com/ks/web/nokbg0240.nsf/webProductListingAZKongsberg?ReadForm&Lang=English [Accessed 01.06. 2014].

KONIJNENDIJK, P. A. 1994. Coordinating marketing and manufacturing in ETO companies. *International Journal of Production Economics,* 37**,** 19-26.

LESTER, A. 2014. Chapter 11 - Project Life Cycles. *In:* LESTER, A. (ed.) *Project Management, Planning and Control (Sixth Edition).* Oxford: Butterworth-Heinemann.

LUSZCZAK, ANDREAS. 2013. *Using Microsoft Dynamics Ax 2012: Updated for Version R2*, Springer

MELLO, M. H., SEMINI, M. & HAARTVEIT, D. E. G. 2012. A Framework to Integrate Engineering, Procurement, and Production on the Customer Order Decoupling Point.

MICROSOFT. 2011a. Microsoft Dynamics AX 2012. Available: http://download.microsoft.com/download/F/E/5/FE5E998F-8B80-46B7-A47F-1003898CF96B/Microsoft_Dynamics_AX_2012_brochure.pdf [Accessed 17.04.2014].

MICROSOFT. 2011b. *About project types [AX 2012]* [Online]. Available: http://technet.microsoft.com/en-us/library/aa496605.aspx [Accessed 27.05.2014].

MICROSOFT. 2011c. *Generate and manage quotations [AX 2012]* [Online]. Available: http://technet.microsoft.com/en-us/library/bb220746.aspx [Accessed 29.05.2014].

MICROSOFT. 2011d. *About project budgets [AX 2012]* [Online]. Available: http://technet.microsoft.com/EN-US/library/hh242139.aspx [Accessed 29.05.2014].

MICROSOFT. 2012a. *Create a project [AX 2012]* [Online]. Available: http://technet.microsoft.com/en-us/library/aa569913.aspx [Accessed 27.05.2014].

MICROSOFT. 2012b. *About project quotations [AX 2012]* [Online]. Available: http://technet.microsoft.com/en-us/library/hh242089.aspx [Accessed 29.05.2014].

MICROSOFT. 2013a. *About Microsoft Dynamics AX integration with Microsoft Project Server [AX 2012]* [Online]. Available: http://technet.microsoft.com/EN-US/library/gg213008.aspx [Accessed 04.06.2014].

MICROSOFT. 2013b. *Transfer quotation to project wizard [AX 2012]* [Online]. Available: http://technet.microsoft.com/EN-US/library/hh450758.aspx [Accessed 27.05.2014].

MICROSOFT. 2013c. *Create and submit an original project budget [AX 2012]* [Online]. Available: http://technet.microsoft.com/EN-US/library/hh242692.aspx [Accessed 30.05.2014].

MICROSOFT. 2014a. Project management and accounting [AX 2012] [Online]. Available: http://technet.microsoft.com/en-us/library/hh242752.aspx [Accessed 27.05.2014].

MICROSOFT. 2014b. *About work breakdown structures [AX 2012]* [Online]. Available: http://technet.microsoft.com/en-us/library/hh227544.aspx [Accessed 27.05.2014].

MICROSOFT. 2014c. *Create a work breakdown structure template for projects [AX 2012]* [Online]. Available: http://technet.microsoft.com/EN-US/library/dn528661.aspx [Accessed 29.05.2014].

MICROSOFT. 2014d. *Procurement and Sourcing [AX 2012]* [Online]. Available: http://technet.microsoft.com/en-us/library/hh208778.aspx [Accessed 29.05.2014].

MICROSOFT. 2014e. *Product information management [AX 2012]* [Online]. Available: http://technet.microsoft.com/en-us/library/hh242257.aspx [Accessed 29.05.2014].

MICROSOFT. 2014f. *Production control [AX 2012]* [Online]. Available: http://technet.microsoft.com/EN-US/library/hh208549.aspx [Accessed 29.05.2014].

MICROSOFT. 2014g. *About the production process [AX 2012]* [Online]. Available: http://technet.microsoft.com/en-us/library/aa571840.aspx [Accessed 29.05.2014].

MICROSOFT. 2014h. *Service management [AX 2012]* [Online]. Available: http://technet.microsoft.com/EN-US/library/hh208509.aspx [Accessed 30.05.2014].

MICROSOFT. 2014i. *Microsoft Dynamics AX 2012 R3 Preview* [Online]. Available: http://download.microsoft.com/download/5/A/E/5AEC22B0-3DBF-4E57-8E9C-7D63E2204234/Microsoft%20Dynamics%20AX%202012%20R3%20preview%20final%20English%20040914.pdf [Accessed 07.06.2014].

MICROSOFT. 2014j. *SharePoint Overview* [Online]. Available: http://office.microsoft.com/en-us/sharepoint/sharepoint-2013-overview-collaboration-software-features-FX103789323.aspx [Accessed 08.06. 2014].

MING, X. G., YAN, J. Q., WANG, X. H., LI, S. N., LU, W. F., PENG, Q. J. & MA, Y. S. 2008. Collaborative process planning and manufacturing in product lifecycle management. *Computers in Industry,* 59, 154-166.

OLHAGER, J. 2003. Strategic positioning of the order penetration point. *International Journal of Production Economics,* 85**,** 319-329.

OLSEN, K. A. & SÆTRE, P. 2007. IT for niche companies: is an ERP system the solution? *Info Systems J***,** 37-58.

ONESUBSEA. 2013a. *About OneSubsea* [Online]. Available: http://onesubsea.com/about.aspx [Accessed 03.04. 2014].

ONESUBSEA. 2013b. *Swivel Stack Systems* [Online]. Available: http://www.onesubsea.com/products_and_services/swivel_marine_systems/swivel_stack_systems.aspx [Accessed 03.04.2014].

ONESUBSEA. 2013c. *Multiphase Subsea Pump* [Online]. Available: http://www.onesubsea.com/products_and_services/processing_systems/pumps_subsea_systems/multiphase_pump.aspx [Accessed 04.04.2014]

PANDIT, A. & ZHU, Y. 2007. An ontology-based approach to support decision-making for the design of ETO (Engineer-To-Order) products. *Automation in Construction,* 16**,** 759-770.

PINTO, J. K. 2010. *Project Management - Achieving Competitive Advantage*, Pearson.

PORTER, K., LITTLE, D., PECK, M. & ROLLINS, R. 1999. Manufacturing classifications: relationships with production control systems. *Integrated Manufacturing Systems,* 10**,** 189-199.

