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Abstract

The oil and gas industry is in a situation where changes are required to remain competitive. Lean has proven to be a successful mean to improve companies worldwide, which is why there has been a growing interest in Lean among the oil and gas companies in the past few years. The corporate management in Statoil decided to use Lean as a way of working to reach the goal of a continuous improvement culture.

This thesis provides a detailed literature study on Lean. The literature study includes historic background of Lean, Lean principles, Lean tools, and a presentation of Lean implementation with some potential challenges. This can be found in section 2.1. Lean has traditionally been applied to typical, repetitive production systems, while this thesis focus on how Lean can be used in other contexts. How Lean has been used in projects and project management is the example which is presented in this thesis in section 2.2. The presentation of Lean in projects is done through comparison of traditional project management and Lean project management, where a few examples have been included to illustrate the effects of Lean. The last part of the literature study presents a brief overview of oil and gas industry, which can be found in section 2.3. This part is included as a courtesy to the reader to get a better understanding of the industry, which is useful further in the thesis.

The objective of the thesis is to discuss the Lean implementation process in Statoil, as well as how Lean can be used as a way of working in the company. The discussion is conducted in chapter 4. Through interviews and the literature study, issues have been addresses such as limitations and challenges. An extra focus has been on discussing Statoil's relation with contractors. Potential improvement areas have also been identified, along with how Lean tools can be used in Statoil. The Lean implementation process has been thoroughly reviewed, addressing both advantages and disadvantages. Furthermore, the new roadmap for digitalization in Statoil have been put in the context of Lean.

Maintaining a focus on Lean in Statoil along with a continuous improvement culture is the final topic discussed in this thesis, along with how Lean can assist Statoil in preparing for the future.

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1 Introduction

This thesis is based on using *Lean* as a way of working for companies. Lean has been implemented by numerous companies in many different industries, and is now receiving the attention of companies in the oil and gas industry. Among these companies in the oil and gas industry is Statoil, which uses Lean as a mean to "develop a *continuous improvement culture* focusing on safe, sustainable and profitable operations" (Statoil, 2017b).

The focus of this thesis is to investigate how Lean implementation have been done in Statoil, and identify improvement potential, challenges and limitations in Statoil's projects and in the organization in general. Interviews with Statoil employees was conducted and the analysis of the interviews will be discussed. The discussion part of the thesis will connect the statements in the interviews with a literature study on Lean theory and Lean in a project setting.

1.1 Background and Research Motivation

In recent years, the petroleum industry has experienced a setback due to the decrease in the oil price. The consequences include less operational activity, downsizing, and a high focus on cutting costs. Thousands of employees have lost their jobs, and it has become obvious that some changes need to be made to adapt to the situation. Unfortunately, the downturn has spreading consequences as the oil and gas industry is getting more skepticism from the public. The Norwegian people are searching for *the new oil* in Norway, as people have come to realize that the oil and gas industry will not be forever. The energy industry is fundamentally changing, as the focus on the environment and new energy solutions increases.

The oil and gas industry has become less appealing to the younger generation, compared to only a few years ago. Looking at a study of the most attractive employees for Norwegian students performed by Universum, there is a trend in which petroleum related companies are becoming less popular by the year (Universum, 2017). The same trend can be seen in students applying for higher education within petroleum related subjects (Løvås, 2017).

A single company cannot influence the oil price. However, a company can determine how it is run, and thereby influence how the company can handle a difficult situation. The focus on efficiency and continuous improvements has become a necessity to survive, and

thus the interest in *Lean* is increasing among many of the big actors in the oil and gas industry. Lean can be described as a way of working to eliminate wasteful activities, create flow in the business, and keep the focus on adding value to the customer.

The idea of writing a thesis on Lean came from Tor Livar Halvorsen and André Henning Aspevik in Statoil. Tor Livar and André have been supervisors from Statoil throughout this thesis. The theme is relevant to Statoil as the company is on the rise of a Lean transformation, where the goal is to develop a culture for continuous improvement. Given the current situation, an investigation on how Lean principles could assist Statoil in improving their work, as well as addressing the Lean implementation process, could be interesting.

Statoil was established in 1972, and has about 20000 employees. Statoil is an energy company which mainly operates within the oil and gas industry, but also in new energy solutions such as offshore wind. The company operate over 40 assets along the Norwegian coastline, and is the world's largest offshore operator as well as the largest operator in Norway (Statoil, 2017c).

