UNIVERSITETET I AGDER

A study on the effect of re-organizing a project based engineering company from an integrated project structure to a matrix organization

JAN KNUT FISKAA

CONFIDENTIAL

SUPERVISOR
Øystein Husefest Meland

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School of Business and Law
Department of Management

Preface

This thesis is part of the Executive Master of Business Administration (EMBA) program at School of Business and Law at University of Agder (UIA) in Kristiansand.

I have chosen to study the effect of reorganizing the company where I am employed from a project organized to a matrix organized model. Project data from the last ten years have been analysed to assess the influence this has had on the efficiency of the project execution.

My interest in this comes from my position in the company. I was engineering manager for the first project executed under the new model, and in an ever more competitive business it would be of great benefit both for me and the company to pinpoint effects this have had on project performance, for thereby being able to make improvements in the future.

I would like to thank for all support received during this work, particularly project controller Vetle Røyneland for assistance in making project data available, APL Norway AS for allowing information to be used in the thesis, colleague and fellow student Svein Bjornes for mutual assistance and discussions during the complete EMBA program, and associate professor Øystein Husefest Meland, Department of Management at UIA, for his guidance on the subject.

Jan Knut Fiskaa
Grimstad, December 07, 2016.

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1 Abstract

This thesis investigates how re-organizing an offshore oil service engineering company from a project organized to a matrix organized structure influences on its project performance. A series of 45 projects over a 10 year long period has been investigated.

The project data forming basis for the investigation are not directly comparable with each other since all products are engineered specifically to order and the projects vary considerably in volume. But by looking at categories of products and trends in the project performance, there are indications that effectiveness in project execution has improved after the reorganization. Review of previous research has been done to compare with this study case, but very little empirical data exists. General characteristics of the matrix structure and how this fits in with this study case has been discussed in order to find support or explanation for the analyses results in this thesis.

2 Introduction

2.1 Objective of this thesis

This thesis has been written in order to investigate the effects on the project execution of the offshore engineering company APL Norway AS when changing from running an integrated project organization to a matrix organization.

The change was made after the company was acquired by National Oilwell Varco.

APL Norway AS is a project based engineering company operating in the offshore oil service industry. All products are engineered specifically to client requirements, and the business is based on delivery of a limited number of large projects per year.

There are several parameters that have led me to study the effects the organizational change have had on the project execution. My interest in the topic started after I was appointed engineering manager for the first project delivered under the new model. In a position like this you can always to some extent observe:

- Technical interface issues.
- Technical sub optimizations within various disciplines.
- Sub optimizations of procurement packages.
- Schedule and resource conflicts.
- The efforts required by project management to keep the project running according to plan.
- In addition, personal reluctance to the change was observed within the organization, and even scepticism from clients when meeting with them early in the process.

All projects, even the best managed, have a certain element of inefficiency to them, and in this case an interest to investigate the realities behind my observations surfaced. What are the pros and cons with the new model, are my observations correct, or will the company in fact benefit from it?

While reviewing previous research, many articles have been found describing the advantages and disadvantages of implementing a cross-functional/matrix organization, the challenges met during implementation, the type of businesses that tend to select this organization form and their reasoning for actually selecting such a form. But very little has been done to investigate the effect this actually has on the project execution and its effectiveness. This impression is supported by a recent study (Schnetler, 2015) stating there are no empirical data to show the impact of the matrix structure on the project execution. For a company like APL Norway AS the efficiency in executing projects is a key factor in its daily business, the company survives on doing the projects effectively with as good results as possible both financially and technically. In this thesis, I use actual project data to try and identify the consequences of the change. I have looked into projects in the period from 2008 up until 2016. Keeping in mind the fact that there are no identical projects, all engineered to order, a model has been established allowing a comparison between the various project data sets. From this I have tried to extract conclusions; knowledge and experience that may help the company to improve its project execution model in an ever more competitive offshore engineering business, and not the least help me to improve in my role within the company.

In the thesis I present;

- The company, its business, its organization before and after the restructuring.
- Two consecutive projects that were run according to the new company set-up in order to give examples of how the project execution model works.
- Theories on project organization and how my case fits in to this.
- Project data sets.
- Method of data analysis
- Findings from the analysis
- Conclusions
- Recommendations for further work.

2.2 Limitations in this thesis

While working with this thesis it has become clear that some important aspects remain partly unanswered;

- How will the project performance develop in the long run? Experience, optimizing the way of work, consent and commitment among the staff may have a positive effect over time.

- Adapting to a continually changing market with varying capacity demand will challenge the stability of the organization and may thereby have a negative impact. Will the functional teams be able to continue in an effective manner in a reduced scale, or will other mitigating measures such as merging teams or centralizing certain functions have to be made?

- How will the organization model influence on innovation? Innovation is a key driver for the development in an engineering company, and the effects that the organization model may have on innovation would be worth a study in itself. Some references to literature on this subject have been given in the thesis, but the theme has not been covered in an extent that reflects its importance.

- There are also limitations and validity issues in the data basis used in the investigations. This is discussed separately in section 7.2.

Project performance and optimization influences the business on a day-to-day basis, while innovation secures the basis for developing the business on longer term, thereby innovation stands out as a particularly interesting next step to this thesis.

2.3 List of abbreviations

The following abbreviations are used in this document:

APL - APL Norway AS, the company subject to this study.
DT - Delivery Team, an organizational unit within APL.
DTM - Delivery Team Manager.
FPSO - Floating Production Storage and Offloading unit; an oil production unit.

FSU - Floating Storage Unit; a moored storage tanker.
LNG - Liquefied Natural Gas
NOV - National Oilwell Varco Ltd.
OLS - Offshore Loading System, a system for offshore loading of oil tankers
PMT - Project Management Team.
SAL - Single Anchor Loading system, a system for offshore loading of oil tankers.
STL - Submerged Turret Loading, an offshore mooring and loading system.
STP - Submerged Turret Production, an offshore mooring and production system.

3 Presentation of APL Norway AS

3.1 The company

APL Norway AS (APL) is an offshore oil service company established in Arendal in 1993. It was started as a joint venture between the small engineering company Marine Consulting Group AS and Statoil for the specific purpose of developing the STL concept. The company started under the name Advanced Production and Loading AS. The STL is a submerged turret buoy allowing offshore loading in harsh weather conditions with higher operability than other systems available in the industry.

Over the years the company has expanded its product range, and now designs and delivers a wide range of systems for transferring hydrocarbons from the seafloor to production units or transport vessels. The products are categorized as follows:

- Production systems, i.e. systems for transferring unprocessed hydrocarbons to a production vessel.

- Terminal systems, i.e. systems for transferring processed hydrocarbons to or from a transport vessel, typically offshore loading of shuttle tankers in the North Sea.

The company has developed significantly since the start in terms of technology, revenue, market, and number of employees.

In 2010, the company was acquired by National Oilwell Varco, and is now a part of the completion and production segment within NOV.

The company operates in a late-cycle niche in the offshore oil industry. This means that the company had, by end 2015, not yet seen the full effects of the industry downturn, but had started to adopt its capacity to a projected new market situation, with a first staff reduction effective Q1 2016 and a second staff reduction effective Q2/Q3 2016.

3.2 The products

APL is marketing a wide range of products within its industry segment, both subsea equipment and related shipboard equipment. Here are some of the most of important products:

STL (submerged turret loading):
APL Norway AS was started up to design and deliver this product. The original disconnectable turret came as a unique novelty to the market in 1993. The concept is based on a buoy floating at approximately 40m depth in idle (disconnected) mode, fitted with a mooring system that meets the project specific requirements for position keeping, even for unrestricted long term operation in harsh areas. As a loading system it normally supports a single flexible riser for transfer of product to the shuttle tanker. At arrival of a shuttle tanker, the buoy is pulled into a conical recess in the ship where it is locked, and then the riser connector is engaged. The vessel is free to weather vane with mooring forces being swiveled in the turret internally in the buoy while the product flow is swiveled on top of the buoy. During the last 8-10 years, the system has

been developed further into operating as an offloading terminal for regasified LNG. Operators like Excelerate Energy Ltd have a fleet of STL compatible LNG regas vessels, and STL regas terminals exist both along the coast of US and in the Mediterranean.

STP (submerged turret production):

This is a development of the original turret concept, designed for permanent mooring of production and storage vessels, FPSOs. Compared with traditional large shipboard turrets an advantage with the STP is that it allows all subsea installations to be performed prior to arrival of the FPSO itself. The offshore installation and hook-up period will be shortened and the major investment in the field, the production vessel itself, is brought on-stream quicker. Another advantage with this system is that it can be designed for quick disconnect, typically allowing an FSPO in tropical waters to abandon field prior to extreme storm conditions. A contract on an STP may also open sales opportunities on ancillary systems such as shipboard systems for mating to the STP and stern offloading system.

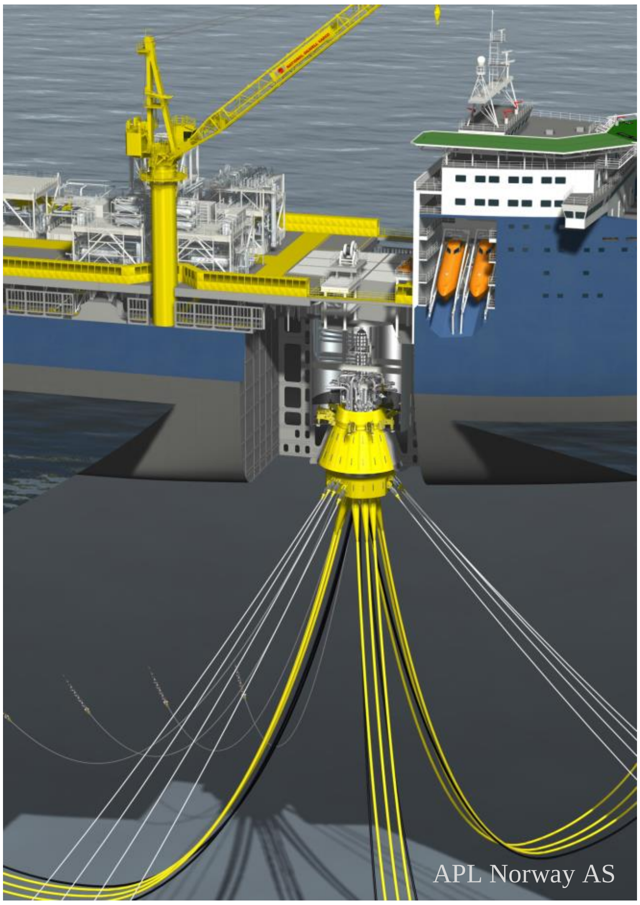

Figure 1 Alvheim FPSO moored on an STP

SAL (Single Anchor Loading system):

The SAL is a well proven concept for mooring assisted offshore loading, and in the North Sea there has now been taken approximately 1500 cargoes through the APL SAL^{TM} Systems. The system is normally installed on a single anchor pile where a turret system allows unrestricted weather-vaning of the attending shuttle tanker. From this the riser system with a single mooring line in parallel extends towards the shuttle tanker. The system operates in significant wave heights up to 5.5m.

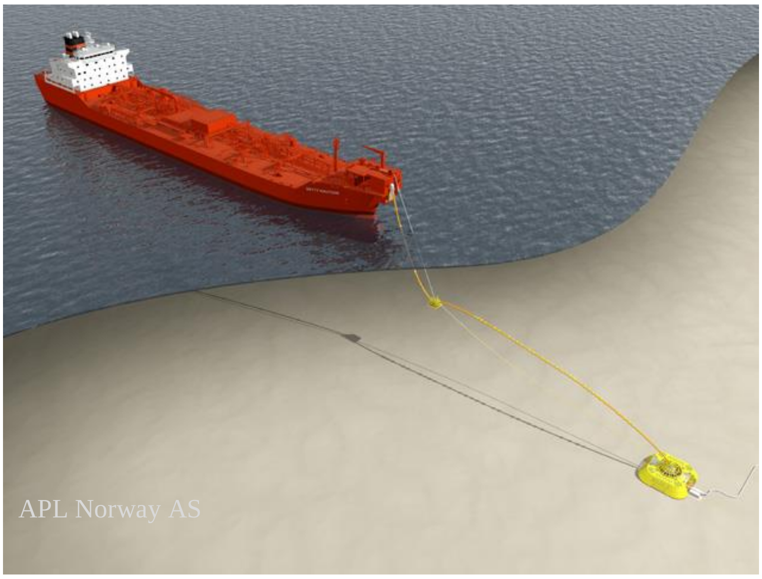

Figure 2 A shuttle tanker loading from a SAL

OLS (Offshore Loading System):
The OLS is an offshore loading system that requires dynamically positioned shuttle tankers for picking up cargo; i.e. the attending vessel remains in position by own propulsion without any mooring. The concept has been used in the North Sea since 1986, and has per today exported more than 5000 cargoes of crude oil. Two OLS systems have been selected for more detailed investigations and have been presented in later in the thesis.

3.3 The business

The nature of the business APL operates in is one of the reasons why I find the investigations in this thesis interesting. The shifting market conditions which at the moment are heavily influenced by low oil prices generate a significant drive towards more cost effective solutions, which again is counteracted by oil companies' demand for stringently specified equipment and high documentation requirements. Learning to understand the organization's pros and cons and using this to run the projects as effective as possible becomes more and more important.

Over the last decade, APL has managed to become one of the dominating suppliers of systems within its various segments:

- Worldwide, 38% of new-built FPSOs are moored on APL turrets, making APL the leading supplier.
- For submerged LNG regas terminals, APL has a 100% market share.
- For disconnectable turrets, FPSO's that can disconnect for extreme weather conditions, APL has a 60% market share.

There are only a limited number of competitors in this market. The largest suppliers are:

- SBM Offshore (Single Buoy Moorings Ltd, based in Monaco)
- Sofec Inc. (based in Houston, Texas)

- Bluewater Energy Services B.V. (based in Hoofdoorp, the Netherlands)

The overall market for mooring systems is shared between the competitors as shown in the figure below:

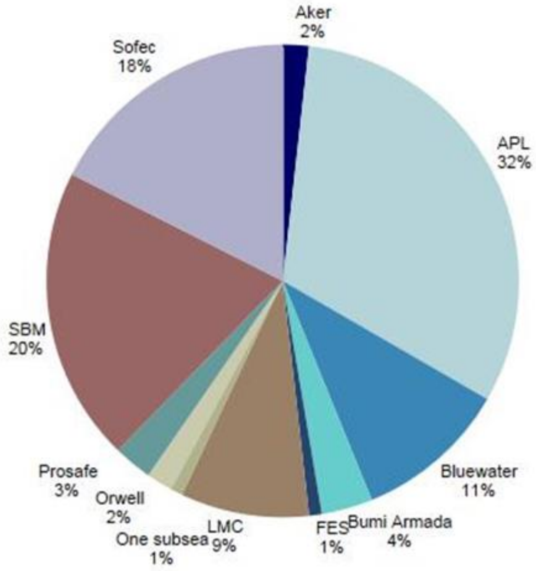

Figure 3 Market share for suppliers in the turret mooring system industry (data source: APL Norway AS)

3.4 Restructuring the company

Following National Oilwell Varco's acquisition of APL Norway AS, adoption of routines, reporting and way of work commenced. From initially being an independent engineering company, via the role as an independent technology division within BW Offshore, the company was to align and fit in with one of the world's major oil service companies. In this process, also reorganizing the internal structure of the company and the way of executing projects was initiated.

APL has always been a project based company. The major change that came into place at this stage was the restructuring from a model where the company was focused on supporting the integrated project teams, to a product oriented matrix organization where projects are supported by specialized delivery teams.