PROJECT MANAGEMENT INSTITUTE. 2000. *A guide to the project management body of knowledge (PMBOK® guide*). Newtown Square, Pennsylvania, Project Management Institute, Inc.

PROJECT MANAGEMENT INSTITUTE. 2013. *A guide to the project management body of knowledge (PMBOK® guide)*. Newtown Square, Pennsylvania, Project Management Institute, Inc.

RINGSETH, K. 2014. TTS Case study. *In:* SØRBØ, G. K. & HØNSI, M. (eds.).

ROMSDAL, A. 2013. Research Methodology. NTNU.

SABIN, D. & WEIGEL, R. 1998. Product Configuration Frameworks - A Survey. *IEEE Intelligent System* 42-49.

SALTER, A. & GANN, D. 2003. Sources of ideas for innovation in engineering design. Research Policy, 32, 1309-1324.

SEMINI, M., HAARTVEIT, D. E. G., ALFNES, E., EMRAH, A., BRETT, P. O. & STRANDHAGEN, J. O. 2014. Strategies for customized shipbuilding with different customer order decoupling points. *Journal of Engineering for the Maritime Environment*.

SHAUL, L. & TAUBER, D. 2013. Critical success factors in enterprise resource planning systems: Review of the last decade. *ACM Comput. Surv.,* 45**,** 1-39.

SHISHANK, S. & DEKKERS, R. 2011. Outsourcing: decision-making methods and criteria during design and engineering. *Production Planning & Control,* 24**,** 318-336.

SILVERMAN, D. 2006. *Interpreting Qualitative Data*, SAGE Publications.

SOMERS, T. M. & NELSON, K. The impact of critical success factors across the stages of enterprise resource planning implementations. System Sciences, 2001. Proceedings of the 34th Annual Hawaii International Conference on, 3-6 Jan. 2001 2001. 10 pp.

SOY, S. K. 1997. *The Case Study as a Research Method* [Online]. Available: https://www.ischool.utexas.edu/~ssoy/usesusers/l391d1b.htm [Accessed 03.03.2014].

TAYLOR, D. 2009. *The Literature Review: A Few Tips On Conducting It* [Online]. University of Toronto. Available: http://www.writing.utoronto.ca/advice/specific-types-of-writing/literature-review [Accessed 03.03.2014].

TTS. 2014a. *About TTS* [Online]. Available: http://www.ttsgroup.com/About-TTS/ [Accessed 10.04.2014].

TTS. 2014b. *TTS Offshore Handling Equipment AS* [Online]. Available: http://www.ttsgroup.com/Companies/TTS-Offshore/ [Accessed 10.04. 2014].

WIKNER, J. & RUDBERG, M. 2005. Integrating production and engineering perspectives on the customer order decoupling point. *International Journal of Operations & Production Management*.

YANG, L.-R. 2013. Key practices, manufacturing capability and attainment of manufacturing goals: The perspective of project/engineer-to-order manufacturing. *International Journal of Project Management,* 31**,** 109-125.

YIN, R. K. 2009. *Case study research: design and methods,* Thousand Oaks, Calif., Sage.

ZACH, O. & OLSEN, D. H. 2011. ERP System Implementation in Make-to-order SMEs: An Exploratory Case Study. International Conference on System Sciences, 2011 Hawaii.

8 Appendix

Appendix A. Criteria for ERP systems in ETO companies

Project management:

1. Have the functionality for project management
2. Include functionality for making the WBS
3. Support for logging and registration of the WBS activities and deliverables in order to measure the progress
4. Generate updated plans, and new cost and lead time estimates as more information of the project and progress is available

Re-use of information/decision support:

5. Ability to view information from earlier projects, and reuse information. Especially in the quotation stage, design phase and the production planning.

Quotation stage:

6. Support for handling the quotation phase in the system, and plan for duedate, cost and capacity.

Engineering and design:

7. Integration of PLM system with the ERP system (or some sort of customized product configurator to integrate the design phase with the ERP system)

Change management:

8. ERP system must react and take action when new information is provided through the PLM system
9. ERP system must react and take action when new information concerning the project or product is added into the ERP system

Production and manufacturing:

10. ERP system should include a solution that makes it possible to initiate production even though the complete product/master BOM is not finalized yet
11. ERP system should support product routing with consideration to job shop, and allow for flexibility in production
12. Should be able to register when a job/operation has been performed

Offshore and maritime industry:

13. The solution should be able to store information of where the products placed, can be met with an installation register
14. Should support the arrangements of the shipment of the product, can be met with a shipment module

Offshore and maritime industry if they perform service and maintenance:

15. The solution should contain a service and/or maintenance module to plan and register service operations of a product
16. The service and/or maintenance module should provide information of previous service operations that have been performed on the product
17. The ERP solution should support for special agreements made on price and service operations, can be met with a contract module

Costs:

18. The solution must be considered in terms of cost, especially for SMEs, not only in terms of implementation today, but how the company can adapt to future updates and changes.

Appendix B. Pre-study Report

Pre-Study Report

Vertical solution for ETO companies using Microsoft Dynamics AX

Guri Karoline Sørbø

Marianne Hønsi

Spring 2014

NTNU

1. Introduction

1.1 Background

This pre-study report is a part of the Master Thesis Spring 2014 written by Guri Karoline Sørbø and Marianne Hønsi at the Department of Production and Quality Engineering at the Norwegian University of Science and Technology. The thesis will be written in collaboration with NTNU and CGI. CGI is a global company involved in business consulting, systems integration and IT outsourcing services. This pre-study report will give an overview of the thesis at an early stage perspective and it will present a detailed plan on how the thesis will be conducted.

The Master Thesis is a continuation of the project conducted in fall 2013 with the title "*ICT-enabled production model in an ETO environment*". The project evaluated the possibility and benefits of implementing an Enterprise Resource Planning (ERP) system into an Engineering-to-order (ETO) company in the maritime and offshore industry. This can be difficult due to the different manufacturing strategy the ETO company uses, as well as making correct choices regarding implementation of the ERP system which impacts the success and budget. There are multiple definitions of ETO, so the project defined the barriers for what it considered to be an ETO company, namely a company that does some type of design/engineering on their products, both when designing a completely new product or when making changes to an existing design.