Ever since the very beginning, Statoil's systems and processes have developed into what they are today. In every company, processes develop constantly along with new technology, new ideas and new people. Adapting to the fundamental changes which the energy industry is facing is essential to be competitive.

Lean have proven to be a successful way of working for many companies worldwide, starting with the car industry and Toyota in Japan. Therefore, it is interesting to follow the Lean journey of others companies, and investigate whether the ideas and principles can be adopted to the oil and gas industry. With inevitably changing processes, adding Lean principles to the changes in a controlled manner could help add value to even major oil and gas companies. However, systematically changing the way people work and think can be a very difficult task for major organizations such as Statoil.

1.2 Problem Formulation

Implementing Lean in an organization can be very challenging. Some industries, such as the oil and gas industry, might have certain limitations or barriers which can affect the way Lean can be used. There will be challenges related to Lean, and especially the implementation process. However, there will most likely be some areas where Lean has the potential to improve Statoil's projects and operations. This thesis will investigate

the above issues using a combination of Lean theory and analysis of interviews with Statoil employees.

1.3 Objective

The objective of this thesis is to create an overview of Lean by understanding Lean principles and how Lean can be used to improve an organization. Firstly, this thesis will include a review of Lean principles and tools, and focus on how projects and project management can benefit from this.

Secondly, it will be investigated why Statoil decided to use Lean, how Statoil has conducted the implementation process, how Lean can benefit Statoil, and if there have been any challenges. Furthermore, the use of Lean in Statoil's projects will be investigated and discussed.

The main objectives are can be summarized as:

- Review Lean theory with principles, tools and implementation.
- Put Lean in a project setting, and investigate differences and provide examples.
- Understand how Lean has been used in Statoil and identify challenges, limitations and potential.

1.4 Structure

The thesis is divided into two main parts; a literature study on Lean described in chapter 2, and the application of Lean in Statoil described in chapter 3, 4 and 5.

The first part describes Lean theory in a thorough matter, including historical background, principles, tools and implementation. The purpose of including Lean theory is to fully understand Lean and create a context to the subsequent sections of the thesis. The content of the first part will mainly be based on a literature study of acknowledged books within the subject area. The literature has been selected based on recommendations from fellow students, the supervisors, and the webpage *thekaizone.com* (which rank popular Lean books). The first part also includes how Lean has been used in a project context. Sections concerning traditional projects have been mainly based on literature from the Project Management Institute, while sections concerning Lean projects have used papers which have been found after advice from fellow students and the supervisors.

The second part describes Lean in Statoil. Chapter 3 is based on an analysis of five interviews with employees in Statoil. The interviewees were selected as they all had

experience with Lean. Chapter 4 summarizes and discusses the analysis while including elements from Chapter 2. Chapter 5 concludes with the findings made through the analysis and discussion.

2 A Literature Study of Lean

2.1 The Theory of Lean

2.1.1 Historic Background of Lean

Lean has its origin from Japan and the car producer Toyota. The entire concept is based on Toyota's internal production philosophy, the Toyota Production System (TPS). TPS has been explained by Toyota executive and founder of TPS, Taiichi Ohno. In 1988, Ohno published the book *Toyota Production System: Beyond Large-Scale Production* where he rejected economies of scale and mass production, and claimed that productivity was made through *flow (Liker, 2004).* He is famous for the quote:

> *"All we are doing is looking at the timeline from the moment the customer gives us an order to the point when we collect the cash. And we are reducing that time line by removing the non-value-added wastes."*
> *(Ohno, 1988)*

The two pillars of the TPS is called *jidoka* and *just-in-time*. The Japanese expression Jidoka roughly translates to "automation with a human touch". This means that machines could use "human intelligence" to find problems in the manufacturing process. For Toyota, this meant that defect units could be identified immediately, and taken care of as soon as possible. Thereby avoiding the need for repair at a later stage. Just-in-time is about creating a continuous flow in the manufacturing process, and only focusing on what the customer needs. This involves eliminating both waiting time and excess inventory, among other things. Excess inventory is said to cause delay, confusion and extra use of resources, in addition to taking up space both on the work floor and in designated areas. (Liker, 2004)