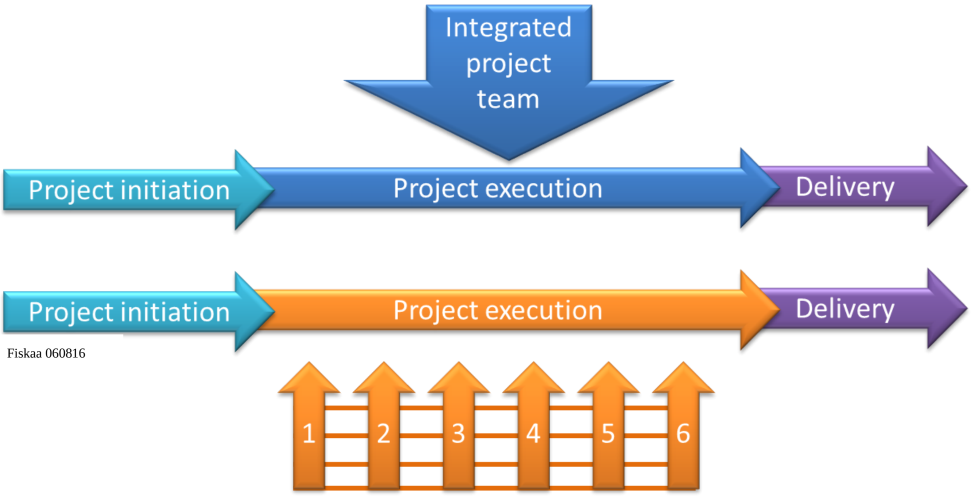

Figure 4 Illustration of the change in project execution

The organizational change was strategy driven; the key drivers were to:

- Be able to handle a larger project portfolio.
- Improve quality, where each subsystem in a contract object would see improvements as the delivery teams gain more experience and expertise.
- Reduce project specific engineering by facilitating standardization.

3.4.1 The original company structure

Prior to the restructuring, the company was set up with a traditional offshore engineering organization; a management team with necessary staff functions and engineering disciplines reflecting the business of the company.

Figure 5 Integrated project team

For each new contract, a project organization was established headed by a project manager. Resources to execute the project were drawn from the different engineering disciplines and high work load would call for hired staff to support the project organization. Noticeable characteristics for this organization are:

- Integrated team. Often, but for practical reasons not always completely collocated in the same office space.
- Easy information flow once the project team has been established.

- One point of contact for all procurement and subcontracting.
- Relatively stable work force throughout the project duration.
- But quite often the project team members are re-assigned to other projects shortly after the hardware is delivered, resulting in lack of resources during the very final phase of the project when final documentation is completed and assembled.

3.4.2 The new company structure

Following the restructuring, the company was set up with nine delivery teams where the individual teams where designed from the key technical disciplines existing in a STP project. These teams are:

DT1 - Mooring
DT2 – Foundation
DT3 – Buoy and turret
DT4 – Naval architecture
DT5 – Piping and process
DT6 - Swivel
DT7 – Shipboard equipment
DT8 – Layout and technical safety
DT9 – Fabrication
Technology – product development and general technical support.
Service – maintenance, service and installation support.

Each team can be considered a functional team, they are product oriented and set up to become experts on supply of their specialized products. Each team is staffed to handle its complete value chain, engineering, procurement and fabrication follow-up. For each new project, a Point of Contact is nominated to act as a team leader towards the project. He will liaise with the PMT and coordinate his team's project deliveries. He will also interact with his Delivery Team Manager which is overall responsible for his team's deliveries to all projects, resource allocation, planning and budgeting. DT9 will have responsibility of integrating all deliveries into a finished product.

DT5 and DT6 was early merged into one team; DT56. Further adjustments have been made in order to optimize the DT structure recently.

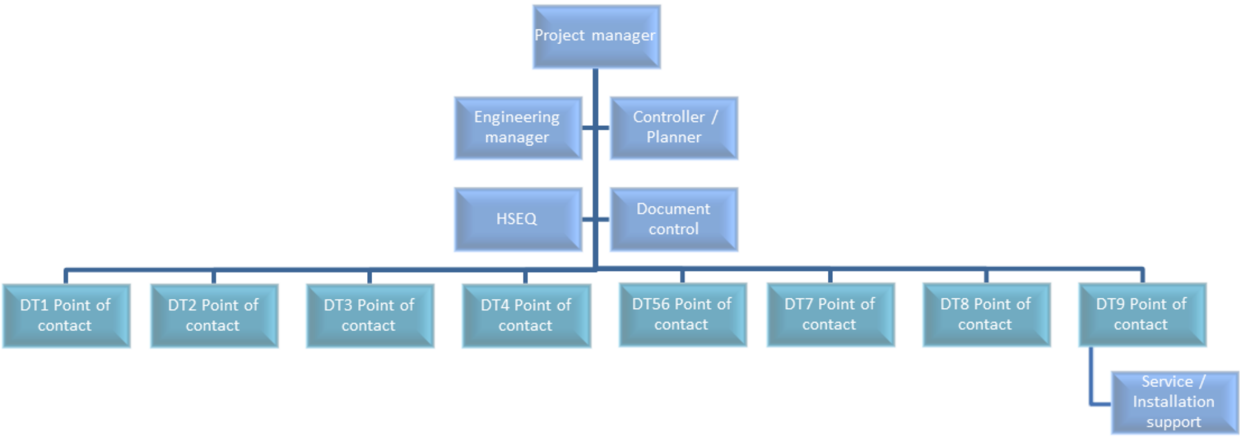

Figure 6 The new project organization

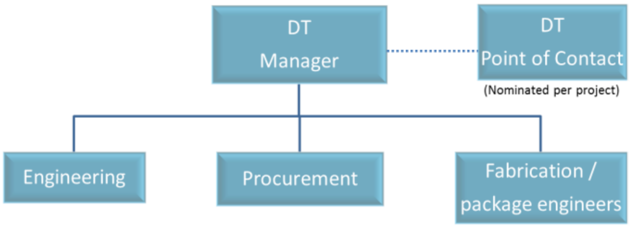

Figure 7 The delivery team organization (typical, some variations occur)

The project organization chart does not directly identify this as a matrix organization, but the matrix is recognized through the project execution plan; the company's defined way of executing projects which describes a project to be set up like this:

- For each new contract, a project management team (PMT) was formed, and PMT would establish the project on the basis of "contracting" the project to the various delivery teams. Depending on the scope of the contract, PMT would involve a number of delivery teams, but not necessarily all.

- Each delivery team manager allocates resources to the project, while a nominated delivery team point of contact is the team's project lead on a day to day basis. This means that all interfaces; commercial, technical, schedule and resources are handled on several levels, information flow has multiple patterns, and the project manager is not in complete charge of his project team. As a result of this structure, a delivery team manager may prioritize his resources to one project at the expense of another in case of resource shortage.

- Within a delivery team, a person may quite often be involved in more than one project. The Point of Contact will then be his liaison towards each project.

Communication becomes more complex on an overall level in the company as DT Point of Contact, i.e. the delivery team's allocated project responsible, will have to maintain a multiple communication lines. He shall report to the project management team, to his own team manager, he shall exchange information with the other project members, and his own subcontractors. The communication matrix becomes extensive with extensive reporting.

A particular characteristic to be noticed is that all projects do not require input from all delivery teams. The delivery team structure was made up to fit the large STP projects, while for smaller projects maybe only 5-6 teams would participate.

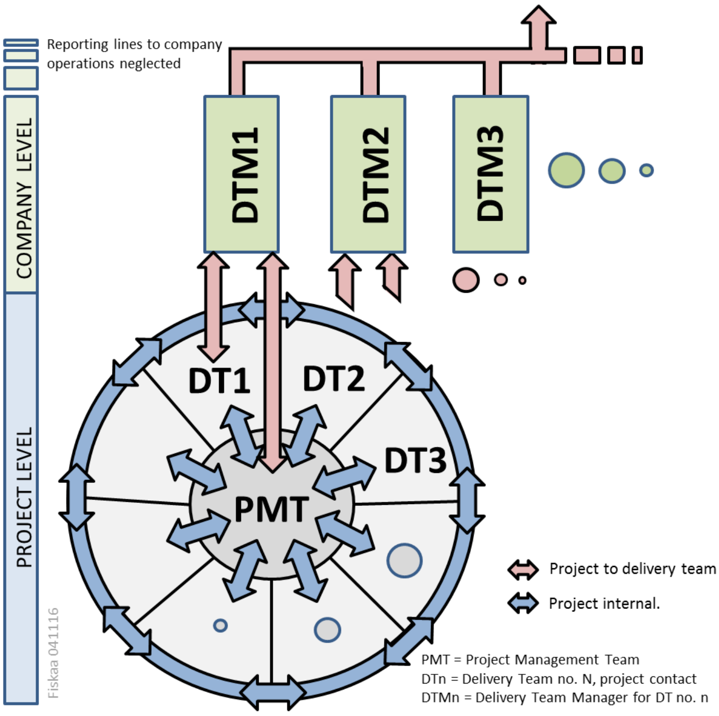

Figure 8 Communication on project and company level

4 Project execution after restructuring

4.1 General

In order to illustrate the way of work under the new organization, two projects are presented briefly;

- Gullfaks OLS1 Offshore Loading System is the first project carried out under the new model.
- Harding OLS, a similar concept as Gullfaks, but run the year after.

These two projects were carried out sequentially, Harding OLS started upon completion of the Gullfaks OLS, but with only limited continuity of personnel between the two. The idea behind looking at two projects is that this may help detecting effects from gaining experience and learning on an overall level in the organization; i.e. increasing the competence on how to run projects by the new model.

The Gullfaks OLS1 was the first project run under the new organization model. There was a particularly high focus on adhering to the new routines, so even with no previous experience it is considered to be a representative project. This project is described a little more in detail in order to illustrate the project set-up.

The Harding OLS was a quite similar project to the Gullfaks OLS1 from a technical point of view, thereby analysing project data from this project gives indications of the effect of the new organization settling in, i.e. the internal learning curve of project execution in the company.

4.2 The project execution plan

APL has defined its way of running projects in a dedicated document, the project execution plan. The project execution plan includes description of all activities that form part of normal project execution within the company, providing relevant information and a basis for the project teams to perform their work in a consistent manner in line with the company requirements. When a contract is signed, depending on the extent of the contract, a project specific execution plan may be developed in order to ensure that both APL's and the client's requirements are captured.

In this thesis I do not study the details of the project execution plan itself, but I have made the basic assumption that the projects behind the data acquisition have followed the specified way of work, and thereby at least by intention should be comparable with the limitations described in section 7.2.

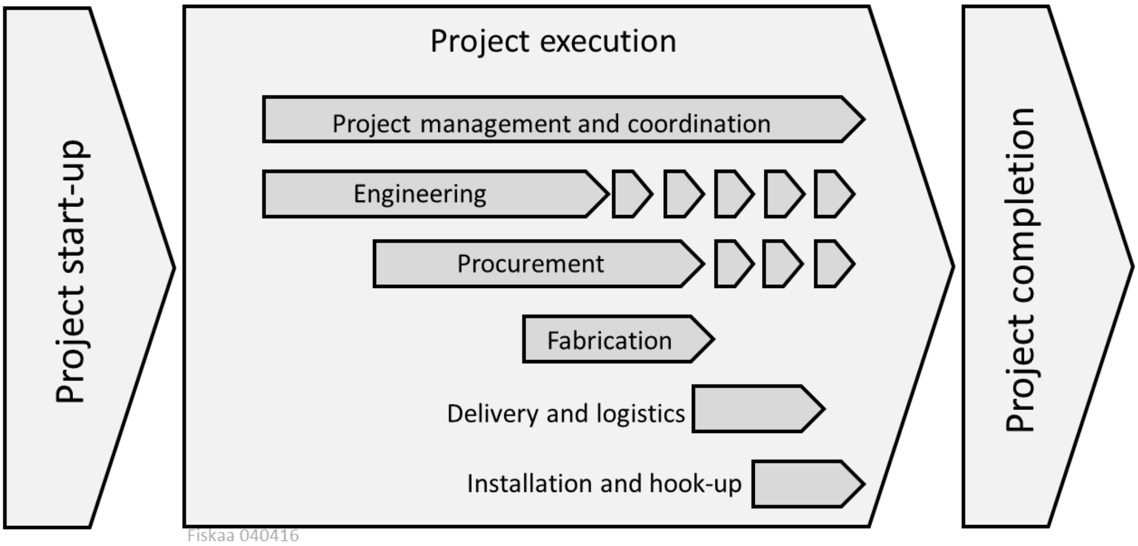

Figure 9 The project phases.
Note that the engineering and procurement will have follow-on phases; support phases for the remainder of the project here illustrated by the stapled arrows.

All the phases illustrated in Figure 9 are covered in the project execution plan. I addition references to specific requirement in the company's business management procedures are made in order to make the project execution plan as complete a project guideline as possible.

4.3 Gullfaks OLS1 offshore loading system

The Gullfaks oilfield in the Tampen area in the central North Sea has been a major producer of crude oil for more than 3 decades. The field is developed with three Condeep production platforms, i.e. large gravity based concrete structures with oil storage cells integrated in the foundation. Oil has been exported through two articulated loading platforms where the shuttle tankers connect with both mooring line and oil export line. As part of operator Statoil's major field upgrade and preparation for another 30 years, the old offshore loading platforms were decided de-commissioned and replaced with two new systems. APL was awarded the contract for supply of two new loading systems in November 2012 with a scheduled delivery in May 2014.

The two contracted systems are briefly described as flexible riser systems, suspended at 40m depth by a 70t buoyancy element, fitted with swivels to allow unrestricted weather vaning of the attending shuttle tanker. The systems are fitted with hydro acoustic positioning transponders and a hydro acoustic remotely controlled isolation valve at the riser base. Offloading capacity of each system is 8500m^3/hour or a full oil tanker cargo in 16 to 24 hours.

For the data acquisition and analyses done later in this thesis, data has been extracted for only one of the two identical systems.

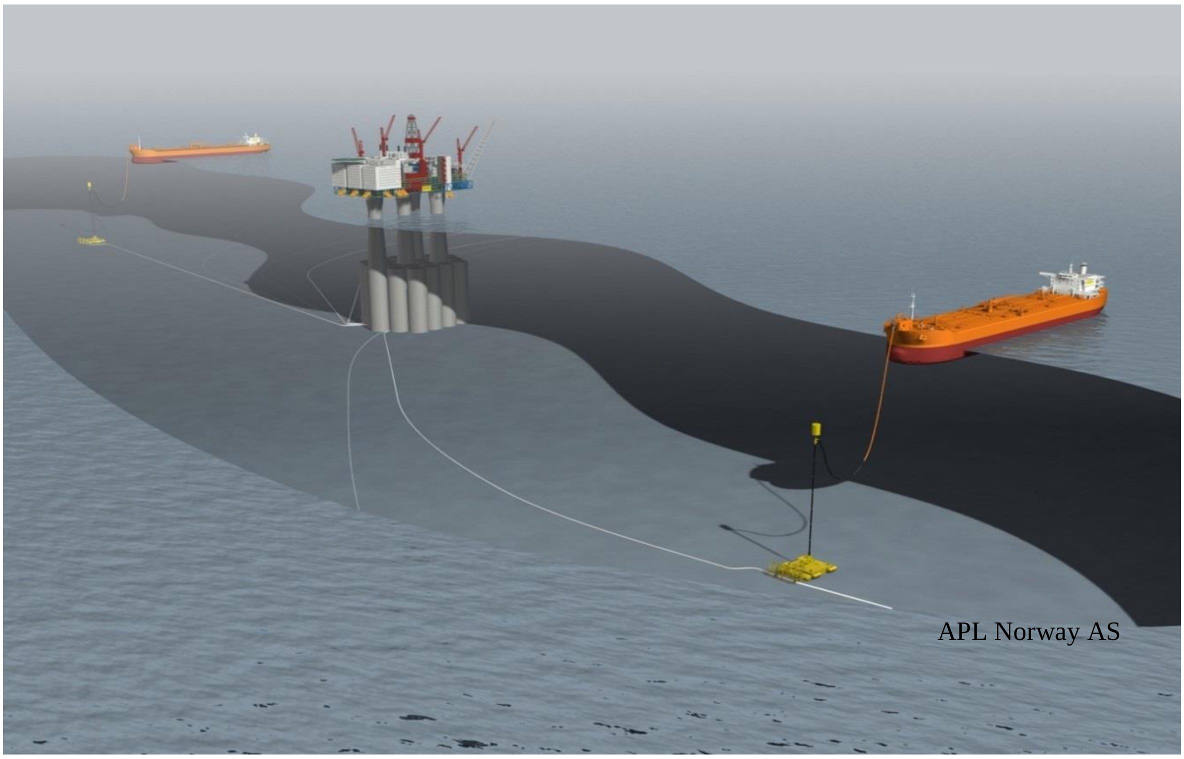

Figure 10 Gullfaks OLS

During project start-up, the following delivery teams were identified as project contributors:

DT1: Engineering and supply of riser system with buoyancy.
DT3: Engineering and supply of subsea steel structures.
DT56: Engineering and supply of piping, valves, connectors and hydraulics.
DT7: Engineering and supply of hose end valve, which is the shuttle tanker interface.
DT8: Risk analyses.
DT9: Fabrication surveillance and commissioning at yard.