The result of the Project Paper was a list of criteria that should be present in an ERP solution in order to benefit an ETO maritime/offshore company. Lastly, there was also made a list of what was considered the most important modules in an ERP solution to best suit the special requirements. In conclusion there were in total 18 requirements, and the modules that were considered the most applicable for such a solution was project management, quality management, material management, maintenance/service management, contract management, inventory management, finance, accounting, HR, marketing, PLM, SRM, and CRM. A big difference in this type of ERP system is the change of what is considered the main, key module. Previously, the MRP module was critical to the production and planning aspect, while this is not true for an ETO company because it is not possible to plan material requirement ahead of the design phase that often happens during the production phase. As a result the focus now shifts to concentrate on the project management module to get the best fit into an ETO company.

For the Master Thesis there will be more focus on ETO companies that perform some sort of project. The thesis will also take a deeper dive into ERP, and focus on a specific ERP software Microsoft Dynamics AX (AX). The problem at hand will therefore be summarized as follows: How can an ERP solution in AX be implemented to benefit companies who conduct ETO projects in the offshore and maritime industry?

After ERP and ETO, one of the most important keywords for this thesis will therefore be “Project”. Projects can be challenging to manage and control because of the complex delivery aspects. There are continuous changes and updates made to a project, different departments are collaborating during the project, and projects move through different life-cycles based on the product. This calls for a complex ERP solution that can adapt to specific requirements the industry has. By using the criteria produced in the fall 2013 Project Paper there will be done an extensive study on how an AX solution can cope with these requirements.

Developing knowledge of the system Microsoft Dynamics AX will be a big part of the thesis. From earlier, we have some experience with the system, but in order to develop a vertical solution on Dynamics AX we need to go deep into the software in order to evaluate the system’s strengths and weaknesses. This will be done through both practical training in the system and reviewing literature and system documentation. In addition, it is crucial to get some information from users of the system. To get this knowledge there will be conducted case studies of companies that are using Dynamics AX.

1.2 Collaborating company CGI

As previously mentioned, CGI is global company involved in business consulting, systems integration and IT outsourcing services. CGI has customers within the maritime and offshore industry that operates with an ETO strategy and production, where they offer the ERP system, Microsoft Dynamics AX together with supporting systems.

The collaboration with CGI will give benefits to both sides of the group. From the authors point of view, there is expected to gain inside knowledge on CGI’s AX software solutions and experience. There is also a hope that CGI will provide case companies that can be used to conduct case studies on. This information will be critical in finding a solution to our research questions. As for CGI, the results of the thesis will be a product that can use in their own work for creating a system portfolio.

2. Thesis Description

2.1 Goals

Our goals are:

- End up with a generic Microsoft Dynamics AX solution based on the specifications and requirements of offshore and maritime ETO companies.
- Conduct survey studies on existing solutions in the industry to supplement the little information that exists on the subject.
- Create a walkthrough of a simple project in AX to illustrate the functionality to better understand the capabilities of the solution from a non-IT perspective. Customers of CGI are often not familiar with AX.
- To present a thesis of such high quality that it can result in the grade A.

2.2 Research Question

With consideration to the project description our scientific question will be phrased as follows:

- Q1:
    - How can Microsoft Dynamics AX solve the requirements of project oriented production companies in the offshore/maritime industry?
- Q2:
    - How have offshore/maritime companies solved the special requirements for ERP solutions today? (Case study)
- Q3:
    - What benefits can a company expect from implementing such a solution on Microsoft Dynamics AX?

3. Methods

In order to reach the goals of the thesis and answer the research questions we will use a qualitative research approach. This will include literature study and case studies.

The first step of the thesis is to clarify our goals and research questions, and plan how to further execute the thesis. All of this is presented in this pre-study report.

A literature study will be done on the topics ETO and ERP, where information can be reused from the Project Paper. Other material will be gathered by doing searches on online databases for new articles matching the criteria we decide are relevant for the thesis. These criteria will be presented in the formal thesis. From experience, searching for articles online can result in very different outcomes in papers based on small changes in search word formulation. This forces us to exhaust more possibilities and combinations of search words to be sure we get enough information to continue the literature study. In addition, there were many relevant articles found by using the snowball effect during the Project Paper, which will also be used during the thesis.

Another example of experience gained from the previous Project Paper is to connect and evaluate the topics ETO and ERP in the light of each other throughout the entire paper. Also, the message of why the information is relevant should be very clear. In addition, there is also a wish to create more frameworks in order to get the results out more clearly.

Further on, the thesis will include a case study where hopefully companies using ERP software will answer a survey. This process is still being planned properly. There will be set criteria for what companies can be included in the case study. To get empirical results that can be compared in relation to each other there will be asked the same set of questions in each company. These questions must be carefully planned in order to receive the most beneficial information that can help answer the research questions. Therefore, if possible, a test interview will be conducted to see if the questions are good enough. The test company is a known associate of the department of Production and Quality Engineering at NTNU. This company does not meet the preliminary criteria for being a case company because they do not use Microsoft Dynamics AX, but they are in the segment of ETO. On the other hand, it is an opportunity to evaluate how other solutions have coped with challenges.

In the survey we want to test if the ERP-solutions of the case companies meet the set of criteria we developed in our project. Giving the same survey to the companies will give us the opportunity to compare results, and see if there are any factors that are present in all solutions and can have an effect on the vertical solution the thesis will generate.

After analyzing literature, system documents, practical experience of the system, and the case studies we will design the solution on Microsoft Dynamics AX. This solution should be presented in such a way that someone not already familiar with Dynamics AX can read it and understand how the system works and how it can benefit a company. To present the information visually may be a tool in order to explain how the solution works, therefore there will be focus on making simple and self-explaining illustrations.

4. Preliminary Sources

As previously mentioned, this thesis is a continuation of the project paper from fall 2013. Therefore, the preliminary sources will be made up of some of the same sources as used in the project paper, in addition to new searches done in databases such as Sciencedirect, ACM, Google Scholar, and Emerald.