To understand TPS, one have to look at the post-World War II circumstances in Japan. In the 1940s and 1950s, Japan was struggling with lack of vital resources and challenging business conditions. Raw materials, technology, machines, financial resources, and land were all hard to get a hold on. Additionally, the market for cars in Japan was minor compared to western countries. This was a key factor in the evolution of Toyota, and contributed to the development of TPS. At the time, American car companies was known for mass production and the assembly line. This was not an option for Toyota, which had to make their production flexible in order to make a variety of cars to satisfy all of its customers. This led to the discovery that when lead times are short, and focus is on keeping the production lines flexible, the overall quality improved along with customer response,

productivity and utilization of equipment and space. Basically, Toyota developed a manufacturing system which addressed "the need for fast, flexible process that give customers what they want, when they want it, at the highest quality and affordable cost". Such a system is what most companies strive to achieve. (Liker, 2004)

Lean and TPS are in fact two different concepts, but they carry many of the same principles, as Lean is developed from TPS. The Lean expression was first introduced in 1988 by John Krafcik in the article *Triumph of the Lean Production System*. The article compared the production level between American car producers and Toyota, and identified two different production systems; a robust system and a fragile system. While the robust production system had widely used storage capacity, advanced technology and economies of scale, the so-called fragile system had low inventory, simple technology and small safety margins. Krafcik meant that the word fragile had a negative association, and replaced it with Lean. (Liker, 2004)

Since then, the Lean concept has caught the interest of many major organizations, and have been described in literature from 1990 until today. The book *The Machine that Changed the World* is based on research showing how Toyota has reached a productivity and quality level which no car producer could come close to. (J.P. Womack, Jones, Roos, & Technology, 1990). In this book, the authors claimed that Lean was a product of cooperation, communication, efficient use of resources, elimination of waste, and continuous improvement. Six year later, Womack and Jones published another book, *Lean Thinking*, which had a strong focus on how to use what they had learned from Toyota, and implement it in any company in any industry (J.P. Womack & Jones, 1996). The book suggests five principles which will be described in detail in section 2.1.3. *Lean thinking* has become essential in Lean theory, as most subsequent literature on Lean is based on the five Lean principles brought to light by Womack and Jones.

In recent years, the Lean concept has spread like wildfire within various industries. This is partly due to successful Lean transformations which tend to flourish in media and literature. When reading about Lean, it is easy to be caught up with the ideas and principles which should ideally improve your business. Even though the thoughts behind Lean is simple, the implementation in an organization is often complicated.

2.1.2 Introduction to Lean

Modig and Åhlström (2015) defines Lean as an operational strategy where flow efficiency is in focus. In short, this is how an organization shall deliver what the customer wants, when it is needed, with an absolute minimum of non-value-creating activities, and with an overview of the entire process. Lean is about continuous improvement of processes, and thereby always striving to increase the time spent on value adding activities compared to the total *lead time*. This means eliminating unnecessary time and resources used in the process, which is known as *waste*. The lead time is defined as the time between identifying a need until the need is fulfilled. Since lead time is defined from the customers' point of view, this also include waiting or queue time. In a manufacturing setting, the lead time is the time from when an order was placed until the customer receive the product. This time can be used as a performance indicator of an entire process.

Lean prioritizes flow efficiency rather than resource efficiency. Flow efficiency defines efficiency from the perspective of the unit, and the purpose is to maximize the fraction of value-creating time to total lead time. Resource efficiency on the other hand is the traditional form of efficiency, and the purpose is to maximize the time of which an organization's resources are in use. Resource efficiency dominates most how organizations in different industries are managed, because it is natural to most humans to think that if all resources are utilized, the process must be effective.

A large fraction of Lean literature is about implementation into various industries; manufacturing, hospitals, entrepreneurs, construction, etc. For this purpose, many Lean tools have been created and described, where the majority is based on the tools Toyota's production system. The tools are meant to identify improvements, find root causes, motivate the employees to see hidden waste in the organization, and help actualize improvements. Some of the most common tools will be described in section 2.1.4.

What can be viewed as a goal with Lean is to create what is referred to as a Lean Enterprise (James P. Womack & Jones, 2003). A Lean Enterprise fosters a company culture where all employees strive to continuously improve their skill level and work processes. The Lean Enterprise follows the value chain and operates across company boundaries. The key word in Lean is doing things right: the right things, in the right order, in the right amount, at the right location, at the right time, and in the right condition.

2.1.3 The Five Lean Principles

Womack and Jones (2003) presented the five Lean principles derived from the Toyota Production System. These five principles are the ground pillars of how Lean is defined.