Each team delivered input to project management team in terms of:
- budget,
- schedule,
- engineering document register,
- procurement plan
- a nominated contact person for the project.

The project management team (PMT) was established with a
- project manager
- engineering manager
- controller
- HSEQ
- Document controller

PMT assembled input from all the delivery teams into overall plans for the project.

At project start-up, it soon became clear that co-operation between the teams, handling technical interfaces between the teams, and adherence to the project management team's requirements on schedule and progress would be challenging. Typically, the resource situation made some of the delivery teams plan their deliverables as late as possible, in some cases too late relative to the contract schedule since other projects was given higher priority. For several hardware deliveries, the schedule was planned with as late as possible delivery and even with very little slack. It was early in the project phase identified several issues like this, and a series of efforts was initiated to mitigate possible problems resulting from this. This included:

- Project management meetings twice a week.
- Technical meetings twice a week.
- Meticulous focus on project progress once the overall engineering schedule was agreed in order to be able to detect and recover delays as early as possible.

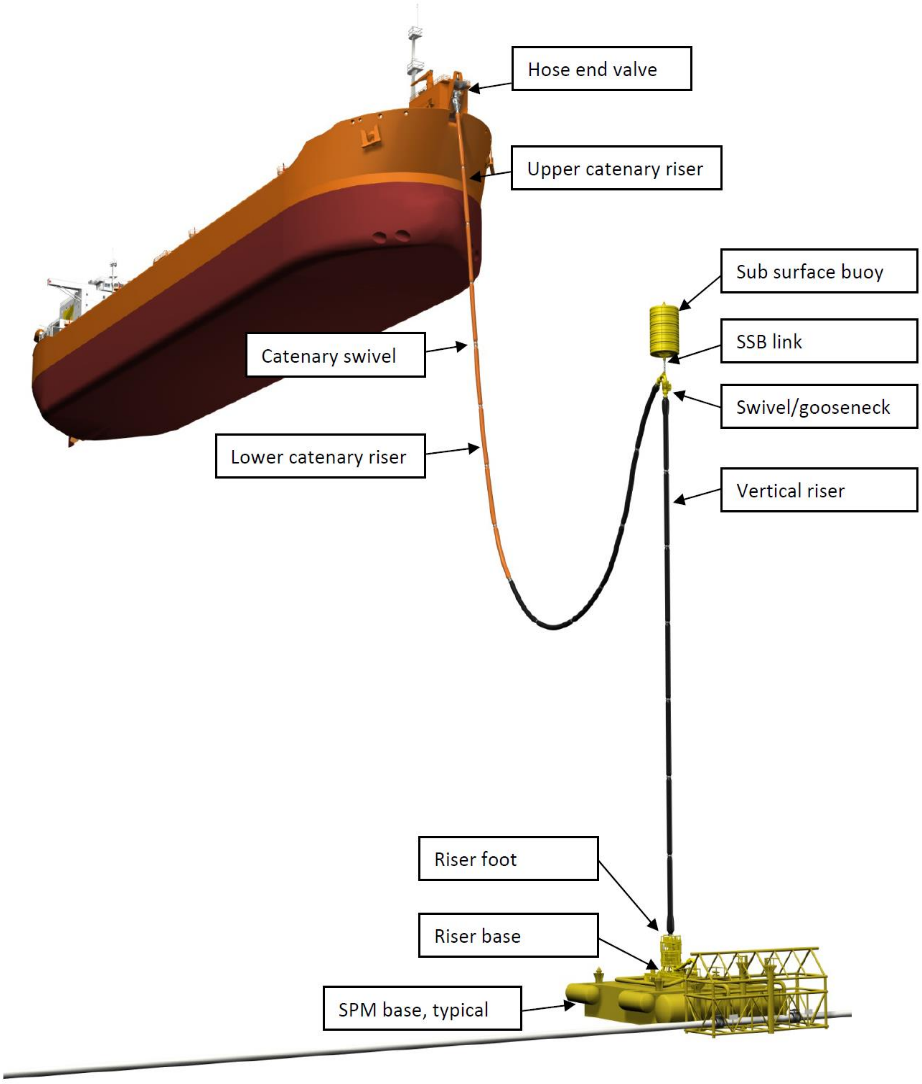

Figure 11 Gullfaks OLS – main components

The project became a success with delivery on time and at budget. A number of various points for learning and improvement were logged upon completion of the project, with the following particularly relating to organization:

- The Delivery Team structure was new to APL and meant that resources were no longer allocated directly to the project. Communication directly to project members was therefore more difficult than in the past and had to go through the PoC role. This role was poorly defined in the beginning which caused the “distance” from the engineers to the project to feel longer than normal. A counter measure was to introduce technical morning meetings twice a week.

- There was a noticeable delay in engineering progress from start of the project. This was however mitigated during the course of the project and did not have impact on delivery.

4.4 Harding OLS offshore loading system

The reason for presenting this project is that it was a consecutive contract to Gullfaks OLS1, and thereby effects of experience and improvement in project routines may be identified. It should be noted that only a few project team members followed both projects and thereby a direct copy effect is not obvious. But as for Gullfaks OLS1, attention was paid to following the established project execution plan.

Figure 12 Subsea view of the new Harding OLS loading system

The contract was awarded to APL when the original Harding export system was getting close to end of its design life.

The new system is an OLS, as for the Gullfaks systems. Due to different water depth and a completely different subsea structure only limited direct benefits from the Gullfaks project was noticed. The project team was almost completely new, but the project start-up was simplified by having an initial document register and schedules for some component deliveries readily available. Learning from Gullfaks, high focus on progress and information flow was initiated immediately with very good effect. Frequent management meetings and technical meetings was established as a project way of work. High focus on schedules and need dates for design documents was informed to the team early, and project management focused more on upfront actions rather than correcting once delays was observed.

The project resulted in a very precise delivery. All hardware was on schedule with a comforting margin, and so was also the documentation. Financial results also came well over budget.

In the project experience report, there are no notes to the performance of the organization as such. All disciplines have delivered on time, communication and cooperation has worked well. Only minor delays on single documents have been logged, and some minor hardware delays have been caused by subcontractor errors.

The primary differences between these two projects were experience with working according to the new model, and that the mitigating actions from Gullfaks now were implemented from the start.

5 Applicable theories

In the company's original organizational structure, each new contract will initiate the establishing of an integrated project team that would deliver the complete product. The project team would remain throughout the life of the project, even though adjustments would be made with varying need for manpower and competence during the project execution. Heavier workload on design and analyses would dominate early in the project, fabrication expertise during manufacturing, while the installation and commissioning phase would require personnel with operational experience. The project team would have its own procurement function to handle all purchase orders and contracts, ranging from small details such as bolts and nuts large fabrication contracts.

In the new model, a project will be run by "subcontracting" parts of the work scope to relevant delivery teams. Interface information is managed by the project management team, but also on a daily basis across the technical disciplines in the delivery teams.

A review of selected research articles have been made in order to get an overview of the characteristics of the matrix organization model and what could be expected in terms of advantages and disadvantages with the re-organisation.

5.1 Basic theories

5.1.1 The matrix organization

The matrix organization was developed in the early 1960s and initially used by the US aerospace industry to cope with problems relating to sharing common resources in multi-project organizations. In the following, the characteristics of such an organization are looked into.

Due to the continually changing nature of project based organizations, it is a challenge for the management to improve performance (Koskinen, 2012). The matrix organization offers a compromise solution for project-oriented businesses that cannot dedicate resources over the life of their projects, but must share them among many or all projects. Matrix organizations are overlaid on the functional structure of the firm which, when designed right, combines the strength of both the functional and the projectized organization (Thamhain, 2013). In the matrix, business functions are carried out both within projects and along functional lines (Hobday M. , 2000).

The term matrix organization is used for a variety of organizational designs in the gap between purely functional and purely project-based organizations. In this gap, a variety of models around the matrix concept can occur and it can be argued that each organization will have its own uniquely tailored structure based on its business needs. Mike Hobday illustrated this by six ideal organization forms, shown in Figure 13.

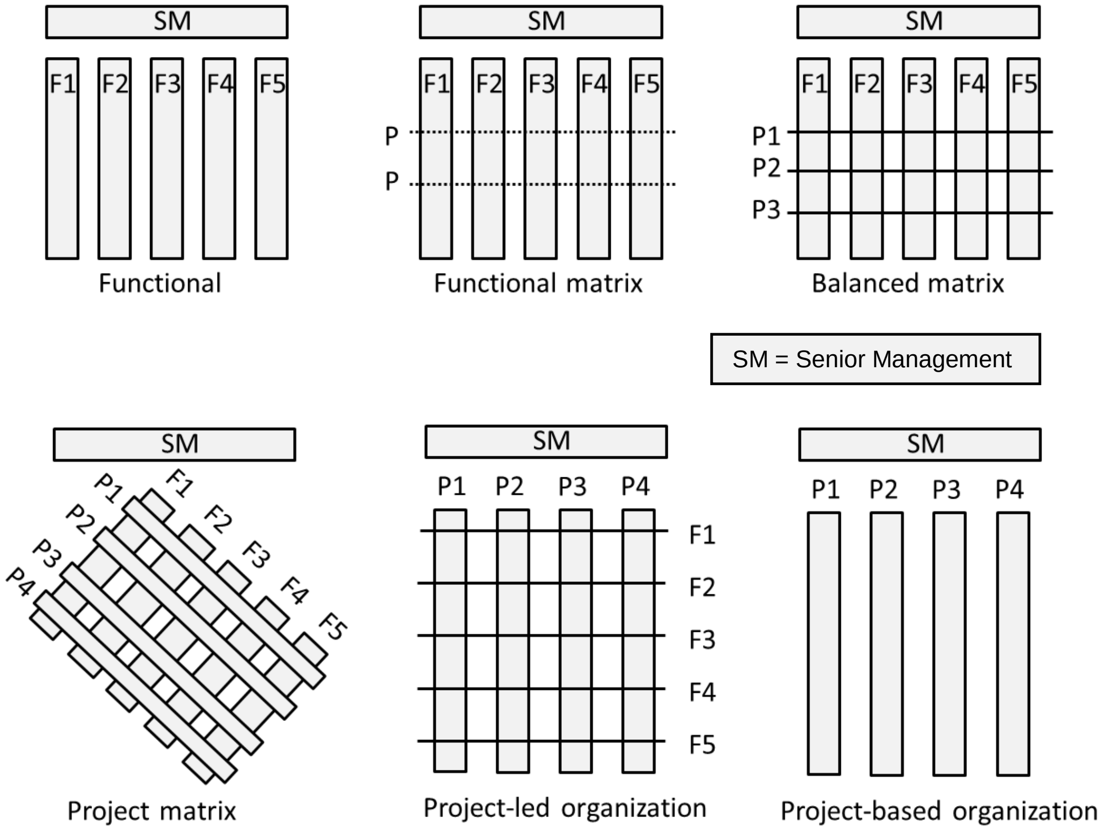

Figure 13 Six ideal-type organizational forms; (Hobday M. , 2000)

In this illustration the organization forms range from the pure functional form to the purely project-based organization. The functional matrix is characterised by weak project co-ordination, the balanced matrix has stronger project management authority, the project matrix project managers have equal authority to functional managers, while the project-led organization is characterised by strong project managers.

According to S. M. Davis (Davis, 1978) companies tend to turn to matrix form when:

1. it is absolutely essential that they be highly responsive to two sectors simultaneously, such as markets and technology;
2. they face uncertainties that generate very high information processing requirements; and
3. they must deal with strong constraints on financial and/or human resources.

The research by S. M. Davis is rather old, but his bullet points are supported by others in later publications such as (Parker, 2003) who states that typical industries that value adaptability, speed and focus on responding to customer needs are pharmaceuticals, telecommunications and computer industries.

The matrix organizations are said to create lateral communication channels (Ford, 1992). But at the same time, some states that matrix structures create ambiguity over roles and resources and a tendency towards conflict between project managers and functional managers, and that this may compromise communication and collaboration in the matrix organization. In the following sections, the characteristics of the matrix organization are looked further into.

5.1.2 Communication in matrix organizations

On a corporate level, several measures have been initiated to improve communication and learning in NOV. Examples are Technology Village, an online engineering resource centre, NOV Wiki where individuals can look up information or ask questions to subject experts, or Yammer which is Microsoft's system for a corporate internal social network which has not yet been able to reach its full potential user base in NOV. These initiatives illustrate the focus the top management have on communication, but they do however not have any noticeable impact on a project level in APL. Attempts and reattempts to establish discipline and project groups in Yammer for improved information flow have for instance failed.

While reviewing articles on communication in organizations there are contradicting findings:

- On one hand, an easy lateral flow of communication has been identified in research by several parties; (Lawrence, 1977), (Joyce, 1986) and in fact summarized as one of the key advantages of the matrix organization in several studies. The easy flow of communication is one of the characteristics that form the basis for the recommending the matrix organization in complex multi project businesses.

- On the other hand some researchers have pointed towards to the completely opposite observation. The article by (Holland, Critical success factors for cross-functional teamwork in new product development, 2000) highlights what they call well documented barriers between functions, stating that there is little well documented guiding on how to achieve cross-functional teamwork. Thereby the success in establishing a good environment for communication rests with the project management team.

On the subject of communication, it is important to keep in mind that there has been a global change over the last decade, and especially older research should be studied with caution. But the principal ways the organization work will still be the same, regardless new technologies for passing on information. It seems though that some early studies have particularly highlighted the positive effects the matrix has on communication. As stated in 1969 by Nick Horney: "A primary advantage of the cross-functional structure is that it solves an information processing problem. It creates lateral communication channels not available in the classical bureaucratic form of organization". The nature of communication has changed dramatically since this, and later studies are more diversified. In a recent study (Schnetler, 2015) the challenge of miscommunication in matrix organizations has been addressed. In this study communication, collaboration, trust and the effect on overall project success has been investigated based on a number of 106 respondents to a questionnaire sent out in various South African industries. The study shows that improved communication can lead to improved trust and improved collaboration, and trust and collaboration will in turn contribute to project success. But it also highlights the need for managers in such organization to promote both frequency and quality of communication.

5.1.3 Interface information in matrix organizations

In complex projects, handling of interface information is of great importance. In order to ensure that all parties ranging from the internal functional teams, the client and subcontractors have sufficient information to start and complete their tasks as per the project schedule an efficient way of handling this particular type of information is critical. As discussed in section 5.1.2, there are several research articles pointing out the benefits of the matrix organization when it comes to communication in general, while others again point out that there are certain challenges. It is however surprisingly little research or studies that look into handling of interface information, as a particular form of communication, under various organization types.