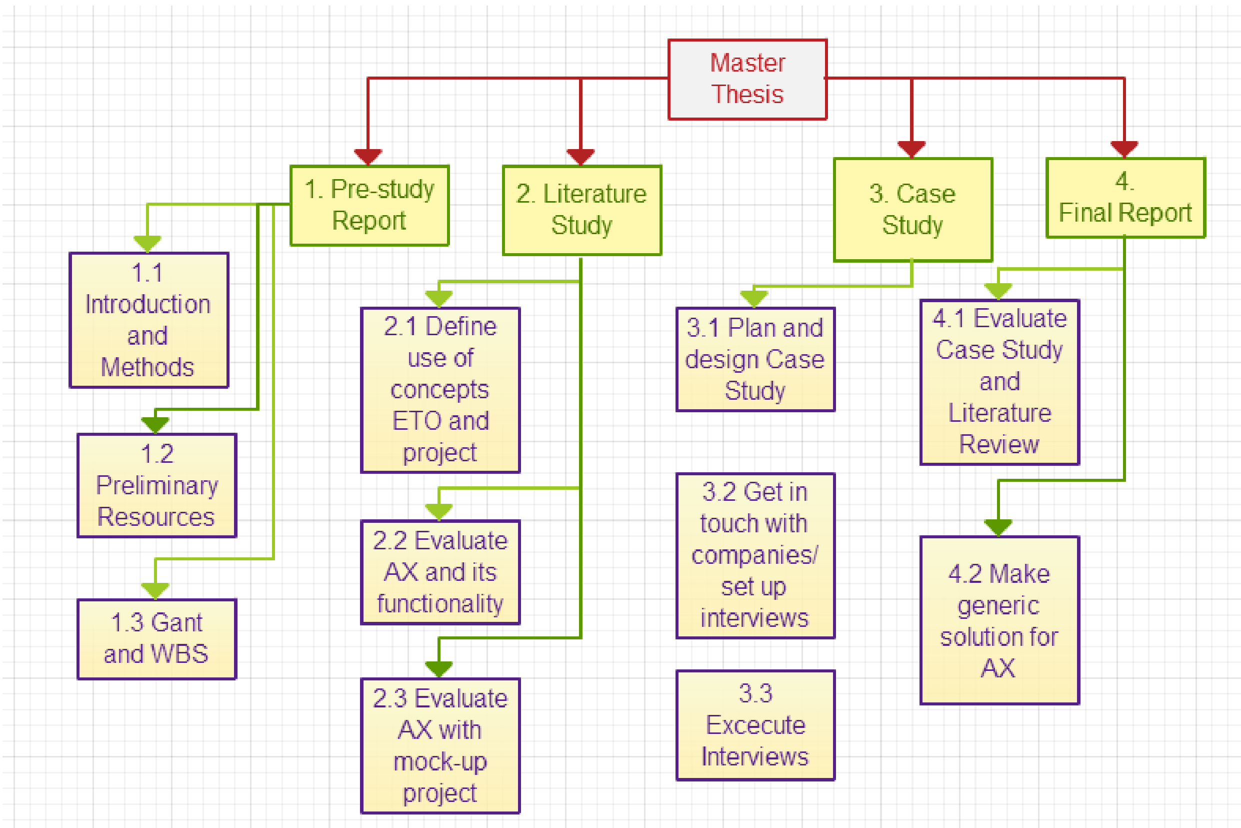
At this moment we have found some articles regarding new topics that may be of interest for the thesis.

New articles:

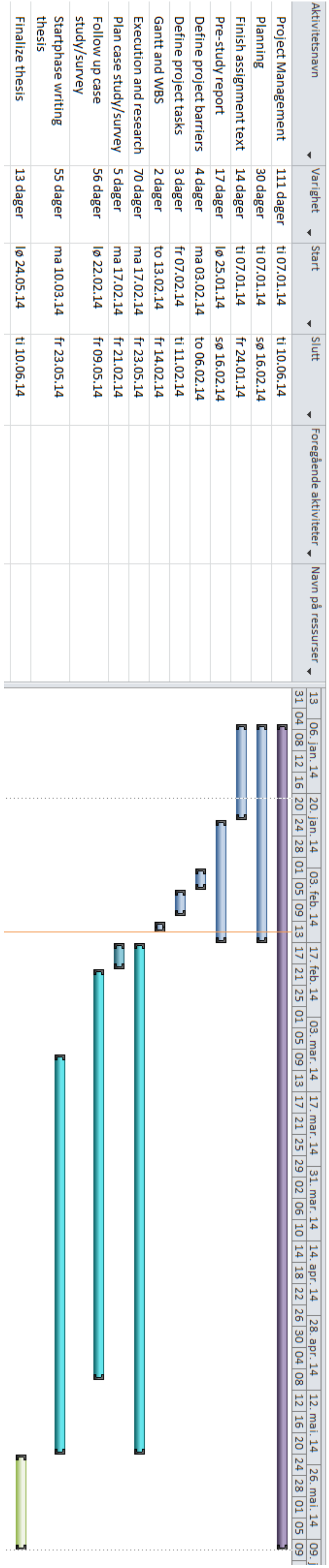
- MICROSOFT. 2013. *Project Management and Accounting (AX 2012)* [Online]. Available: http://technet.microsoft.com/en-us/library/hh242752.aspx [Accessed 24.01 2013].
- MAHMOUD-JOUINI, S. B., MIDLER, C. & GAREL, G. 2004. Time-to-market vs. time-to-delivery: Managing speed in Engineering, Procurement and Construction projects. *International Journal of Project Management,* 22**,** 359-367.
- ISHII, N., TAKANO, Y. & MURAKI, M. An order acceptance strategy under limited engineering man-hours for cost estimation in Engineering–Procurement–Construction projects. *International Journal of Project Management*.
- YEO, K. T. & NING, J. H. 2002. Integrating supply chain and critical chain concepts in engineer-procure-construct (EPC) projects. *International Journal of Project Management,* 20**,** 253-262.
- CARON, F., MARCHET, G. & PEREGO, A. 1998. Project logistics: integrating the procurement and construction processes. *International Journal of Project Management,* 16**,** 311-319.

- BERNROIDER, E. W. N., WONG, C. W. Y. & LAI, K.-H. 2014. From dynamic capabilities to ERP enabled business improvements: The mediating effect of the implementation project. *International Journal of Project Management*, 32**,** 350-362.

5. Work Breakdown Structure



6. Gant



Aktivitetsnavn	Varighet	Start	Slutt	Foregående aktiviteter	Navn på ressurser
Project Management	111 dager	ti 07.01.14	ti 10.06.14		
Planning	30 dager	ti 07.01.14	sø 16.02.14		
Finish assignment text	14 dager	ti 07.01.14	fr 24.01.14		
Pre-study report	17 dager	lø 25.01.14	sø 16.02.14		
Define project barriers	4 dager	ma 03.02.14	to 06.02.14		
Define project tasks	3 dager	fr 07.02.14	ti 11.02.14		
Gantt and WBS	2 dager	to 13.02.14	fr 14.02.14		
Execution and research	70 dager	ma 17.02.14	fr 23.05.14		
Plan case study/survey	5 dager	ma 17.02.14	fr 21.02.14		
Follow up case study/survey	56 dager	lø 22.02.14	fr 09.05.14		
Startphase writing thesis	55 dager	ma 10.03.14	fr 23.05.14		
Finalize thesis	13 dager	lø 24.05.14	ti 10.06.14		