2.1.3.1 Principle 1: Value

The process of creating *value* within an organization is done in steps or activities, often in a specified order. Value is defined in many ways, but in Lean theory, the common understanding of value is that *the customer is the only one able to define value*. This means that value should always be defined from the customer's point of view. For a customer, the purpose of an organization is the value which the organization is creating. (James P. Womack & Jones, 2003)

All activities should add value to the customer, and for an activity to be value creating there are three criteria. First, the customer must be affected by the outcome of an activity. Secondly, the activity must change the product or service in a way which the customer care for. And lastly, it must be done right the first time. Rework is never value adding. (Modig, 2015)

It is not always obvious who the customer is, and the term often cause confusion. If it is difficult to determine who the customer is, it is often easier to focus on the *need* which the organization should cover. For example, the customer of the police is not obvious. Instead of searching for the customer, the need which the police cover can be defined, which is (among other things) fighting crime. (Modig, 2015)

Value can be difficult to define, especially for larger firms as each employee tends to define value from his or her point of view. An activity might appear to add value to a single employee, but in the big picture, which means for the end customer, the activity is non-value adding. Different definitions often make it hard to agree on what the value is. The problem is often the lack of an overall view of the process, and when the focus is shifted to see the whole picture it is easier to define the value. This involves challenging the traditional definitions of value by rethinking the entire firm, ignore all existing assets and technologies, and keep focus on the deliveries. (James P. Womack & Jones, 2003)

According to Womack and Jones (2003), the most important task in specifying value is to determine what they refer to as the *target cost*. The target cost is based on the resources and effort required for the specified deliverables, given that all the waste is removed from the process. This is the key to removing waste, and maximize the customer's value. Opposed to the strategy of determining *acceptable costs* for a delivery given an

expected income, the ideal Lean organization focus on the expected income and search for the cost of their activities once all unnecessary steps are removed. This cost is most likely much lower than the competitors cost which provide some choices to the organization; reduce prices, increase volume and utilize freed-up resources, add features to increase sale, add services, expand, or take profit which can be used for other purposes.

2.1.3.2 Principle 2: Value Stream

The challenge for many companies is identifying the *value stream,* which is the line of activities where the actual value for the customer is being created. The value stream is the set of specific actions required to create something, also known as a work process. Identifying the value stream almost always exposes non-value adding activities. (James P. Womack & Jones, 2003)

When analyzing the activities in the value stream, the activities fall into one of three different categories (James P. Womack & Jones, 2003):

1. The steps which create value and should be kept in the process.
2. The steps which do not create any specific value, but cannot be avoided. However, these steps can often be improved.
3. The steps which have been found to create no value and can be removed or avoided with immediate effect.

Basically, these steps can be summarized as: *value adding*, *non-value adding* and *non-value adding but necessary*.

The goal of identifying the value stream is to have a process containing only the value adding and non-value adding but necessary activities. The non-value adding activities should be eliminated. A so-called value stream analysis is not to be confused with benchmarking, where a value stream is compared to competitors or industry best practice. Although benchmarking can be useful in some cases, this would be considered waste for a true Lean organization. The purpose is to compete against perfection, and not with similar companies. (James P. Womack & Jones, 2003)

2.1.3.3 Principle 3: Flow

The next principle is to make the value stream *flow*. In Lean, flow is viewed from the unit which is undergoing a process. The customer does not want to pay for all the waiting which could be avoided, although waiting is generally accepted since it is normal in most

industries. Flow is applicable for almost any task if the focus is shifted towards the objective of the process. (James P. Womack & Jones, 2003)

A central term within flow is one-piece flow. This is a situation where one product is completed at a time, without having semi-finished products piling up. This ensures no defects and full attention on one product to create the exact value that the customer wants. One-piece flow is contrast to batch-and-queue, meaning that one step in the system produces a large amount of its delivery before sending it to the next step in the process, thereby piling up work at every step in the value chain. (Modig, 2015)

There are certain techniques or guidelines in achieving a good flow in an organization. The first technique is to follow the course of the process objective from start to finish. This is similar to what is done in a value stream analysis, but the difference is that this technique focuses on removing all the hold ups along a value stream, and distribute the work to the available resources. When an activity is finished, the next activity in the process should be ready to handle the request, and not pile up in a batch of other requests. (James P. Womack & Jones, 2003)

The second technique is to ignore the traditional and well-established boundaries which follows certain roles or functions (James P. Womack & Jones, 2003). The goal is to establish a Lean enterprise which is built around the purpose of the process, and has removed all impediments to the continuous flow.