By interface information, I think of any formal information that needs to be passed on from one party to another in order to commence work. This can be:

- Detailed technical information required by one party from another to allow work to commence, being drawings, dimensions, material specifications or similar.
- Schedule information, such as need dates for information or hardware.

Peter W. G. Morris (Morris, 1983) looks into interface management as a success factor for projects in general. He points out that the general interface management identifies the following:

- The subsystems to be managed on a project.
- The principal subsystem interfaces requiring management attention.
- The ways in which these interactions should be managed successfully.

In the mind of a project oriented person, these bullet points are quite familiar, there will have to be focus on each subsystem, certain systems will require additional attention, and there need to be a system on how to handle the information, or interactions. But then he also points out that the more complex the project, the more uncertain the technology and the more changes in environment there is, the more integrated the project team needs to be. This actually indicates that the matrix or cross functional organizations may raise concerns when it comes to interface management, since the organization will be more complex with multiple reporting lines.

In APL, possible interface issues where highlighted early in the reorganization phase, this is discussed further in section 5.3.

5.1.4 Resource constraints in matrix organizations

One of the ideas behind cross-functional project structures is that the project manager shall have access to competent resources. The technical expertise can be shared among multiple projects, allowing the overall technical capabilities of the company as such to develop. Having highlighted the cyclic market of the offshore oil service industry, how will the organization respond to resource constraints caused by high workload and conflicting project schedules?

Z. Laslo and A. I. Goldberg (Laslo, 2008) say the matrix structure has become the primary organizational means for maintaining an efficient flow of resources in multi-project environments, but that critics of the matrix describe an inherent propensity for conflict among managers that substantially limits its effectiveness. In this article they describe a simulation procedure for resource allocation which goes beyond the routines used in APL. But regardless the simulation procedure, they state that resource conflicts are believed to be unavoidable, and will reduce the effectiveness of the matrix structure because the project managers and functional managers struggle for greater control over the allocation of resources. In some research, the term “coopetition” is used to describe the joint occurrence of cooperative and competitive behaviour within the organization.

Mats Engwall and Anna Jerbrandt investigated the nature of organizational settings where a substantial share of the company’s operations is organized as simultaneous or successive projects (Engwall, 2003). The size and number of projects in this study is comparable to APL, but the business is telecom. Still their findings and their description of the “resource allocation syndrome” are interesting. Their research questions were:

- On a large project portfolio level, are there any operational problems that are general to multi-project management?
- If so, which underlying mechanisms of the multi-project setting cause these problems?

In their research, however with limited empirical data, they discovered what they call the “resource allocation syndrome” where the primary management issue in the business revolves around resources; prioritization of projects, distribution of personnel from one project to another and negative effects on de-prioritized projects. They summed up the following answers to what causes the syndrome:

- The mechanisms influencing resource demand:
  - Failing project scheduling.
  - Over-commitment.

- The mechanisms influencing resource supply:
  - Dysfunctional management accounting systems for multi-project environments.
  - Opportunistic project management behavior.

In APL, as further discussed in section 5.3.3, means have been implemented to improve resource allocation and planning thereby trying to counteract the resource allocation syndrome described by Mats Engwall:

- All projects are planned down to Level 5, i.e. to a detailed activity and document level. This means that each single design document is planned with start and finish dates. In order to make the plan as realistic as possible, each project establishes it as a joint effort between the project management team and the delivery team managers. The project management team ensures that contract requirements are met while the delivery team managers focus on required resources.
- An overall resource model is maintained continuously to ensure that resources are available. This model includes all projects, all personnel and all planned holidays, which is used to visualize capacity utilization and detect resource constraints.

In practice there are still many parameters that disrupt the ideal resource plan. Projects do never run strictly according to plan and there are many details that divert from the agreed schedule even for a well-managed and well-planned project that reports to be on schedule on an overall level. Typical issues can be:

- The complexity of the products and projects brings uncertainty to all planned activity durations. The planned durations will vary with experience and type of activity. Has a similar component been designed and delivered earlier?
- How is the engineering deliverables received by client and classification society? Will there be more document revisions than expected, and will there be need for design review meetings and client meetings to reach an approved design? Such events may increase time to finish considerably compared with the original and maybe optimistic Level 5 schedule.
- General delays caused by such as missing interface information from other parties, subcontractor delays, personal effectiveness issues, personal commitment to the communicated schedule and commitments to other projects.

An important aspect that I have not found mentioned in any literature, is the “set-up cost” that follows from sharing resources and trying to allocate resources on the basis of scheduled needs. All projects have their own technical and contractual requirements. Design standards, rules and regulations, even reporting formats vary, and by allocating available resources to a project, it will take time for each engineer to adapt to each project. This will also complicate the efforts to optimize schedules and plans.

When planning on a detailed level in order to be able to handle a large workload, there is a high risk that consequential effects of errors and inaccuracies will be large, creating schedule conflicts and delays which is beyond the control of the project manager, unless, as per (Malhotra, 2016) the project manager is able to compensate for this through his personal skills, i.e. to negotiate priority for his project and create a favorable working environment within his project.

It should be kept in mind that resource allocation and resource constraints on some level are among the key management issues in almost any business regardless their organizational model. A statement in the book by RW Spühler and RG Biagini (Spuhler, 1990) says “there is hardly a company to be found which does not launch more projects than it can master with available resources”. This is the case also in APL; projects are not known to have been turned down from a resource concern.

5.1.5 Innovation in matrix organizations

The oil and gas industry has become more technology intensive over the years. In order to maintain or develop its position it is of vital importance for APL as for any other company in the business to encourage and facilitate innovation and unabated product development. The global need for oil and gas will continue and the majority of the remaining resources will be in more and more demanding to produce, driving the need to improve technology and cost effectiveness.

A survey conducted by Robert K. Perrons (Perrons, 2014) presents how innovation and R&D happen in the upstream oil and gas industry. One of his conclusions is that 63% of deployed innovations reported in the survey originated from the oil service companies, the sector which APL belongs to. Looking at the history of APL, originally an innovation based start-up business, it is easy to acknowledge that innovation is important for the future.

In the search of previous, comparable studies where the innovation rate in matrix-type organizations has been investigated, very little has been found that compares well to the APL case. In (Song, 1998), positive effects of the cross-functional organization of in product development projects are described. This article does however relate to the cross-functional organization on a higher level, where R&D, marketing and manufacturing are the organizational entities that collaborate, while in APL the collaboration and interaction is working on a much more detailed level.

There are however investigations on organizations set up for running innovation projects, such as (Blindenbach-Driessen, 2015) where they conclude that it is the cross-functional knowledge that is important, not necessarily cross functional organization as a means to provide this knowledge. This is not directly comparable to my study case, and in a sense the APL organization model may be considered to base innovation on three levels:

- Driven by the Technology Department, particularly when innovation results from strategic choices on where to be in the future market. A typical recent development is the Submerged Soft Yoke System where the technology department has been running the development and this has resulted in a contract.

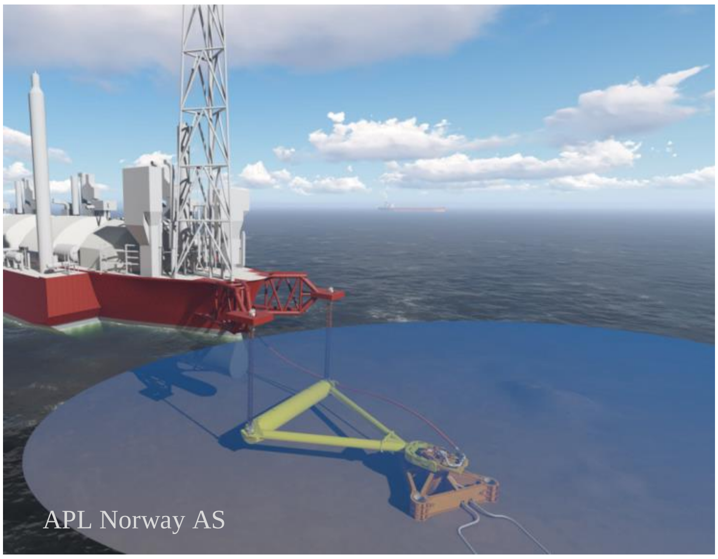

Figure 14 Submerged soft yoke system, new technology on the market

- Driven by the cross-functional project teams, particularly when the innovation is comes from project needs. A typical product here is the AIS transponder buoy, a small (35kg) marker buoy that transmits signals on the naval Automatic Identification System format to allow vessels to identify it on radar. Thereby a submerged offshore loading system can be picked up on radar by any passing vessel, preventing its pick-up line from getting entangled in the vessel's propellers. This was developed during the Harding OLS project.

Figure 15 AIS buoy, developed from a project need

- Driven by the Delivery Teams, especially as a result of long term product development and increasing competence within the discipline. An example of this is the subsea foundation on the Harding OLS, a suction anchor and a riser base structure combined into one unit, saving both weight and cost. In addition, it allows effective offshore installation by just one single offshore lift.

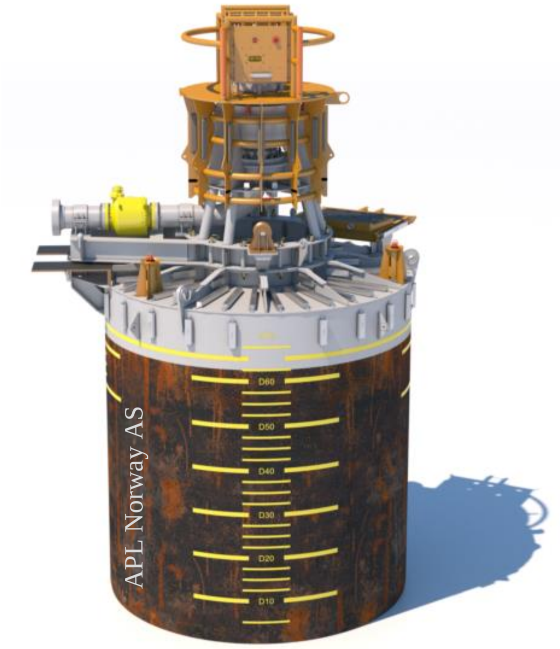

Figure 16 Harding OLS suction anchor / rise base unit

Without studying in detail the preconditions for innovation in the new organization form of APL, one may assume that technological development has been well accounted for with the dedicated technology department. Whether or not this is sufficient to facilitate new “game changers” like the first STL remains to be seen.

5.1.6 The matrix organization in a market down turn

As discussed in section 5.1.1 the term matrix organization covers a variety of forms in the gap between the strictly function based and the strictly project based organizations. The study case here can be considered a balanced matrix where a project is executed under the command of the project manager, ideally with sufficient authority to meet both contract and budget requirements with resources allocated by the function manager. But it is a noticeable characteristic in the study case that each delivery team basically shall be responsible for their complete chain of value, they shall provide engineering, procurement and construction up until a point where final assembly takes place. Each function, or delivery team, can almost be considered a complete business unit by themselves, running complete "sub-projects". At the time of introducing the new organization model a significant increase in demand was foreseen, and the capability to handle a larger project volume under resource constraints was an important factor.

In Figure 17, the annual investment level on the Norwegian continental shelf is shown. The idea here is to show the point in time when the organization change was implemented in light of the market situation. It is not at all a fully comprehensive illustration since the company serves a global market in a special sector of the offshore oil industry, but it gives a picture of the anticipated peak in demand that was one of the reasons for the change.

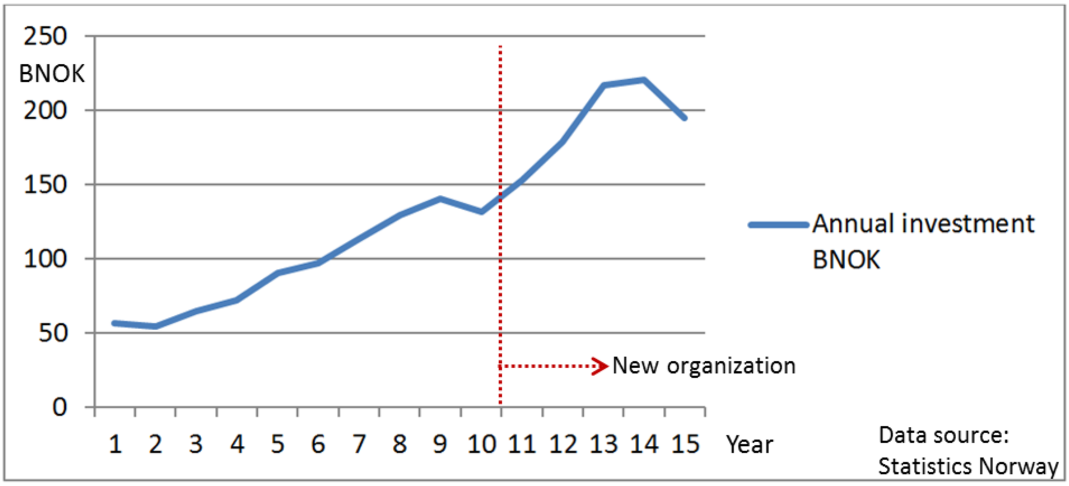

Figure 17 Annual investments in the Norwegian offshore oil and gas industry

The new organization was established to handle an expected upturn, but what then when the market moves into a recession?

There is little literature found to describe the performance of the matrix organization in an economic downturn. But in the research by R.J. Oviedo-Haito (Oviedo-Haito, 2014), where the focus is on the civil construction business, it is emphasised that flexibility through a lean hierarchical organization is one of the key factors for survival during periods of economic recession.

Looking at the APL organization, the following principles behind the organization are encumbered with problems during periods of reduced demand:

The principle of self-supported delivery teams:
The principle of self-supported delivery teams being responsible for the complete chain of value for their defined scope of work will require a certain volume both on personnel and on projects. At high work load with large teams, it is possible to plan for required manning and adjust as required by hiring additional resources during busy periods. It is however more difficult to reduce since specializing makes it difficult to

share resources. If the demand from one delivery team reduces so much that you can't maintain certain functions, for example procurement, then you must either share resources or re-organize to a form which centralizes these functions.

The principle of specializing to improve quality:
The same problem will occur here; you can allow an engineer to specialize in his field, but only as long as there is a high demand for his expertize. If the demand is reduced, you will have to rely on flexibility to solve tasks with fewer personnel.

The principle of product orientation to improve capacity:
Another concern that has been observed during project execution, and which also has been acknowledged by the management as an issue in the APL set-up, is a problem to detect slack in the organization i.e. spare capacity. The multiple reporting and multiple project assignments for each person tend to reduce the focus on completing tasks from each single engineer. This was detected during the Harding OLS project, where strict surveillance from the management team was initiated to ensure that all activities were formally completed and closed for logging hours as early as possible.

It can be assumed that the matrix organization, at least in the form observed in APL, will have disadvantages in a period with reduced demand, since the structure requires a certain size of the functional teams to be able to operate as planned. At the time of completing this thesis the company management has observed and acknowledged the problems with running the matrix organization in a market downturn, and is initiating changes to the organization to meet the rapid drop in sales. The extent and type of changes, as well as the effects of these changes remain to be seen at the time of concluding this thesis.

5.1.7 Advantages with the matrix organization

The following key advantages have been found in the literature, which are all highlighted in several articles:

- Flexibility and quick adaption to changing market and technical requirements (Davis, 1978), (Schnetler, 2015).
- Effective resource allocation (Schnetler, 2015)
- Increased formal lateral communication (Lawrence, 1977)
- Flexible use of human resources (Schnetler, 2015)

In the matrix organization, reporting lines are divided both by functional area, in our case the delivery teams, and by project. Each employee answers to two or more immediate supervisors: a functional supervisor and one or more project supervisors.

An advantage with the matrix structure is that individuals can focus on their area of expertise, which for APL is reflected in the various technical disciplines that rests with the delivery teams. The product focus that follows with the delivery team structure will increase the competence in design and delivery of the components and sub systems going into a project. Individuals will to a greater extent specialize in particular fields, making basis for improving quality and developing technology in the same fields. However, some may argue this will be the case only within the same focus areas, not on an overall system level benefiting the project where the business makes its revenues.