Appendix C. Survey and Interview Questions

Survey

Project management

Does the solution have functionality for:

1. Project Management? YES / NO
2. making Work-Breakdown-Structure (WBS)? YES / NO
3. logging and registration of WBS activities and deliverables in order to measure progress? YES / NO
4. generating updated plans, cost, and lead time estimates as more information of the project and progress is available? YES / NO

Re-use of information/decision support:

Does the solution have functionality for:

5. viewing information from earlier projects? YES / NO
6. reusing information in other projects? YES / NO

Quotation stage:

7. Does the solution support quotation? YES / NO
8. Does the quotation functionality include planning for due date, cost and capacity? YES / NO

Engineering and Design:

9. Does the software support integration with PLM systems or other design software? YES / NO

Change Management

10. Does the ERP system update dependent variable when changes are made in the integrated software? YES / NO
11. If not automatically, does the solution have functionality for warning users that dependent variables need to be updated? YES / NO

Production and manufacturing:

12. Is it possible for the ERP system to initiate production even though the complete product/master BOM is not finalized? YES / NO
13. Does the ERP system support product routing with consideration to job shop, and allow for flexibility in production? YES / NO
14. Does the solution register when a job/operation has been performed/completed? YES / NO

Offshore and maritime industry:

Does the system support functionality for:

15. an installation register? YES / NO
16. shipment of products in form of a shipment module? YES / NO

Service and Maintenance:

17. Does the company offer service and maintenance of the products after delivery? YES / NO
18. If yes; does the solution contain a service and/or maintenance module to plan and register service operations of a product? YES / NO
19. Does the service and/or maintenance module provide information of previous service operations that have been performed on the product? YES / NO

Semi-structured interview questions:

ETO Strategy:

1. Where would you place the company based on this framework?
   ETOed (engineer to order, everything from scratch), ETSed (engineer to stock, do the engineering first, then sell product), ATOed (adapt to order, use previous finished product and customize to new customer order)
2. Does the company conduct any production that does not fall under the ETO category, for example any standard components or products?
   a. If yes, how many percent of the products are not ETO?

Project management:

3. How would you describe the size and complexity of these ETO product projects? (be specific: cost, number of parts, size of product, man hours per project, etc.)
   a. How many projects per year are ETO?

4. What type of project management functionality does the ERP system support?

Functionality	Yes	No
Resource Allocation		
Cost Control		
Workflow Scheduling (Time management, Gantt)		
WBS (activities, project structure)		
Collaboration Management		
Role Management (assign roles to people working on project)		
Quotation		
Reuse of information (quotation, WBS, product spec, etc.)		

Other functionality?

a. Is there one, specific module for project management, or is the functionality divided among multiple modules?
b. Does the company use predefined simplified calculation and properties/decision model (that concern functionality, dimension, material type, material quantity, and/or selection of manufacturing processes) to make the quotation stage easier?
c. How is material planning and procurement conducted in an ETO project? Is either MPS or MRP used?
d. How does the WBS couple with other functionality (e.g. design and production)?

Other:

5. Was there any alterations made to the system when implementing?
    a. What changes were made?
    b. Why was this done, and did it benefit the business?

Appendix D. Deviation Report

Introduction

This report is an overview of the work done in this thesis, and an evaluation of how the thesis went according to the original plans made in the pre-study report. The thesis looks into the concept of ERP into ETO companies in the offshore and maritime industry. The topic is therefore very large, and scoping the problem down was therefore extremely important so that the workload was possible to conduct in the defined timespan. The thesis started on January 14th 2014, and is due on June 10th 2014.

Progress, deviations, and thesis work

The pre-study report introduced the original scope of the project, which was to focus more on projects that are conducted in the ETO companies, in order to see if the way ETO companies conduct their production with its business processes could fit into an ERP system. In addition, to get a better understanding of the ERP software functionality the thesis chose to use a specific software, namely Microsoft Dynamics AX (AX). Because of little information on the topic in the academic literature, case study was proposed as an alternative to gather data.

In addition, goals, research questions, and the preliminary method was introduced in the pre-study report. The research questions stayed the same throughout the entire thesis period, but one of the goals was cut during the thesis work. The goal that was cut was to create a "walk-through" in AX. The reason for not conducting the walk-through was to scope down the project and cut the workload. The thesis rather focused on the general functionality in AX with consideration to ETO business processes, which can also be used to orient ETO personnel on the possibilities in AX. In addition, as the thesis progressed it was revealed that additional software had to be used in order to conduct the entire project, which the authors did not have access to. The mock-up project conducted in AX would therefore not have been applicable to ETO companies, as it was discovered that the functionality was not sufficient.

Regarding the WBS, it was conducted as it was presented, but with the exception of the mock-up project. The Gantt chart was followed as presented in the pre-study report, and was designed in a way that the literature study and case study could be conducted in parallel. This was due to the interviews happening on short notice, and the days that the interviews were conducted could not be planned with certainty early on. The only deviation that can be mentioned is that the survey was created during/in the late phase of the literature review in order to benefit from the findings. This was originally planned to happen at the start of the literature review.

Throughout the thesis the authors have been disciplined, and because of this we have been able to follow the plan we set up with great precision. We have worked full days throughout the semester, and defined smaller goals with deadlines in order to achieve the progress we wanted.

With concern to the case studies we were aware of the possibilities that it could be difficult to get interviews with the preferred people in the companies. Because of a busy time schedule, and the company being in the middle of the implementation phase, we were not able to get an interview with the AX expert at Kongsberg. However, this was solved by conducting the interview with a CGI consultant on the implementation project and supplementing with information from Kongsberg where additional information was needed. This way we were able to get the information we needed and the problem was solved in a sufficient matter.

Appendix E. White Paper

CGI

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WHITE PAPER

ERP Solution – ETO Offshore and Maritime Industry

While benefits from implementing an ERP system in companies doing mass production, skepticism exists to whether ERP systems can benefit companies producing highly customized products in the same way. This paper discusses the challenges within these engineer-to-order companies with focus on the offshore and maritime industry and introduces an ERP solution designed to meet their requirements. With a solution designed specifically for ETO companies within the offshore and maritime industry the paper also identifies the benefits that are possible to gain.

BACKGROUND

Enterprise Resource Planning systems, also called ERP systems, are enterprise wide integrated information systems. The goal of ERP systems is to integrate business procedures, applications and departments while sharing one source of information and by doing so drastically change the way a company gathers, stores, and uses its information.