The third technique is to rethink specific work practices and tools to eliminate rework and stoppages of all sorts. (James P. Womack & Jones, 2003)

These techniques are meant to reassure that all processes should proceed continuously without stopping the flow.

2.1.3.4 Principle 4: Pull

Having flow in a process does not help if it leads to overproduction or over processing. In a process, the next step should be ready for the work which arrives, and thereby *pull* work from the previous step. This is opposite of *pushing*, which means that an activity has finished the previous step before the next step is ready to handle that work (James P. Womack & Jones, 2003).

> *"In a pull system, you are trying to respond to the demands of your customers as quickly as possible without creating any excess inventory."*
> *(Byrne & Womack, 2012)*

Basically, this means that a deliverable should not be produced until the customer places the order. This may sound simple, but in practice it is very complicated to follow this principle. This logic contravenes with the concept of most retail stores which have to make customer demand projections depending on historic data and the current marked.

A push strategy results in inventory buffers between each step, and is meant to keep resources in use at all time. The problem with pushing inventory, is that it leads to overproduction, which is considered was waste in Lean. (James P. Womack & Jones, 2003)

Pull can also be viewed as the opposite of batch production or batch handling of tasks. It is customary in many organizations to create large batches of a delivery in one go since processes are designed to handle these types of batches. However, this type of processing hampers the possibility of achieving flow. Flow is achieved at its best when work is pulled by the next step. (James P. Womack & Jones, 2003)

In terms of retail, the pull principle has a major advantage when it comes to diversity of goods. Customers may have many different needs, one more specific than the other. However, the customer does not want to wait for the good to come in stock, which means that the store should always carry a high variety of items. Otherwise the customer will seek to a competitor. Toyota realized that if a store keeps a low stock of different types of items, and order replacement for the item(s) which has been sold that day, the inventory will be reduced and the variety of items may increase. For this type of system to function properly, the pull principle must be implemented by all parts of the value chain. (James P. Womack & Jones, 2003)

2.1.3.5 Principle 5: Perfection

The perfection principle is the last of the five principles introduced by Womack and Jones. It is based on continuous improvement in the process, and finding more ways to remove waste in terms of effort, time, space, and errors. Perfection also leads to higher flexibility within a specific activity and thereby increases the responsiveness to customer's demands. (James P. Womack & Jones, 2003)

A problem is that a company can experience a state of satisfaction if an activity has been improved to a certain level. This might arise when an organization has the feeling of being the "most Lean" within an industry, and is comparing itself to its competitors. However, the purpose is continuously improve, and not settle when a single goal has been reached. (James P. Womack & Jones, 2003)

Inefficiencies in a process can be exposed by *lowering the river to reveal the rocks*. Like lowering the water in a river exposes rocks, lowering the buffers exposes problems in a value stream. Exposed problems can be dealt with and often demands immediate solutions (Ballard, 2008). The process is illustrated in Figure 1.

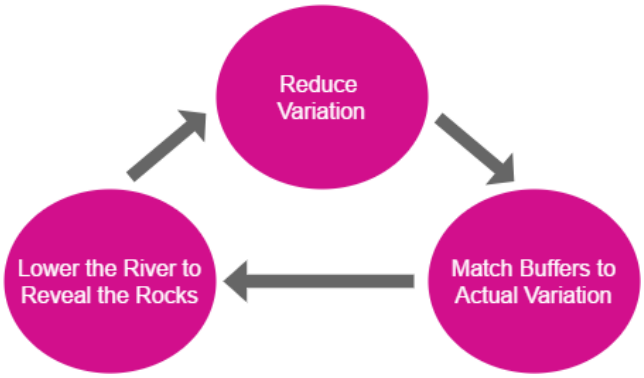

Figure 1: Exposing problems by lowering the river. Adapted from (Ballard, 2008)

Improvements of processes are achieved through deviations from the standard solution (Ballard, 2008). Deviations may be intended, in the form of experiments, or unintended such as breakdowns. Deviations reveal variations and root problems in the process. In any process, there are always buffers which are meant to absorb variation. Buffers can be inventory, contingencies, capacity, time and money (Ballard, 2008). For instance, getting the value stream to flow faster always exposes hidden waste, and more impediments to flow are revealed the harder you pull. (Liker, 2004)

If variation can be identified, it can sometimes be reduced. The next step in the process is to match the buffers to the actual variation. Doing this starts with selecting the right type of buffer to reduce. The next step is to identify where in the process the specific buffer was required, and reduce the buffer accordingly. When the buffers match the variation, a system is stabilized. (Ballard, 2008; Liker, 2004)

The idea is then to experiment by deliberately destabilize the system again, by reducing buffers to below the required level.