The matrix allows for employees having extensive contact with colleagues in other disciplines, with easy flow of information between the disciplines and better utilization of the skills found in other disciplines as a result. The matrix shall because of this improve the capability to handle more complex projects. This characteristic of the matrix prerequisites that the management encourage communication to avoid that the functional structure behind the matrix is not allowed to develop as closed boxes. Some companies, such as Statoil has used internal professional networks to link people together to improve learning and experience transfer.

In the research by G. M. Parker (Parker, 2003), the following positive elements have been pointed out:

- Cross-functional teams reduce the time it takes to get things done, especially in the product development process.
- Cross-functional teams improve an organization's ability to solve complex problems.
- Cross-functional teams focus the organization's resources on satisfying the customer's needs.
- By bringing together people with a variety of experience and backgrounds, cross-functional teams increase the creative capacity of an organization.
- Members of cross-functional teams are more easily able to develop new technical and professional skills, learn more about other disciplines and learn how to work with people who have different team-player styles and cultural backgrounds than those who do not participate in cross-functional teams.
- The cross-functional team promotes a more effective cross-team effort by identifying one place to go for information and for decisions about a project or customer.

5.1.8 Disadvantages with the matrix organization

The very definition of the matrix organization itself can be highlighted as a possible disadvantage; the multiple supervisors with the corresponding multiple reporting lines. A matrix organization does not have clear lines of authority or responsibility in that the boss-subordinate relationship may not be clear. A cross-functional team member may receive one direction from a functional manager and a different direction from the cross-functional team manager. The ambiguity and conflict that may arise from this can result in high worker dissatisfaction and increased employee turnover.

One of the key characteristics of the matrix, multiple managers, can give conflicting policies and procedures, and contradictory loyalties towards function or project can lead to ineffective management. Functional managers and project managers are forced to compete for the time of the individual team members. Matrix organizations do not have the structural stability of a purely functional organization, and the sharing of resources between multiple projects reduces the amount of routine work. This can lead to inefficiency for both the individual worker and the business processes. In addition, in line with the six ideal organization forms presented in Figure 13, the project manager (cross-functional manager) may lack the authority to make critical decisions required to maintain project progress.

A typical characteristic of the oil service business is stringent client requirements in the form of technical specifications. In an integrated project team, these will be familiar and consistent throughout the project duration. But in a matrix organization with extensive sharing of common resources, it will be a disadvantage that each individual will have to be familiar with both contract and technical specifications to a sufficient level that allows him to perform his work for each project he is involved with. There will always be a "cost" involved for a person to share his time between projects, since he will have to relate to multiple sets of requirements, different reporting routines, different people to relate to, and to be able to handle various schedules and work expectations. The following points appear as disadvantages by the matrix structure across many articles, among others the study by R.C. Ford (Ford, 1992):

- The tendency towards anarchy.
- Power struggles: the essence of the matrix is dual command, and this may trigger one part struggling for power when the organization concept requires balance in the dual command. In our case, this is visualized as a struggle between the need of the project manager and the delivery team manager. Conflicting interests occur due to resource limitations.
- Group decision making, where a sense that decisions shall be made in groups dominate the organization.
- Collapse during economic crunch. When the business declines, the matrix becomes the scapegoat for poor management and is discarded.
- Excessive overhead. The matrix organization is associated with a fear of high costs. In this thesis, this is one of the parameters that have been studied, however not on a corporate level, but on the project level.

A study was done (Arvidsson, 2009) to investigate to what extent tension is a concern in projectified matrix organizations, to find what are the main sources of tensions in project oriented organizations and project based organizations, and how firms manage the different sources of tensions. In this study, the following parameters came out as important:

- Access to critical resources.
- Complexity, especially in terms of roles and responsibilities for line functions and the projects as they interact.

He does however point out that resource constraints are at the very essence of businesses and economic analyses, thereby likely to be present in all types of organizations. Regarding complexity, he does point out that for a project based organization complexity seems to be reduced because the majority of both revenues and costs rest with the same organizational entity.

In (Denison, 1996), a model for measuring cross-functional team effectiveness was established. It is a three-domain model, where the organizational context, the internal process of each team (here: delivery team) and the outcome measures (here: project results). The model describes investigations on each level. A brief discussion of my model vs. this model is made in Section 6.

A quite recent article (Malhotra, 2016) concludes that mitigating the impact of functional dominance in cross-functional process improvement teams to a large extent rests with the team leader (analogue to project manager in APL). Even if this investigation is on manufacturing process improvement projects, the findings are interesting also in this case. It indicates that a team leader with high interpersonal justice will improve team efficiency through a psychological safe work environment.

5.2 Former research on the effectiveness of matrix organizations

According to research by Packendorff and Lindgren (Packendorff, 2014), research on project activities has traditionally been focused on single projects as unit of analysis. This is also supported by (Petro, 2015). In the study by (Schnetler, 2015), it has been found that there are numerous studies on implementation of the matrix structure and the advantages and problems associated with it, but that empirical data on the impact of the matrix structure on the project management are lacking.

Still, some former research has been found that brings light on the subject of this thesis.

An examination of the effectiveness of complex high value products, systems, networks, capital goods and constructs (Hobday M. , 2000) in a project based organization compared with a functional matrix organisation shows the project based organization to be a more innovative form. The argument is that the project team is formed specifically to meet the demands of each project and its client. But this research also shows that the project based organization is weak where the matrix organization is strong; in routine tasks, achieving economies of scale, co-ordinating cross-project resources, facilitating company-wide technical development and promoting organization-wide learning. Looking at these research results in comparison with APL, certain recognizable factors can be seen:

- Innovation has been discussed internally as an issue. Specialization within the delivery teams can easily be accepted as a means of improving quality and optimizing design and technology. But the question is whether this actually prevents new development when the daily work of each individual is specialized like this. In APL the answer has been to strengthen the technology department which operates as a cross-functional resource for the technical disciplines, for business development and to drive innovation forward. See also the discussion in section 5.1.5.
- The parameters recognized by research as the strong features of the matrix organization has partly been part of the reason for doing the organizational change, but also partly questioned. Cross-project resource allocation and co-ordination was one of the reasons for introducing the matrix organization, but also one of the problems at least during the introduction. Routine tasks are not a significant part of the daily business. Economies of scale may be achieved to a certain extent, but in general all projects are engineered to order and thereby this is more difficult to achieve, or at least to document.

An investigation has been made of the relationship between the organizational design and the effective management for the project portfolios which leads to their success (Petro, 2015). This research claims to be the first to investigate organizational elements and tested them against the success of the project portfolios, or the effectiveness of their management. The research focuses on project portfolio management. Organizations aim to build a solid and reliable project backlog of carefully selected projects, where the perfect balance of the project pool reflects the technological capabilities and the investment needs that are tuned into the organization's resources and processes. The difficulty in maintaining the balance lays with the wide range of possible project combinations that forms the project portfolio, considering the capacity and capability constraints in the organization. This study proves a relationship between project portfolio management effectiveness and portfolio success, and a strong relationship between project manager influence and the portfolio success.

Comparing the latter investigation with the APL set-up, there are indications that the project manager influence has been reduced with the new organization, as personnel resources are made available from the functional manager and when constraints occur one project may suffer on the expense of another.

In the research done by (Denison, 1996), a model for evaluating the effectiveness of a cross-functional team, which can be translated to a project in APL, was developed. They consider a three-domain model, where the first domain represents the organizational aspect, how co-ordination, resource allocation and other organizational aspects work. The second domain is the work process, while the third represents the results of the cross functional team. Compared with the model I put forward in Section 6, this model is a more sophisticated approach where more parameters are entered into the evaluation of the effectiveness of the team, or the project, which is the APL equivalent. Where I look at efficiency on a project level, this model also takes into account overall processes and goals, such as learning, growth and development over time.

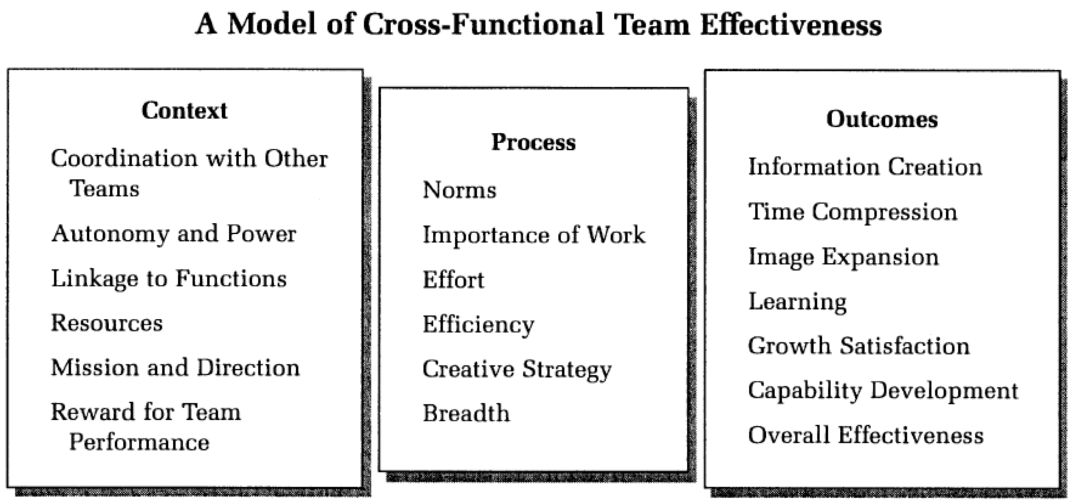

Figure 18 Cross-functional team effectiveness model (Denison, 1996)

There are a number of investigations of the cross-functional organization and its success factors in product development projects. On one hand this can be seen as not completely relevant for an oil service company where project effectiveness and project success may be defined differently than for a purely product development project. But on the other hand there are analogies by the fact that an "engineered to order" product in itself can be considered product development. In this view, there are some interesting findings in the literature. Edward F. McDonough (McDonough, 2000) highlights defining project goals and assigning sufficient decision making power to the project team as most important.

Research of later date can be found in the article by Schnetler, Steyn and Van Staden (Schnetler, 2015). They established a project success model where they test out whether or not there is a correlation between the positive matrix structure characteristics and the quality of communication, collaboration and trust among project teams.

In this study, they concluded that there are strong positive correlations of:
- quality of communication,
- collaboration, and
- trust among team members

with overall team performance and project success.

5.3 APL in light of the theories

While looking at how APL fits in with the theories and former research, I have to highlight one particular issue worth keeping in mind:

- Throughout the article reviews, I have found very little that matches the organization format as I find it in APL. A lot of articles, in their evaluations and investigations of the matrix organization, are discussing organizational entities like Engineering, Manufacturing and Marketing, organization forms which can be considered high level compared with my study case. In APL, the organization is operating on a more detailed level, piping, mooring, anchors, i.e. on a sub-component level. This makes a difference in how the organization operates, in APL consequences of inefficiencies in the organization will be seen on a very detailed level. The issue is not that a product comes late to the market, but that the engineering drawing of a component comes too late for the project.

Still, while reviewing articles and books on the subject, a number of recognizable aspects in my study case have been observed:

According to P. M. Davis (Davis, 1978), there are three typical conditions where companies tend to find the matrix organization beneficial; requirement for responsiveness to two sectors simultaneously (such as technology and market), need for very high information processing, and resource constraints. For APL, responsiveness towards the market and with continuous product adaption is a key characteristic, the products are always designed to order and there are always challenges to be met either in the form of purely technical issues or special client requirements. Others, such as (Parker, 2003), is describing the same, but he use the term “responding to customer needs”. Resource constraints were highlighted as one of the criteria behind the restructuring, and it was expected that the new structure would allow a larger project volume being processed with a given set of resources. Looking at the financial results of the company, this has turned out to be correct. APL delivered a record number of projects during 2014 and 2015.

Looking at the ideal-type organizational forms described by Mike Hobday (Hobday M. , 2000), the APL organization would be similar to a balanced matrix or project matrix type of organization in Figure 13, but likely varying with project size and complexity. An important observation at the time of introduction of the new model is that the organization was behaving more like a very functional oriented matrix where adherence to stringent reporting lines created problems for communication. When the Gullfaks OLS project was started it was very function oriented with a project management team that struggled to get required attention, allocation of resources and focus on the project schedule. But as the project progressed and the organization settled into the new structure, a move towards the balanced matrix / project matrix was observed.

5.3.1 Communication

On communication, the academic articles are not consistent, as presented in 5.1.2. Where the quite old article (Lawrence, 1977) identifies an easy lateral flow of communication, the APL experience showed near watertight bulkheads between the delivery teams. In the Gullfaks OLS project it was early identified that communication would be a concern. In order to overcome this, technical meetings were held twice a week for the duration of the project and the additional hours spent on this were negligible from an overall project point of view. In retrospect, the information flow that was arranged by meetings may very well have established itself as natural, lateral information flow if the organization itself was well established and not in a rapid growth phase where many of the staff did not know each other. In the Harding OLS project, the project management team was prepared for the communication obstacles and took a more proactive approach. Frequent meetings were fixed for the entire project duration from the start on management, technical, procurement and risk subjects.

The article by (Holland, Critical success factors for cross-functional teamwork in new product development, 2000) highlights what they call well documented barriers between functions, stating that there is little well documented guiding on how to achieve cross-functional teamwork. This corresponds with the observations in APL, where mitigating actions in the form of meetings worked well in the observed projects. It is worth mentioning that APL's formal way of work; the project execution plan does not describe or facilitate the free, cross-functional communication. It is in fact specific in its description of internal communication in the form of:

- Internal interfaces handled via an interface register.
- Bi-monthly project meetings.
- Internal design reviews.

Thereby the success in establishing a good environment for communication rests with the project management team. The APL experience, where facilitating communication through frequent meetings seems to coincide with the results of the study by (Schnetler, 2015) which highlights the effect of frequent communication on project success and at the same time puts the responsibility for improving communication on the managers.

With limited formal internal communication, it is likely easier to reach sufficient information flow in smaller projects where the team members know each other, compared with the larger ones. This is discussed further also in the project data investigations in section 8.2.3.

5.3.2 *Interface information*

On interface management, APL identified this early as a concern. However, the project execution plan focused on the overall picture, i.e. external interfaces towards client and subcontractors. This is in line with the reviewed research articles where focus typically is on engineering vs manufacturing and engineering vs marketing, i.e. on a high level. In APL, this problem actually appeared more on a detailed level; internal interfaces between the various delivery teams. An example can be a component from one team not being installable onto the component from the other team. However, means to manage this were implemented;

- A supply matrix for each project that clearly identified the detailed delivery scope of each delivery team.
- An interfaces register which is maintained during project execution.
- Design reviews with focus on interface details.

In combination with the additional focus on internal communication, interface information seems to be managed well. On Harding OLS, only one interface conflict requiring on-site repair occurred, as illustrated in Figure 19.