Historically, ERP evolved from Material Requirement Planning (MRP), which was one of the first systematic material planning systems. The calculations done in MRP are based on the use of Bill of Materials (BOM) that made it possible to plan component manufacturing and assembly of products ahead of time based on forecasts. Due to the evolution of MRP to ERP, the MRP functionality has also been important in ERP systems. As a consequence, certain types of manufacturing companies have had a larger advantage of using ERP. Companies with strategies such as make-to-stock (MTS) and assemble-to-order (ATO) can plan ahead with MRP functionality due to the knowledge of finished BOMs and routings.

Engineer-to-order (ETO) companies have a more complex strategy than MTS and ATO, and there have existed skepticism to whether companies operating with an ETO strategy can gain as good results by implementing an ERP system. For ETO companies, almost all customer orders are the result of a project, and during the projects there exist uncertainty of the design and BOM. ETO companies can therefore not benefit in the same way from forecasting and scheduling with MRP, however this does not mean they cannot benefit from ERP systems. It means that ETO companies have other requirements and therefore requires a special solution.

In ETO projects, the final design of a product is often not completed until late into the project. A method that has been taken into use in order to decrease the lead time is concurrent engineering. Concurrent engineering relies on parallel scheduling of activities throughout the product development cycle. All functional areas of the company participate simultaneously in the product design and engineering activity, as well as procurement and production activities are being initiated. ETO therefore sets requirements of handling changes and uncertainty that occurs throughout the project in procurement, design and production, in addition to the handling of a complex information flow.

While the early ERP systems might have been developed to meet the requirements of mass production, the ERP systems of today are getting more and more advanced. New editions and enhancements are developed as the industry discovers new needs. CGI has invested in developing an ERP solution that fulfill the requirements of ETO companies in the offshore and maritime industry, and can help create strong value for their customers in the industry.

CGI

MANAGING THE ETO PROJECT LIFE CYCLE

ETO is often referred to as project based manufacturing or project based production. The key aspect of the ERP solution for ETO companies has therefore been on how to manage the project through the entire project life cycle. The ETO ERP solution moves away from the traditional view of clarifying the BOM, routing and lead time of the product, in order to plan procurement and production with forecast and master scheduling. The new focus for ERP in ETO is to manage the entire life cycle of a customer order project in an efficient and flexible way. Instead of planning production, managing ETO projects becomes the core of the solution. Today's ERP systems are advanced and comprehensive information systems, and will help the information management and flow in the project.

IMPORTANT BUSINESS PROCESSES TO BE HANDLED

When creating the ERP solution for the offshore and maritime industry, a lot of work has been put into the identification of the important and specific business processes for ETO companies in this industry. Because ETO customer orders are conducted as projects, project management is a very important business process in the ERP solution that requires a lot of flexibility. In addition, each stage in the project must be able to process through the ERP solution. In a typical project in the offshore and maritime industry these business processes are identified as the most important ones:

- Quotation
- Project Management
- Design & Engineering
- Procurement
- Production
- Service and Maintenance
- Installation Register
- Shipment

Functionality for meeting the requirements of each business process has been facilitated for in the solution. The vertical solution for ETO companies in the offshore and maritime industry is built on the ERP system Microsoft Dynamics AX. CGI has long experience with delivering fully integrated solutions built on Microsoft Dynamics AX. One of the strengths of the Dynamics AX system is that it is a Microsoft product. The system is a combination of extensive Microsoft research, development, and innovation investment to business customers wrapped in a unified solution. When using the ERP system the user interface reminds of the layout of Microsoft Office, which most people are already familiar with. The user interface is therefore very user friendly and easy to learn.

Further every business process with the requirements of each process which the solution is designed to handle is presented. From CGI's experience some companies have a strong wish of integrating the solution with the project management software Primavera, This is a strong Project management tool used by many of the big actors in the industry. CGI has therefore designed two very similar solutions. Option 1 will provide the integration with Primavera, while option two will provide the integration with other Microsoft software, namely Microsoft Project Server and Microsoft SharePoint.

CGI

QUOTATION

The quotation process is extremely important for ETO companies and support for this business process is facilitated for in the solution. Quotation is the root to all customer orders, and thereby revenue. In the ETO environment the process is not straightforward. Heavy customized products means that there are no price lists, the design is not complete, and the production process is still unknown. In order to support this process, there has to be good support for documentation management in order to keep track of requirements, resources, designs, and other information that is generated during the different rounds of negotiation.

Within the Project Management module in AX there is support for quotation of simpler projects, but for the more complex ones it is integrated with one of these alternatives:

- Option 1: If the solution is integrated with Primavera all quotations should be executed in Primavera, and data will be transferred from Primavera to AX. Primavera has strong built in support for the quotation process.
- Option 2: The more complex quotations need support for handling documentation. Dynamics AX is integrated with Microsoft SharePoint, and a site for quotations can be established. Data and documentation for every quotation can be gathered and sorted, and the possibility to bring up information from previous quotations and projects is provided for with easy access. This eases the information flow of the quotation process.

PROJECT MANAGEMENT

Project management is considered the core of the solution and is also one of the core capabilities in ETO companies. For an ETO project it will be how to initiate, plan, execute, monitor and control the ETO business processes, and eventually the close up. Some ETO companies also participate in the After Service market.

One of the most vital planning mechanisms in a project is the Work Breakdown Structure (WBS), with the intention to divide the project into sub-steps and deliverables in order to establish critical interrelationships among activities and more manageable components. This functionality is critical in a software solution that will represent the business processes in an ETO company. The WBS almost becomes the core of the solution, as it is the modeling of the project. By creating a representative WBS of the project, project schedules and a project budget can be produced. This gives tools for managing the project further. In the solution cost and hours are logged for the activities. From this progress can be monitored, and the company is able to follow if they are on schedule and within budget. If deviation is discovered, it gives the possibility to prepare new plans and schedules.

Dynamics AX has the built in project management and accounting module but by integrating with supporting software for project management the company can gain more flexibility and possibilities for visualization of data throughout the project. This is why CGI recommends these alternatives; Primavera or Microsoft Project Server.

- Option 1: Primavera is a strong project management software. In this solution the data between Primavera and Dynamics AX are shared which leaves for a more efficient way of controlling the project. In this case Primavera acts as the master and shares all data with Dynamics AX.
- Option 2: MS Project is used as the planning tool. The activities are planned for in MS Project as well as the determination of resources for each activity. The WBS is created in MS Project can be transferred to Dynamics AX. Dynamics AX functions as the execution tool and the logging of activities. With a two way integration between these systems, information must only be logged once, and both systems are updated. Both systems allows for use of templates when creating the project and WBS, which can help save time, as well as reuse important information from earlier projects.