What is sometimes difficult to get a grasp on is that there is always room for improvement. To find the improvement, the four previous steps should be applied. The principles can be used in a continuous circle, as shown in Figure 2.

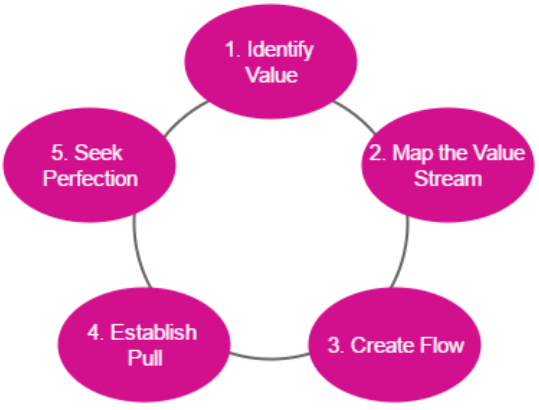

Figure 2: The five Lean principles. Adapted from Lean Enterprice Institute (Insititute, 2017).

2.1.4 Review of Lean Tools

To identify and operationalize improvements in an organization, different tools have been developed. The tools are mostly based on tools used in the Toyota Production System, and have either been kept as is, or been alternated to increase the field of application. Many of the tools are very much connected and used in a combination, as they often complement each other. Some tools are used without even knowing it, as many of the tools are based on common logic and comes natural in a Lean implementation.

2.1.4.1 TIMWOODY / The Eight Wastes

Waste is an essential term in Lean, and is in many ways the root of many tools. Waste is any activity which requires resources, but does not create value. Toyota has described seven different types of waste and Womack and Jones (2003) added an additional type, to a total of eight. These eight types of waste have become infamous and is well associated with Lean. They can be applied not only in a manufacturing setting, but also to product development, order taking, in projects, in construction, and in an office, to mention some examples.

The eight wastes are also known under the acronym TIMWOODY, which spells out Transfer, Inventory, Motion, Waiting, Over processing, Over production, Defects, and Staff. For a Lean organization, waste can be viewed as an opportunity to do things better, faster and/or cheaper. The types of wastes are summarized in Table 1.

According to Modig and Åhlström (2015), there are three main sources to waste; long lead time, many units in the process, and many resumptions. An organization's purpose is to fulfil a specified need, which is referred to as the *primary need* for a customer. The problem with the three main sources of waste is that they cause *secondary needs*. A secondary need is the result of an unfulfilled primary need, and one secondary need often generates a chain reaction of secondary needs. Since secondary needs also takes up the time of an organization, it produces redundant work, which can be categorized as waste.

Waste	Example
Transportation	Moving unfinished work, materials, parts or finished products over long distances, or in and out of storage.
Inventory	Excess raw material or finished goods. High inventory causes longer lead times, degradation of material, damaged goods, transportation and storage costs. Extra inventory hides problems such as production imbalances, late deliveries from suppliers, defects, equipment downtime, and long setup times.
Motion	Any wasted movement employees must perform during their work, such as looking for, reaching for, and walking to external meetings. Walking is in general waste from a Lean perspective.
Waiting	Waiting due to repair, delay, capacity bottlenecks, or in general no orders (no pending requests).
Over processing or incorrect processing	Inefficient processing due to poor work process, causing unnecessary motion and producing defects. Waste is also generated when providing higher-quality products than necessary.
Overproduction	Producing items for which there are no orders. Overproduction is wasteful due to overstaffing, waste or resources, storage and transportation costs because of excess inventory.
Defects	Defects lead to rework, scrap, replacement production, and inspection, which involve wasteful time and effort.
Your talent	Waste occurs when the capacity of the staff is underutilized. The results might be losing time, ideas, skills, improvements, and learning opportunities by not engaging or listening to your employees.