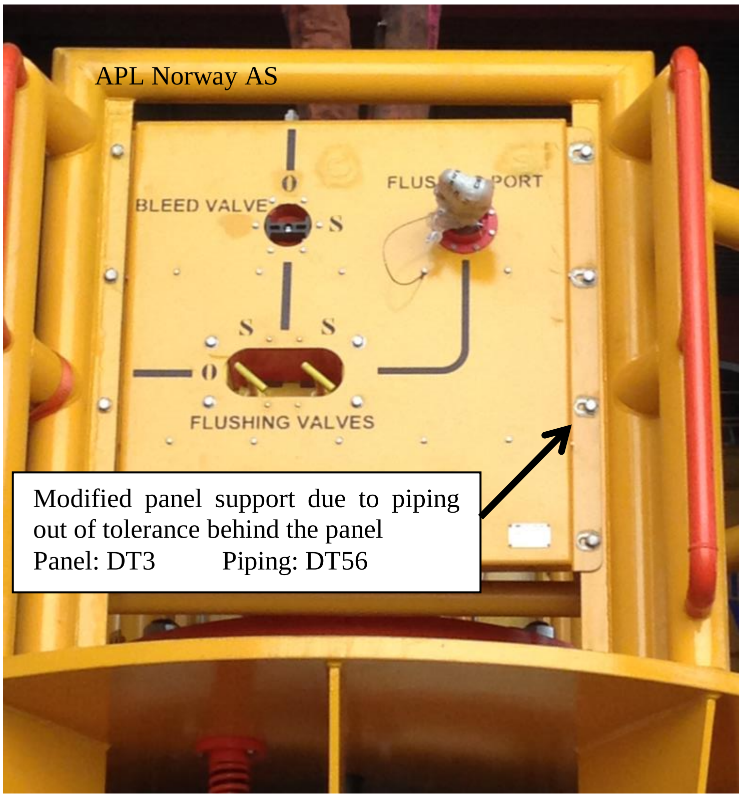

Figure 19 Interface problem: On-site modification of operating panel

5.3.3 *Resource management*

On resource management, APL has done significant efforts to avoid the constraint issues that are described in the theory, but still the problems are observed. The responsibility to provide engineering resources rests with the delivery teams, and the allocation of resources to a project is made as result of a process between the project manager and the delivery team manager as illustrated in Figure 20. Resource planning for each delivery team is based on the accumulated requirements of all projects.

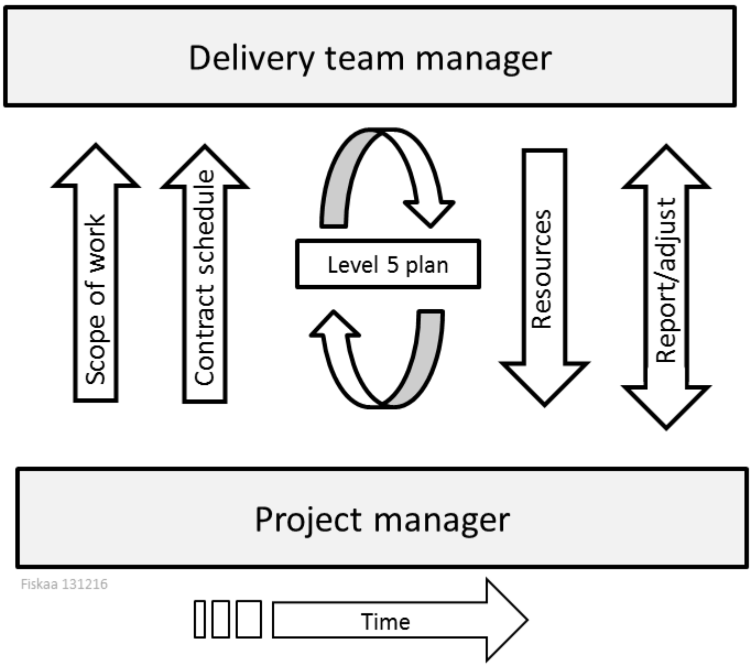

Figure 20 The resource allocation process

Projects are planned to a Level 5 schedule, which means that each project is detailed down to a detailed activity or document level. Project progress is reported based on accumulating data from detailed reporting for all activities. Each single document and drawing required to deliver an offshore turret mooring system is planned with dates and persons, using contract schedule requirements and fabrication lead times as starting point. In order to reach a contract delivery date, the project will be planned based on need dates for systems, subsystems, components, and further down to each single design document. Each delivery team will provide input to their design engineering and deliveries, but with a typical project having a tight schedule given by the contract, there will normally be limited slack to play with. Having several projects running simultaneously, the result will be conflicting resource requirements at some point in time during the project execution phase. This will result in the conflict described by several studies:

- A project with weak project management will suffer under the priorities by a stronger functional manager when resources are limited.
- A project with weak project management may also suffer, if another project competing for the same resources has a stronger project management.

Good resource planning will require continuous updating and of plans and adjusting resource allocation as the project progresses. Subjective priorities such as retaining or not allocating sufficient resources to cover unexpected work, or in fear of not getting new resources when required, may distort resource planning.

There seems to be improvement with experience, though. During the Gullfaks project (the first project) several examples of resource conflicts where found, typically engineering document delivery dates that did not meet the project management requirements. On the subsequent Harding project this tendency seemed to be much more controlled. This can be the result of three things;

- Improved general understanding of how the organization work
- Better understanding of how to prioritize resources
- Increased focus on, and clear communication of contract milestones.

All these three factors can be expected to improve over time, and may be assumed to drive the organization towards a balanced matrix or project matrix structure as per Mike Hobday's illustration, ref Figure 13.

5.4 Hypothesis and research questions

As presented above, a matrix organization is known for being able to handle more complex projects through effective communication and improved competence. According to Davis and Lawrence (Davis, 1978) the matrix is often introduced when the firm is faced with the need for increased focus and resource constraints. These parameters can be recognized with APL's situation at the time of reorganisation. The company was in strong growth, particularly resource constraints became an issue. At the time of introduction, there was reluctance to the change and the following was noted as arguments against the re-organization:

- Complex organization; who to talk to for a particular matter.
- Unclear interfaces between delivery teams.
- Focus on sub-systems rather than overall system performance.
- Conflicting interests, cheap solutions in one team could drive cost in a different team.
- Resource limitations, why would one team support another team in period with larger work load.
- Would not nine small "companies" require more management resources to run than one large company?
- What will happen to innovation when increased focus is drawn towards optimizing already existing products?

Some of these arguments were early identified and mitigated by various methods. Unclear interfaces were for instance resolved by establishing a register; a matrix of responsibility for the deliveries in a project, detailed down to bolts and nuts.

Despite the reluctance from individuals, the company has delivered very good results during the last years, and from this the hypothesis will be:

- The delivery team structure has been a favourable organizational model for APL in a period with high work load.

The research questions forming basis for investigating this hypothesis are:

- How will the new organization model influence the efficiency of project execution in terms of actual vs. planned manhours, technical vs. management manhours and quality?

- What are the factors contributing to the observed variance in efficiency of projects executed under the two different organization models?

The second question regarding contributing factors is looked at in light of the theories, since direct comparison between projects before and after the reorganization is not possible project-by-project. However, the factors are discussed, including such as:

- Internal interfaces.
- Internal communication.
- Schedule conflicts.
- Resource constraints and resource conflicts.
- Priorities beyond project management control.

6 Research model

A flow chart has been made to illustrate the research model. This shows collection of data, manual sorting of data into two groups depending on company structure at the time, and then analysis and comparison of results.

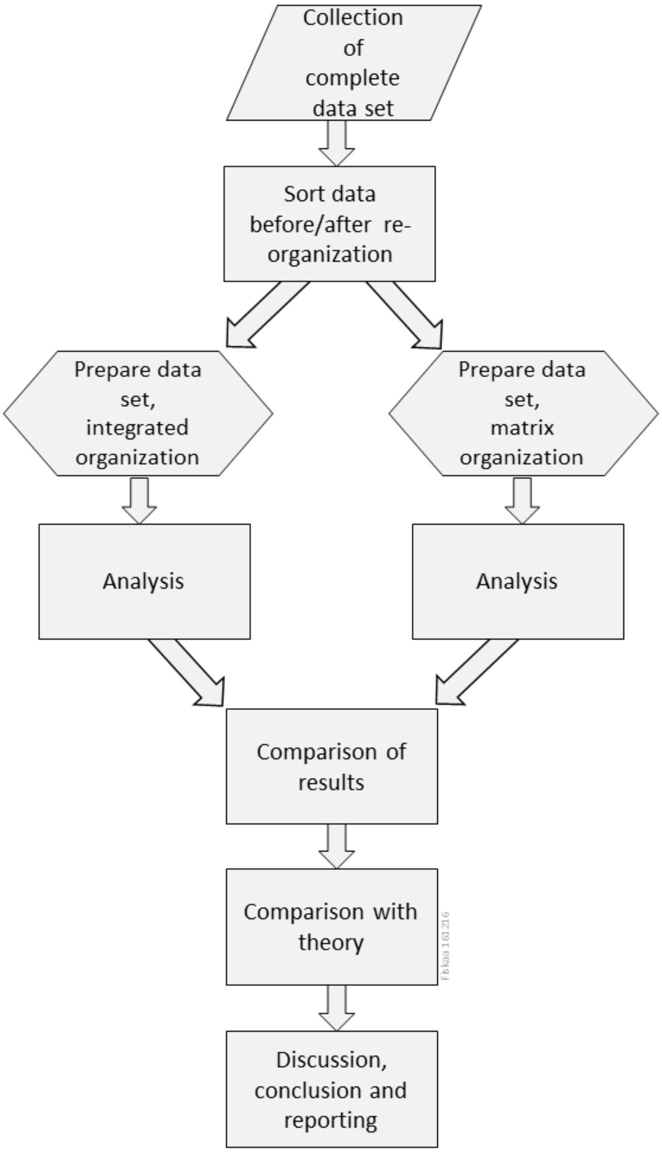

Figure 21 Research model

The research model has been applied on two levels, for the complete acquisition of project data comprising 45 projects, and then on a more detailed level for the two presented projects to try and identify specific parameters that can explain any observed variance in project efficiency.

7 Data

7.1 Collecting data

There have been many personal opinions and discussions on the restructuring of the company. In my experience people can be quite reluctant to change, and my goal with this thesis is to collect data and investigate whether or not it is possible to conclude on any results or trends in this particular case.

A claimed quote by Professor W. Edward Deming says; “without data, you’re just another person with an opinion”. In line with this, valuable assistance from the project control discipline in APL Norway AS has helped assembling historical data as basis for the investigations. Data for a large number of projects have been made available, in practice all major projects delivered in the period 2008–2016. These have been categorized and analysed. In summary a total of 45 projects are included.

The 45 projects have been grouped in two; before and after the reorganization. Data have been collected for the following parameters:

- Management and administration manhours.
- Engineering manhours.
- Total actual hours.
- Total planned hours.
- All hours are purely project related, i.e. they do for instance not include administration within each delivery team.

For the three described projects, more details have been provided in terms of engineering hours per technical discipline.

Following the product categories described in this thesis, the overall project deliveries in the period are illustrated as per the figure below, based on number of deliveries:

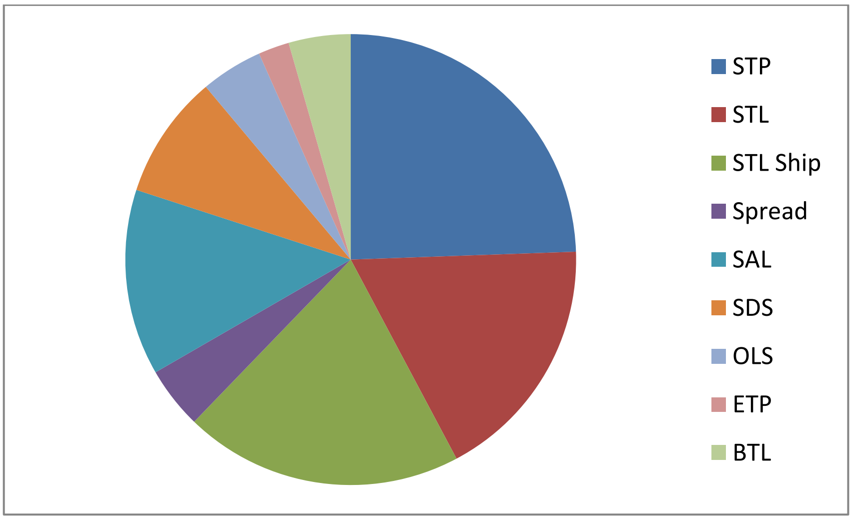

Figure 22 Historical distribution of projects per concept

In a manhour perspective the turret production systems represent a significant share of the company's production. This reflects the nature of the STP, the concept is more complex with its permanent mooring system dimensioned for extreme storm conditions, normally multiple flexible risers and umbilicals. The engineering effort to design the system is significantly higher compared with the relatively simpler loading terminals. The same can be observed for the BTL which is also an engineering intensive concept. The SAL, a single mooring line loading system is far less engineering intensive.

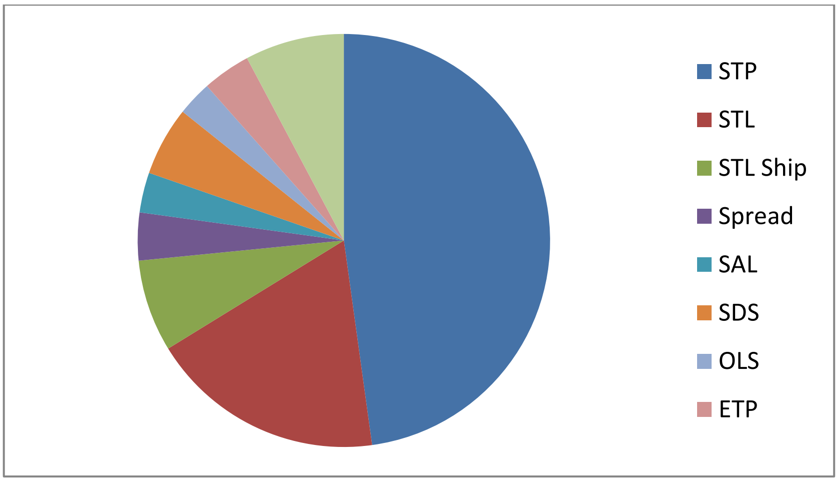

Figure 23 Historical distribution of spent manhours per concept

7.2 Validity and reliability of the data

In this thesis the focus is on effects internally for this particular company, I am not investigating characteristics or particulars for the organization model in general. The collected data are not compared with other similar data directly, but they are discussed in light of other hypotheses and research results presented in the literature.

The business of APL Norway AS is dominated by a small number of large projects per year. Very few of these are directly comparable, and this means that there is limited statistical basis for the investigations. Particularly, the number of projects after the reorganization is limited. But there are also a number of other inaccuracies and sources of errors that need consideration while evaluating the data and extracting the results.

- There are very few directly comparable projects. The product range varies from smaller to larger systems where all are engineered to client specifications. To illustrate this, the largest project in the company's historical project portfolio is eight times as large as the smallest in terms of manhours.

- There are variations in complexity and challenges met during the project execution phase, technical, contractual and schedule.

- Variation orders are significant for some projects, while very limited for others. In general, it can be assumed that in projects with a well-defined design basis and scope of work, variation orders are fewer, while in projects with a more unclear scope they are more significant. This may influence the actual vs baseline hours in the project as a trend, since the more well defined a task is, the easier it is to plan correctly. For this study the assumption that all projects are well defined, engineered and delivered within the base contract scope of supply and all variation orders have been disregarded from the data acquisition.

- There are large variations in customer behavior. Some large clients, typically major oil companies with stringent internal routines and requirements will drive up project manhours. In many cases this may have a significant impact on project management and administration versus engineering hours.

- There are variations in personal performance in the project team. Experience, skills, efficiency and focus will be individual parameters that add to the overall project performance. A typical example can be cases where key persons bring experience from one project to the next and the projects are quite similar.

- There will be inaccuracies in man-hour reporting routines. Even though the project planning provides detailed activity codes down to document or drawing level, it is easy to copy previous week’s activity codes when filling in time sheets in the last minute before cut off.

- In smaller projects it has been seen that engineering activities are underreported as a result of the project management team’s involvement in engineering activities. Typically high level engineering documents such as operating manuals and commissioning procedures may have been developed by the engineering manager, rather than by engineers at delivery team level.

Some projects have been disregarded in the data assembly. These are:

- Modification projects, where additional challenges may arise from operational constraints, technical interfaces and old or incomplete documentation.
- Projects where data are not complete.
- One project where exceptional overruns and heavy workload on management and administration was experienced, but where this to a large extent has been on the account of the client.

Some projects have been included in the data even if they are not complete. These are projects with progress >95%.