DESIGN & ENGINEERING

Design and engineering is the other business process that is considered a core competency in the ETO environment. By using a PLM system it will support management of portfolio of products, processes and services from initial concept, through design, engineering, launch, production, use, and to final disposal. The PLM system may help create a competitive advantage for manufacturing organizations as it connects products through the value chain and can help create better products in less time, at lower cost, and with fewer defects. Which PLM system to choose can be up to each company, but the integration will be created so that the PLM system creates the BOM in Dynamics AX. This allows for automatic creation of BOMs in the ERP system, and help saves time as well as the possibility for human errors. With an automatic update, the ERP system will always have the correct product information in the system.

PROCUREMENT

Procurement in ETO companies can be troublesome because of customization, which makes it hard to estimate lead-time and thereby delivery dates. If components are procured too late it will postpone the entire project. To support this problem, information from earlier projects can be reused. Risk of procuring in the ETO environment will always be there, and by reusing information on previous projects there is a possibility of reducing that risk. From every project there is more knowledge that can be employed to estimate lead-times in a more accurate way. The solution also provides for functionality for keeping track of long lead time items. By putting this information into the system, it indicates that these items should be assessed and considered early in the project.

All though there have existed controversial opinions of the use of MRP functionality in a solution designed for ETO companies, MRP functionality is still useful for generating material requirements. When operating with incomplete BOMs it can give a rough estimate of the parts that are already defined. When doing concurrent engineering procurement is initiated for some parts, even though the design is not complete.

Another functionality that has been added for the ETO need is conditional release in procurement and production. Parts are released to procurement or production, but with conditions on the specific part. The customer therefore has to approve the criteria and conditions before the parts are procured or the production can start. This is a way of controlling the concurrent engineering and a clever way to reduce risk during the project. This way the customer is involved, and has approved the current design. The customer makes a commitment, and procurement or production can be initiated from this.

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PRODUCTION

Production is a complex process for ETO companies because product information is largely unknown at the acceptance of an order, and it continuously changes until product specifications are finalized. Projects with unrealistic production schedules are often the reason for delays, which highlights the need for good project management software. In an ETO where each production schedule will be different, the production can be planned through the use of the WBS. Parts are connected with production activities to be performed and resources to be used. Progress is also measured by evaluation of the WBS. This also gives valuable information that can be used in later projects, when similar activities are planned for in a new project.

Support for deviation projects have also been added to the solution. Here faults on components can be added and the information on the faults can be used to improve both parts and production processes. The functionality for deviation projects is also used on outsourced components. The information generated in the projects can be used to evaluate if a supplier delivers satisfactory products.

SERVICE AND MAINTENANCE + INSTALLATION REGISTER

Service and maintenance is often offered by companies within this industry on the finished products. Functionality that can register the specifics during service jobs is therefore also important for the total software solution. In addition an installation register is necessary in order to keep track of the products that are located around the world. Because of the maintenance aspects, the register is beneficial to keep a complete history of each product and what type of service and work is done on it. Since the installation register is closely linked with the service and maintenance functionality, CGI has looked at modules providing both functionalities in one module. This functionality provides for easy registration of service and maintenance, and up to date information of location and service that have been executed. In addition, by collecting all this information it is possible to recognize any patterns for maintenance and service with concern to time intervals or certain components.

SHIPMENT

Shipment is another important process for ETO companies in the offshore and maritime industry. Often it is expensive equipment that are produced in-house, and must be shipped to the customer for delivery. With functionality for arranging this in the system allows for gathering the data and the project can truly be followed from the beginning to delivery. Shipment during the project execution is also the case for several companies, where documentation, product detail and status should follow the parts as they are shipped around for production purposes. Collecting this information in a module provides for an overview of the entire project, and where parts are sent and can be expected in return.

OTHER

While the business processes addressed above are the processes identified as important, CGI also offers customization of the solution to their customers. Therefore if the company have additional needs it is possible to address these as well.

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BENEFITS FROM IMPLEMENTING THE SOLUTION

Quotation:

- Reduce quotation time and effectively manage time-bottleneck in the project process by including quotation software that is integrated with total solution
- Better handling of the quotation process in ETO environment by increased documentation management
- Effectively manage quotation for other manufacturing strategies by including standard Dynamics AX functionality in addition to ETO quotation software

Project Management:

- Increase project management capabilities in form of an integration of software to effectively and better support the need for conducting ETO customer orders as projects
- Decrease redundant information, as well as keeping updated and consistent information, by using integrated software between project management and Dynamics AX

Design and Engineering:

- Increase the degree of reengineering and adaptation of earlier design, as well as keeping the customization ability, by reuse of information and use of templates in software
- Reuse of information will decrease the time it takes to generate BOM, which in turn reduces total lead-time of the project
- Decrease total lead-time by use of long lead-time item functionality for a quick start of the design and engineering phase of the product
- Decrease redundant information, as well as keeping updated and consistent information, by automatic updates between PLM system and Dynamics AX
- Support of ETO design and integration of new designed components by use of revision control

Procurement:

- Decrease risk of changes in design after procurement has been initiated by the use of conditional release, as well as promote concurrent engineering

Production:

- Increase quality awareness by use of deviation projects
- Recognize similar activity packages for reuse of information

Installation register and Service/Maintenance:

- Effectively follow up unique products as well as keep service history on the products and location

Shipment:

- Increase flexibility by the use of a shipment module that can help organize deliveries that best suits the customer
- Increase in-house logistics by use of shipment module that keeps status, location and additional information on components

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Other:

- Shorten the time associated with making a decision and increase the reliability of the decision processes - by reusing information from previous projects, this can definitely become one of the most important benefits.
- Optimize the supply chain and inventory. By using the ERP system and its planning and overview technology there is a better chance of starting with supply chain activities at the right time and thereby keep inventory as low as possible
- Increase business flexibility. This is highly important in an ETO environment and can be achieved by integrating Dynamics AX with project management software as MS Project or Primavera
- Decentralize information processing by making it real-time
- Achieve balance between decentralization and control among functions to avoid redundancy, ensure synergy, and manage performance indicators

Appendix F. Original Thesis Contract

NTNU

Fakultet for ingeniørvitenskap og teknologi
Institutt for produksjons- og kvalitetsteknikk

Vår dato	Vår referanse
14.01.2014	EAL/KEDA

MASTEROPPGAVE
Våren 2014
for
stud. techn. Marianne Hønsi og
stud. techn. Guri Caroline Sørbø

Vertikal løsning for ETO bedrifter basert på ERP systemet Microsoft Dynamics AX
(Vertical solution for ETO companies on Microsoft Dynamics AX)

CGI er et selskap som leverer tjenester og teknologi for forretningsdrift, og har ca 70 000 ansatte på verdensbasis. Selskapet er ett av Norges ledende innen rådgivning, systemintegrering og outsourcing av IT løsninger. Oppgaven vil løses i tett samarbeid med produksjonsvertikalen hos CGI Norge som ønsker å videreutvikle sine leveranser for å bedre kunne oppfylle kravene til IT støtte i norsk industri.