7.3 Preparation of the data

The available data represents critically sensitive data for the company and is thereby not disclosed directly. All data have been scaled by a confidential factor. This does not influence on the findings and conclusions drawn in the thesis.

7.4 Presentation of overall project data

In the following two tables, the project data is presented. The first table is data for projects run under the original organization; the second table contains project data for the reorganized structure. Note that as mentioned in 7.3 the numbers are factored.

Project code	Managem. Actual	Engineering Actual	Total Baseline	Total Actual
1140	1000	2091	1547	3091
1338	1790	1793	2021	3584
1339	1474	3086	1979	4560
1384	2262	3333	2465	5596
1148	631	1554	1145	2185
1153	628	2073	1150	2701
1676	776	1369	1583	2145
1133	471	454	1360	93
1343	571	920	832	1491
1655	338	1876	1828	2214
1798	937	1131	792	2068
1418	126	249	298	376
1457	192	341	274	531
1258	192	440	341	632
1377	144	303	315	447
1257	435	294	312	729
1417	145	260	304	406
1478	141	303	338	444
1536	164	153	282	317
1586	1197	1145	1552	2342
1354	59	176	103	235
1370	47	59	103	106
1467	252	344	176	596
1670	1461	1602	2063	3064
1724	573	214	546	787
1480	236	373	204	609
1498	353	675	442	1029

Table 1 Planned and actual manhours – integrated project organization

Project code	Managem. Actual	Engineering Actual	Total Baseline	Total Actual
1766	799	994	1637	1794
1829	765	3607	2899	4372
1635	2707	1922	1053	4629
1807	379	927	783	1306
1884	497	1196	792	1693
1747	491	1430	1295	1921
1859	472	833	1034	1306
1905	573	1586	1165	2159
1897	602	2448	1731	3050
1906	1663	3823	3323	5487

1900	350	664	1243	1015
1908	1113	2662	2360	3775
1902	1630	994	4505	2624
1896	1297	2225	1741	3521
1921	1569	5830	4618	7400

Table 2 Planned and actual manhours – delivery team structure (matrix organization)

The data are discussed further in section 8.

7.5 Presentation of detailed project data

In this section, I am looking into detailed data for the two consecutive projects looking for a development or trend in the project performance. Even though this gives very limited statistical basis for drawing conclusions, it will give an indication whether or not the new organizational model shows improvement or learning over time. The following data have been looked at:

- Detailed split of manhours per discipline. The projects are very similar and a direct comparison is a reasonable approach, and where this is not correct a note has been made.

- Details of the progress reports have been made to see if there is any improvement in terms of adherence to project plans. This gives an indication of focus on both schedule and resource allocation to the project.

7.5.1 Management

The project management hours include all activities not covered by the engineering disciplines; project manager, project control and contract management is one category, engineering manager and document control are separate categories in the figures below. The split between these categories are practically the same from one project to the other. This is surprising, considering a majority of the project team, as well as the client, was not the same for the two projects. But both projects were run strictly according to the project execution plan, and thereby stable preconditions for the project have been present.

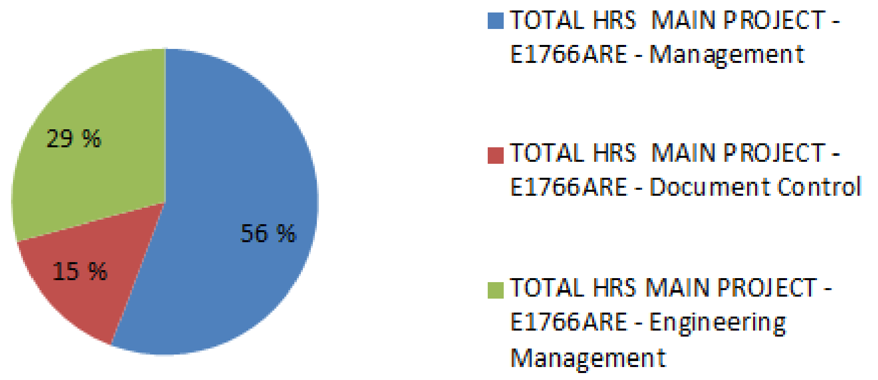

Figure 24 Gullfaks OLS – distribution of management hours

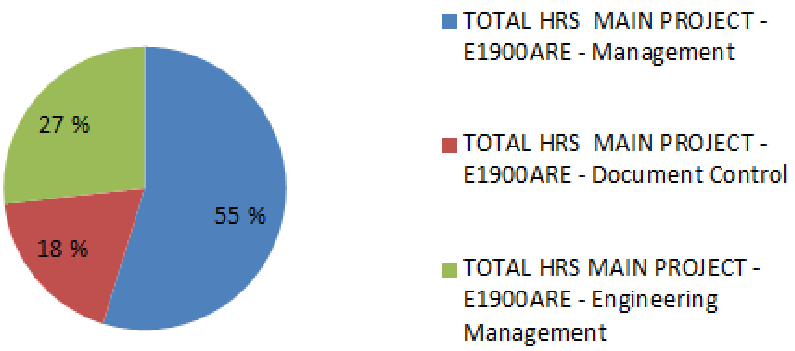

Figure 25 Harding OLS – distribution of management hours

7.5.2 Engineering

The engineering hours are split per Delivery Team. The same tendency can be seen here, distribution between the teams remains the same, with the small change that DT2 was only involved in one of the projects. A comment can also be made to the presence of DT9 on Gullfaks OLS. One of the objections heard about the organization is the ownership on a system level. There are specialized teams owning sub-systems, but who has overall responsibility. DT9 took responsibility of final assembly and yard testing on Gullfaks OLS, but this was included with the various DT's on Harding. This was partly because it was more efficient to use personnel with project knowledge, rather than bringing in new personnel for final testing.

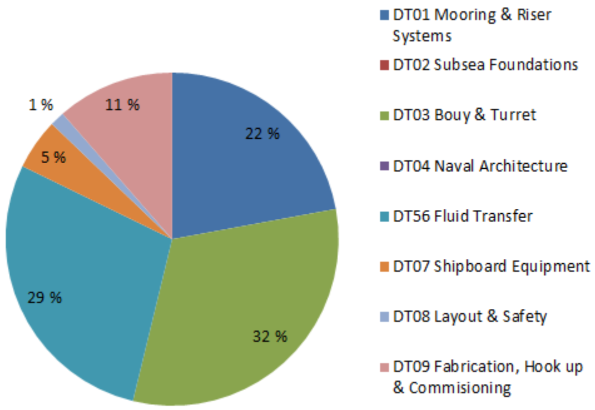

Figure 26 Gullfaks OLS – distribution of engineering hours

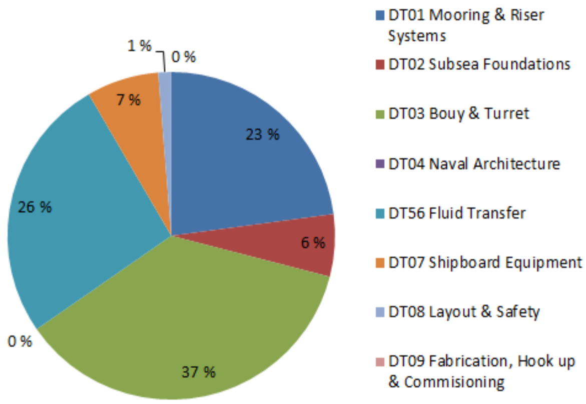

Figure 27 Harding OLS – distribution of engineering hours

7.5.3 Total manhours

In sections 7.5.1 and 7.5.2 it is shown that the distribution between the various disciplines remains similar for the two projects. So then what about the total figure?

An important aspect to mention here is that Gullfaks OLS in fact was delivery of two identical systems, but the consequences of this was limited by the following:

- All engineering was carried out for only one system and then duplicated to the second system.
- The management activities remained at the same level, reporting activities, meetings and scheduling was done as for one system. The management documents though, were issued separately for each system.

In order to make the hours comparable, the following has been done:

- An average of 4 hours per engineering document has been deducted from the total project number, both on design reports and on drawings. This is an estimate made following a discussion with design engineers and document control.
- Hours for follow-up of fabrication and testing of OLS 2 at yard are included in the engineering category. These have been reduced by 750 hours. The estimate comes from review of hours reported by DT9.
- Actual number of hours vs budget hours are directly comparable for both projects.

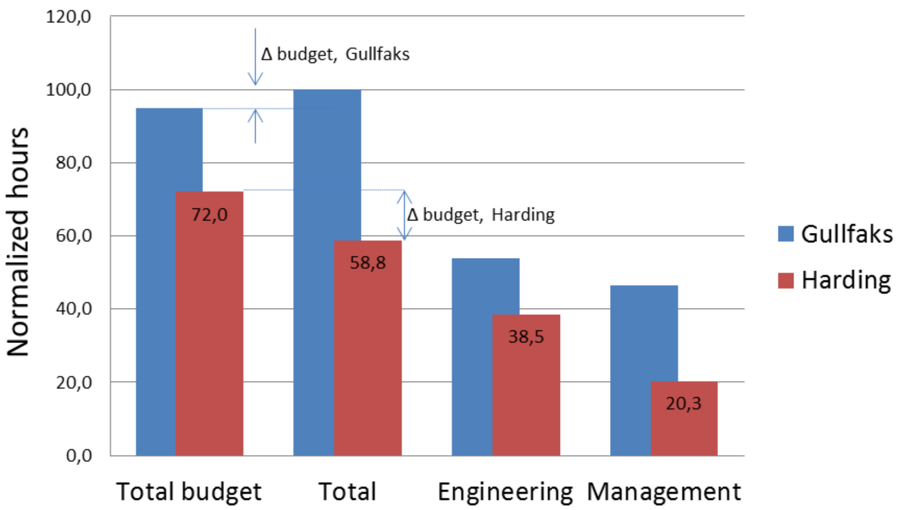

Figure 28 Development in actual hours from Gullfaks to Harding

Figure 28 shows a significant development from Gullfaks to Harding, which is further discussed in section 9.2. But as described earlier, there are significant variations in projects in terms of contract volume, client requirements, schedule requirements and technical challenges that make projects difficult to compare. These parameters are however included in the project budgets.

A key result to observe from Figure 28 is:

- Gullfaks OLS was completed 5% over budget on hours.
- Harding OLS was completed 18% below budget on hours.

8 Methodology and analysis

8.1 Method of comparing data

Mike Hobday investigated the project based organization as a potential ideal form for managing complex products and systems (Hobday M. , 2000), and pointed out: "One of the problems of case study research of this kind is the counterfactual difficulty of knowing what would have happened (e.g. in terms of performance) if another organizational structure had been applied. It is also difficult to attribute particular behavioural and performance attributes (e.g. flexibility, effectiveness, efficiency and return on investment) to particular factors such as organisational form, rather than other factors (e.g. project leadership, company culture, product market differences, and senior management support).

His statement will have relevance for this investigation also. As described previously, the projects are of varying complexity and size. Directly comparable projects before and after the re-organization don't exist. So a key question remaining unanswered is:

- How would the development in project performance have been without the re-organization?

In order to arrive at a conclusion, I look at averages, trends and variations in order to compare the project performance before and after the change. The findings have then been compared with applicable theories.

8.2 Method of analysing data

8.2.1 Average manhour spending

All project data sets have been sorted in two categories; before and after the re-organization. For each of these two groups, the average hours in each category has been calculated, and the percentage of management and engineering hours. In addition, total actual spent hours have been compared with budget hours.

Figure 29 shows management and engineering hours in percent of total project hours for projects under the original project organization, the new delivery team structure and the total average. It also gives results in terms of actual hours relative to baseline, which illustrates adherence to budget for the same categories. The figure gives an indication that, under the course assumption that other governing conditions are the same, the new organization in fact performs better than the original project set-up. However, there are not very many projects to gather data from, and the preconditions for comparing results are uncertain.

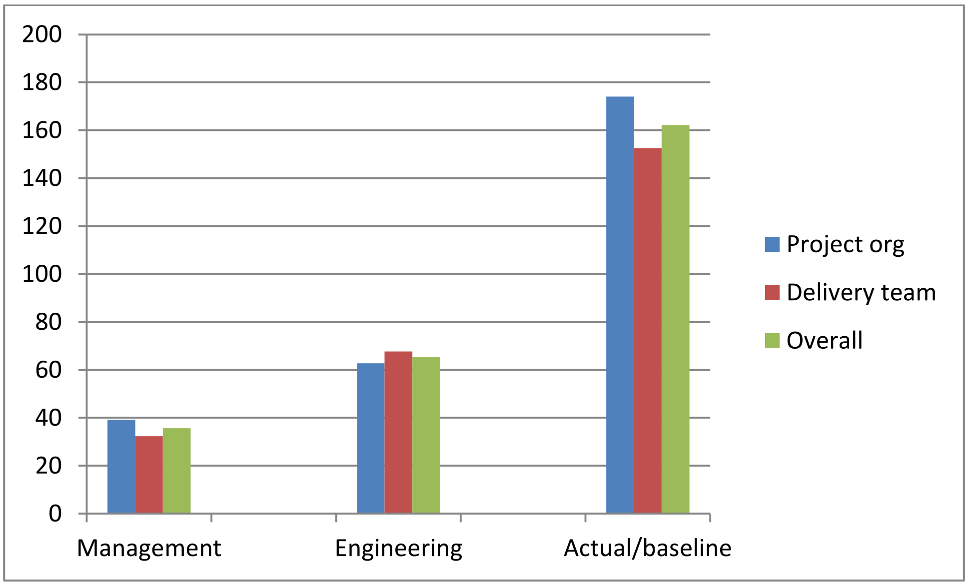

Figure 29 Key project data.
Management and engineering in percent of total project hours.
Average actual hours in percent of baseline.
Note that the figures have been scaled and represents correct trends, not correct absolute figures.

The management hours have been reduced from 39.2% to 32.4%, engineering has increased correspondingly from 62.8% to 67.6%. Exceeding the time budget has been reduced from an average of 174.0% to 152.6%. Under the described presumptions, less overspending and increased share spent on engineering, the indications is that the project runs more effectively under the new model.

8.2.2 Variation in man-hour spending

Variation in the data sets will be an indicator of uncertainty in the project execution. To give a picture of this, the standard deviation within the categories has been calculated.

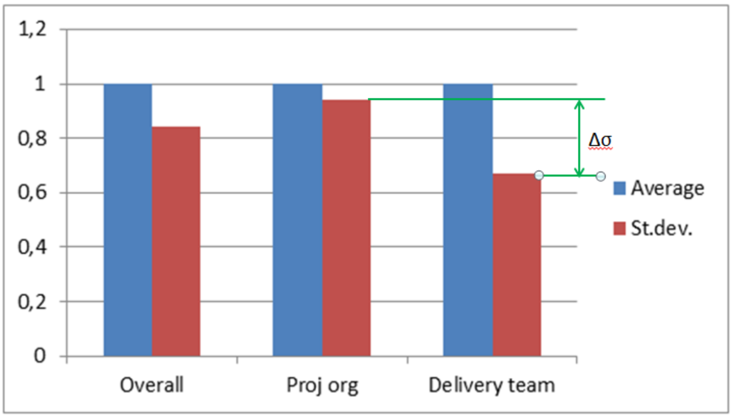

Figure 30 Standard deviation of normalized management hours

In Figure 30, management hours have been averaged and normalized, and then the standard deviation for each data set has been calculated. This has been done to get an indication which data set is more volatile. The standard deviation for projects under the delivery team structure is reduced by 31%, which can be interpreted as an indication of a more predictable project execution. It is however important to keep in mind the limited number of projects, the fact that no projects are similar in size or complexity, and that increased attention to the company's project execution model has an influence. High focus on the execution model by the project team will lead to high focus on the details in the project such as cost and progress relative to plan. This will in turn lay ground for higher possibility for achieving results as per plan.

8.2.3 The effect of project complexity

When comparing project performance before and after the restructuring in sections 8.2.1 and 8.2.2, the basis is average hours from all projects. But with the wide range in project size it is also of interest to consider the influence of project complexity. The statistical basis becomes even more limited, still there is relevance since the larger projects necessarily are of greater importance to the company in terms of revenue. In order to evaluate this selected project data is grouped in "less complex" and "more complex" projects where SAL and OLS go into the first group, STL and STP into the second group.

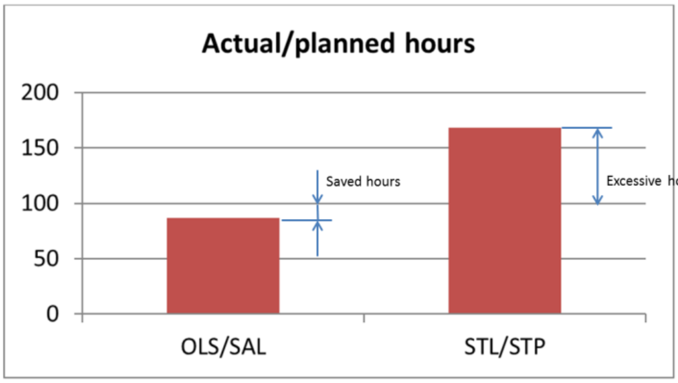

Figure 31 Actual hours as percent of planned hours
Note that data has been scaled.

There is a tendency that the more complex projects shows budget overruns on manhours, while the less complex projects generally will meet budget.

In previous research, several articles point towards the matrix organization as a favourable means of handling complex projects. Even though the limited basis of comparison here shows differently, it is likely not a contradiction as such. A complex project as such is not only complex to execute and deliver, it is also complex to sell where assumptions and estimates that will materialize only during project execution. So the comparison here might just as well be an indicator of either underestimation of complexity or a strategic choice in order to win the large projects.

As discussed in section 5.3.1, there is also an issue with communication flow within the company that may appear more important with more complex projects. The project execution plan describes communication via interface registers or monthly meetings; thereby the effective internal information flow rests with the project management team to create. One may assume that the larger the project the more important this is. And the larger the project, the less information reaches its required recipients by informal communication only. The overspending of manhours in the more complex projects may be a symptom of this as well.

8.2.4 *Evaluation of trends*

Evaluation of trends in the project execution performance would have been considered as an important indicator, for instance as development of manhours spending relative to budget over time, or it could be developed further into quality measurements such as number of non-conformance reports per 1000 hours.

From the trend analysis it would be possible to evaluate the effect of learning and experience develops in the organization over time. At present, the statistical basis for this is very limited. However, there are a few tendencies worth looking at.

In Figure 32 the trend is shown for the nine last STP projects. Note that the figures have been scaled by a confidential factor and offset since project results are sensitive information. The point in time for introduction of the new organization model is shown in the figure.

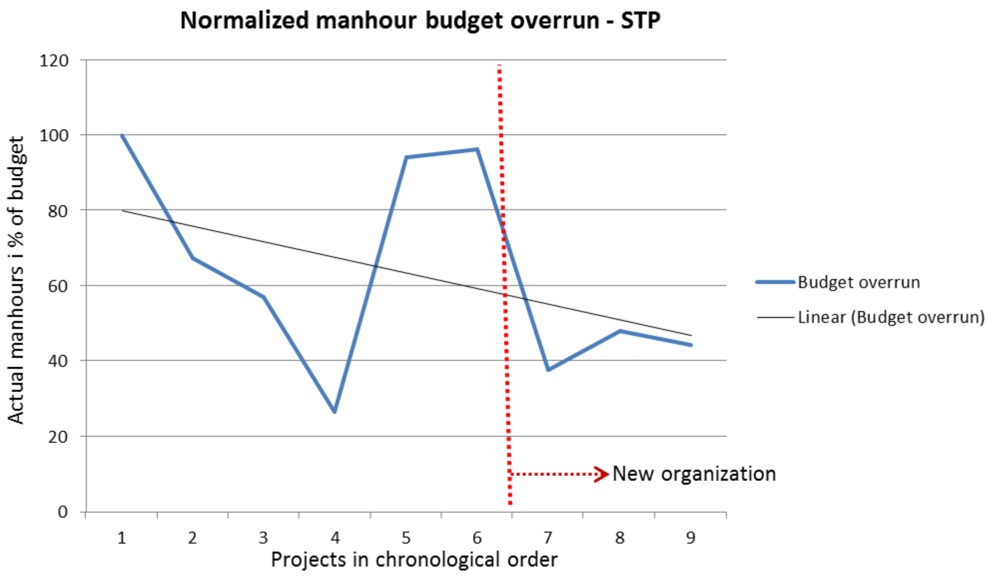

Figure 32 Development in actual manhours vs budget – STP projects
The data series is "anonymized" by scaling the series to 100% for the first project in series. The trend line is linear.

Even though the trend line is based on just nine projects, of which only three have been run under the new organization, there is a tendency towards improved alignment between actual hours and budget hours.

As described earlier, there are variations in projects such as client requirements, schedule challenges, technical complexity and how eager and optimistic the sales team has been in the selling the project. These variations may compromise the validity of the trend line. From this figure it is not possible to detect whether the re-organizing has had any effect, or if the improvement is a general trend in the company resulting from other parameters. Such parameters can be several such as more experienced personnel, improvement in design processes, or it can even be that increased demand for the products has allowed increased budgets during the sales process.

In order to further investigate this trend, Figure 33 presents all projects from the time of implementation of the new organization except one project that has been disregarded as explained in section 7.2. In this figure, the data basis is a little more extensive with 13 projects in the range. The same trend is observed also here, there is a general tendency towards more efficient project execution, measured by manhours vs budget.

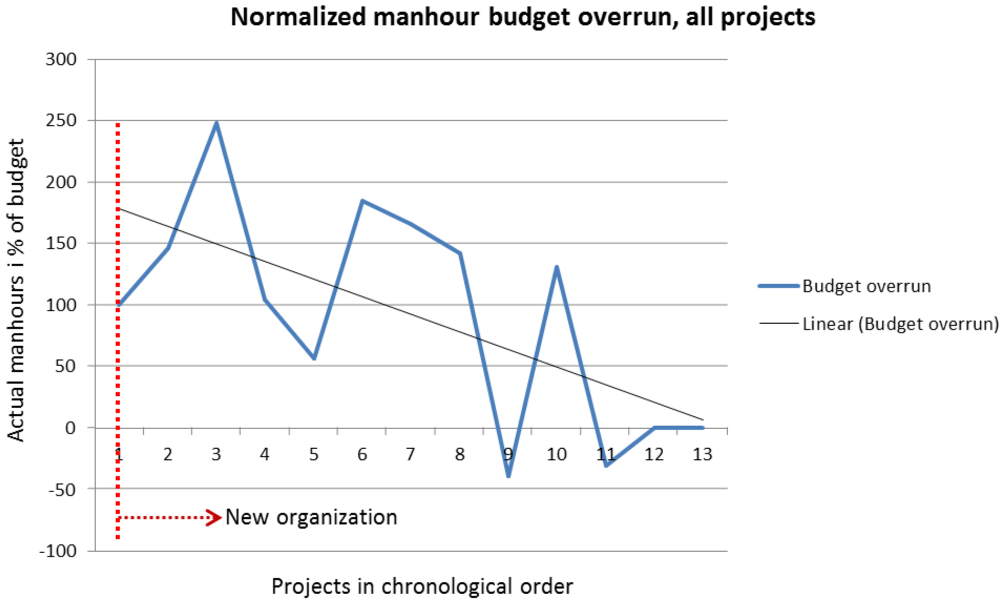

Figure 33 Development in actual manhours vs budget – all projects
The data series is "anonymized" by scaling the series to 100% for the first project in series.
The trend line is linear.

9 Results and findings

9.1 Summary of results

Normally, there is a lot of focus on successful completion of each single project where the “iron triangle” of measuring project performance is used; schedule, cost and quality. In this thesis I have looked at the effect of a change in the organization that was made in order to improve performance in a period where a strong market upturn had started. Even though data from a total of 45 projects have been collected and analysed, the statistical basis for firm conclusions is weak. The fact that all projects are engineered to order under various client requirements and that the contract sizes vary considerably bring uncertainties into the comparison and make firm conclusions difficult to draw.

There are a number of noticeable tendencies, though:

- For contracts run after the reorganizing there are a relatively smaller share on management and larger share on engineering hours out of the total manhours spent on the projects.
- Also, there is less variation in the distribution between these disciplines after the reorganization can be observed.
- There is a trend that the total manhour spending per project develops positively over time, which indicates both better predictability and improved efficiency in the project execution.
- The positive trend can be seen also prior to the reorganizing, which actually complicates making a firm conclusion on the study.

By looking at the Gullfaks and Harding projects, a considerable improvement can be observed. These two projects are probably the two most comparable projects in a technical perspective, they were well defined in terms of scope of work, and thereby they can be assumed to have quite good budget estimates prior to commencing the work. The results are therefore a good indication of an improved project performance from the first to the next project:

- Gullfaks: Manhours +5% relative to budget.
- Harding: Manhours -18% relative to budget.

A general trend in improving project performance has been found, with a development from general overspending in the direction towards on-budget on manhours.

9.2 Discussion of results

Theories on the matrix structure highlight this organizational model as favourable for complex projects with a high demand for communication between teams and individuals and the results found in this study indicates that this is the case also for APL.

When looking at the results in this study, it is important to keep in mind the limitations and uncertainties that can be found behind the data. Each single project having its own sets of characteristics such as:

- Contract size.
- Contract requirements.
- Engineered to order.
- Technical challenges.
- Schedule requirements.

These varying project characteristics make the comparison between projects difficult and the results will have issues on validity. Thereby the results must be evaluated with caution.

However, when looking at the overall trends:

- There is a tendency that the project performance is gradually improved over time. This can be seen from both the comparison between Gullfaks and Harding, but it can also be seen from the overall trend for all projects performed with the new organization.
- There is an indication that the positive trend was ongoing also before the re-organization, ref. Figure 32 which shows the development for the STP projects over time.
- The development from Gullfaks to Harding shows a very good improvement on quite similar project. These two project isolated gives limited basis for concluding anything, but still the effect is noticeable and can be used as an indicator that a learning effect is present which may appear more valid in a future study.

It can be discussed to what extent the improvement in project performance is related to the re-organization itself, and if there are other parameters influencing as well. As mentioned, Harding OLS in direct consecutive order from Gullfaks OLS shows a significant improvement compared with its predecessor. There are little statistical basis to support this as a rule, but all parameters have improved; schedule, actual manhours vs planned manhours, and financial results. Financial result is influenced by the downturn in the industry with generally lower cost level, but to assess the impact of this with certainty is difficult.

The results show that there is likely to be a good effect of learning within the organization. Necessarily a new organization model will require new ways of communicating and collaborating and this will develop over time. The improvement seen from Gullfaks (5% hours over budget) compared with Harding (18% hours under budget) is significant. These two projects are comparable, and there were no particular challenges or issues that stand out as an explanation to this development from technical or contractual view. Both projects were carried out according to the book, delivered on time. It can be assumed that the learning process within the organization significantly to this result.

There are very little in previous research that actually assesses the effect the matrix structure has on project execution effectiveness. Articles point to improved communication and collaboration as one of the key advantages, but little is found on what this actually means in terms of influence on the project success. But in the research by R. Schnetler (Schnetler, 2015), there are investigations on the correlation between the positive characteristics of the matrix organization and key project success drivers. He concludes that there is correlation between the characteristics of a matrix organization, and key drivers for project success. I.e. the matrix organization leads to better communication and collaboration, which again leads to better results. Transferring this to the results in APL, this will in fact support the trend that has been found. But it also points to the issue with internal communication that has appeared as a concern in APL.

10 Conclusions

10.1 General

In this thesis, the effects of re-organizing a project based engineering company from an integrated project organization to a product oriented matrix structure have been investigated. Basis for the investigations have been project data for 45 projects carried out over the last 10 years. Man-hour spending has been analysed with focus on development in engineering vs project management and actual hours vs. budget hours, with identifying development in project execution effectiveness as the primary goal. The results have been compared with applicable theories and other studies on the subject.

The re-organization was met with a certain degree of reluctance, and there is still some criticism of the organization model when discussing with employees. The conclusions are however:

- With the new organization, the company has managed to deliver a record number of projects. This was one of the arguments for introducing the structure in the first place.

- The hours spent on project management relative to engineering have been reduced, which can be seen as an indication of a more effective project execution.

- The manhours budget overruns have been reduced, which indicates a better overall project performance. There is a continuing improvement over time in the project data that implies a certain potential in improvement by learning in the organization. It should however be noted that this gradual improvement can be seen also before the time of re-organizing.

- Variance in the manhours figures have been reduced, both on management vs. engineering and actual vs. budget. This indicates more predictable project execution measured against budget, which again may indicate that the company's generic project execution plan has settled as a way of performing projects.

Looking at details of projects carried out under the new model, there are however some contradicting findings.

- Smaller projects have improved more, while larger project have shown less difference. This is in contradiction to theory that highlights the matrix as particularly suitable for complex projects.

- Improved communication which is also highlighted as one of the key benefits of the matrix, however not coherently supported by previous research, does not seem to be the case in APL. There has however been done efforts on project level to mitigate this, and the results have been good.

10.2 What can we learn from this?

The practical implications from this study will be to propose changes in the project execution plan that strengthens potential advantages the organization model have:

- Improve focus on cross-functional communication. In the reviewed research articles this is generally described as a natural consequence of implementing the cross functional structure, only a few researchers identify the communication challenges that have been observed in APL. The mitigating actions are easy to implement, but should be part of the company's formal, described way of work.

- The organization should further develop a common understanding of the importance of plans and schedules, all the way down to a personal level. The delivery team structure has been implemented to handle a large work load, but this also increases the consequences of delays with subsequent knock-on effects.

- It is also an important lesson that the re-organizing of the company seems in fact to have been successful, measured by the parameters studied in this thesis. This stands in contradiction to a vast number of comments and opinions observed when starting the investigation, but supports the reasons for implementing the change.

As the final conclusion on the investigations in this thesis, I would like to draw the attention back to the hypothesis presented in section 5.4; that the delivery team structure has been a favourable organizational model for APL in a period with high work load. Under the given conditions there are good indications that this hypothesis is correct, an indication that is also supported by a variety of other research.

10.3 What are the needs for future studies?

R. S. Schnetler (Schnetler, 2015) stated that he through his research has found no empirical data to show the impact of the matrix structure on the project execution effectiveness. In this study this is exactly what I have looked at; the effects of implementing the matrix structure in APL in terms of execution effectiveness. It would be highly interesting to expand the study, either by gathering data from APL as these become available or even by investigating results in other companies. Expanding the study with more a more extensive data basis could provide more conclusive results, and could be used to develop the study further into topics such as:

- Investigating the project execution model in detail in light of the findings, and thereby proposing improvements to ensure the potential of the organization is utilized to its best.

- Investigating developments in product quality to see whether the specializing that follows with the product orientation has the desired effect.

- Establish new sets of project performance indicators. There could for instance be performance indicators on the quality of the teams, their communication and collaboration in order to further optimise the organization.

- Establish routines for allowing feedback on project performance to the business development group, where improvements could be taken out as reduced cost in the sales process. This could improve the competitiveness of the company.

At present, it does however seem that APL will introduce new changes in the organization model to adapt to reduced demand in the present market downturn (2016). Thereby future data acquisitions will introduce new challenges in comparing project results. As a basic pre-condition for further studies, the modified organization would at least have to settle and deliver a certain number of new projects prior to collecting more data.

Another aspect where a dedicated study would be very interesting is how the organization model will influence on innovation. Innovation is a key driver for the development in an engineering company, and the effects that the organization model may have on this is of course very important to the future of the business. Some references to literature on this subject have been given in the thesis, but a lot of the previous research has been done on other industries than offshore oil and gas.

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