Prosjektet vil være knyttet CGI Norge og ett utvalg av deres kundeinstallasjoner innen ETO basert produksjon (som: Kongsberg Maritime, OneSubsea (Schlumberger), TTS, Linjebygg offshore, etc.).

En stor del av CGI's produksjonssatsning er rettet mot maritim & offshore basert industri som har en «Engineer to Order» strategi. CGI leverer ERP-systemet Microsoft Dynamics AX med tilhørende verktøy til denne type kunder i Norge. Dynamics AX systemet kan settes opp ulike måter å støtte en ETO selskap, samtidig finnes det ulike andre IT-verktøy som kan brukes i samråd med ERP systemet for å kunne fylle kravene til IT støtte i en ETO bedrift (som PLM, Prosjektplanlegging, Timefangstsystemer, DAK/DAP, etc). CGI ønsker en gjennomgang og standardisering av sine løsninger og løsningsportefølje som tilbys kunder i ETO segmentet.

Oppgaven består i å foreslå oppbygning og innhold av en bransjeløsning mot ETO bedrifter basert på ERP systemet Microsoft Dynamics AX og de løsninger som CGI og relevante partnere har innen dette.

Datagrunnlagets skal hentes fra innleverte prosjektoppgave, relevant litteratur, intervju av aktuelle resurs personer i CGI, dokumentasjon ERP systemet og andre relevante kilder.

Studenten skal besvare følgende spørsmål:

- Gi en teoretisk redegjørelse for en bransjeløsning i et ERP systemer. Hensikt og oppbygning av disse.
- Foreslå hvilke forretningsprosesser en bransjeløsning for ETO bedrifter basert på Microsoft Dynamics AX og CGI's løsninger bør støtte.
- Foreslå hvilke systemkomponenter en bransjeløsning for ETO bedrifter basert på Microsoft Dynamics AX og CGI's løsninger bør inneholde.
- Beskrive hvordan en bransjeløsning for ETO bedrifter basert på Microsoft Dynamics AX og CGI's løsninger vil kunne støtte valgte forretningsprosesser på best mulig måte.
- Gi en forklaring på de viktigste forretningsmessige fordeler en bedrift vil kunne få ved å benytte valgte bransjeløsning for ETO bedrifter basert på Microsoft Dynamics AX og CGI's løsninger.
- I tillegg skal det lages en konsis produktbeskrivelse på CGI's standarder som beskriver valgte bransjeløsning gjennom punktene over.
- Lag en Power Point presentasjon som oppsummerer resultatene fra oppgaven

Oppgaveløsningen skal basere seg på eventuelle standarder og praktiske retningslinjer som foreligger og anbefales. Dette skal skje i nært samarbeid med veiledere og fagansvarlig. For øvrig skal det være et aktivt samspill med veiledere.

Innen tre uker etter at oppgaveteksten er utlevert, skal det leveres en forstudierapport som skal inneholde følgende:

- En analyse av oppgavens problemstillinger.
- En beskrivelse av de arbeidsoppgaver som skal gjennomføres for løsning av oppgaven. Denne beskrivelsen skal munne ut i en klar definisjon av arbeidsoppgavenes innhold og omfang.
- En tidsplan for fremdriften av prosjektet. Planen skal utformes som et Gantt-skjema med angivelse av de enkelte arbeidsoppgavenes terminer, samt med angivelse av milepæler i arbeidet.

Forstudierapporten er en del av oppgavebesvarelsen og skal innarbeides i denne. Det samme skal senere fremdrifts- og avviksrapporter. Ved bedømmelsen av arbeidet legges det vekt på at gjennomføringen er godt dokumentert.

Besvarelsen redigeres mest mulig som en forskningsrapport med et sammendrag både på norsk og engelsk, konklusjon, litteraturliste, innholdsfortegnelse etc. Ved utarbeidelsen av teksten skal kandidaten legge vekt på å gjøre teksten oversiktlig og velskrevet. Med henblikk på lesning av besvarelsen er det viktig at de nødvendige henvisninger for korresponderende steder i tekst, tabeller og figurer anføres på begge steder. Ved bedømmelsen legges det stor vekt på at resultatene er grundig bearbeidet, at de oppstilles tabellarisk og/eller grafisk på en oversiktlig måte og diskuteres utførlig.

Materiell som er utviklet i forbindelse med oppgaven, så som programvare eller fysisk utstyr er en del av besvarelsen. Dokumentasjon for korrekt bruk av dette skal så langt som mulig også vedlegges besvarelsen.

Kandidaten skal rette seg etter arbeidsreglementet ved bedriften samt etter eventuelle andre pålegg fra bedriftsledelsen. Det tillates ikke at kandidaten griper inn i betjeningen av produksjons-maskineriet, idet alle ordrer skal formidles på vanlig måte gjennom fabrikkens bedriftsledelse.

Eventuelle reiseutgifter, kopierings- og telefonutgifter må bære av studenten selv med mindre andre avtaler foreligger.

Hvis kandidaten under arbeidet med oppgaven støter på vanskeligheter, som ikke var forutsett ved oppgavens utforming og som eventuelt vil kunne kreve endringer i eller utelatelse av enkelte spørsmål fra oppgaven, skal dette straks tas opp med instituttet.

Oppgaveteksten skal vedlegges besvarelsen og plasseres umiddelbart etter tittelsiden.

Innleveringsfrist: 10. juni 2014.

Besvarelsen skal innleveres i 1 elektronisk eksemplar (pdf-format) og 2 eksemplar (innbundet), ref. rutinebeskrivelse i DAIM. Det vises til http://www.ntnu.no/ivt/master-siv-ing for ytterligere informasjon om DAIM, uttak, kontrakt, gjennomføring og innlevering.

Masteroppgave våren 2014 for stud. techn. Marianne Hønsi og stud. techn. Guri Caroline Sørbø

Vår dato 14.01.2014

Vår referanse EAL/KEDA

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