Table 1: The eight types of waste, or TIMWOODY (Liker, 2004; James P. Womack & Jones, 2003)

2.1.4.2 Value Stream Mapping

Value stream mapping (VSM) is a tool used by teams to analyze processes with the purpose of identifying the value stream and discover hidden waste. The tool finds the current state of the process, which can be compared to the future state after the process has undergone improvements (Thomsen, 2010). According to Fewings (2013), VSM should consider several aspects of the process and its surroundings including purchasing, design, production, accounting, recruitment and market.

Figure 3: Value Steam Mapping - a six step guide. Adapted from (Thomsen, 2010)

When applying VSM, a project team often finds steps which can be eliminated, reorganized to improve schedule, reduce time, and improve quality of the deliverable.

2.1.4.3 A3 Reports

Liker (2004) states that A3 reports is a way of "capturing all you need to know on one sheet of paper". A3 is a way to communicate and document achieved improvements, and is written on one side of a A3 sized sheet of paper. The A3 size is used since it is the largest sized paper that fits in a fax machine.

The reports vary in layout and what information is included, but the basic idea is to provide a structured layout with a summary of a specific improvement. Common practice is to make the description as visual as possible to highlight important elements. The tool itself is less important that the idea behind it, which is the process from identifying potential for improvement until the improvements have been implemented and standardized. (Ringen & Lodgaard, 2014) For instance, A3 reports are used for problem-solving. Such a report would succinctly state the problem, document the current situation, determine the root cause, suggest alternative solutions, suggest the recommended solution, and have a cost-benefit analysis (Liker, 2004). An example can be seen in Figure 4.

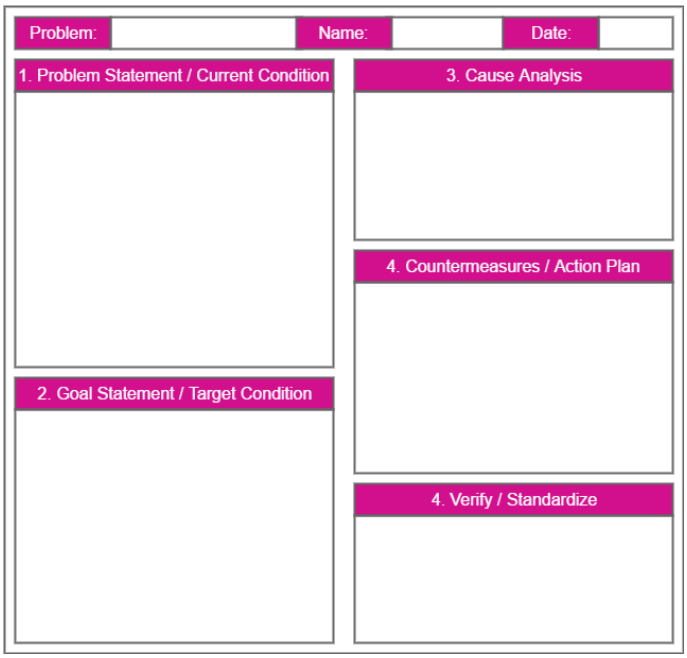

Figure 4: Typical A3 Report Layout

2.1.4.4 The 5 Why's

This method is a qualitative approach to find the root cause of a problem. The principle is simple as the technique is to ask *why* five times whenever a problem is encountered. The exact number *five* is more of a suggestion than a statement, as the root cause might be found after fewer or more than five why's. Besides, a given problem might have more than one cause. Typically, asking *why* leads upstream, which relates to the previous steps in the process (Liker, 2004). Once the problem(s) have been identified, effective countermeasures could be developed and implemented (James P. Womack & Jones, 2003). The countermeasures changes depending on how deep the team digs, in other words how many *why's* is asked. The key is therefore to find the countermeasure which solves the problem at all levels.

2.1.4.5 Fishbone

A fishbone diagram can be used analyze the cause(s) to a problem. The method is originally developed by Ishikawa in 1943, and is also known as a Cause-And-Effect-Diagram (Doggett, 2005). The tool enables a team to focus on the content of the problem, not the history or personal interests of team members.

A typical approach is to define several major cause category branches, and find causes related to the superior categories (Doggett, 2005). Figure 5 illustrates one example of a fishbone diagram with six common major cause branches. The branches are comprised of smaller horizontal twigs, indicating more detailed factors. The horizontal twigs can also have even smaller twigs with even more detailed causes. The fishbone diagram is often used in combination with the 5 Why's.

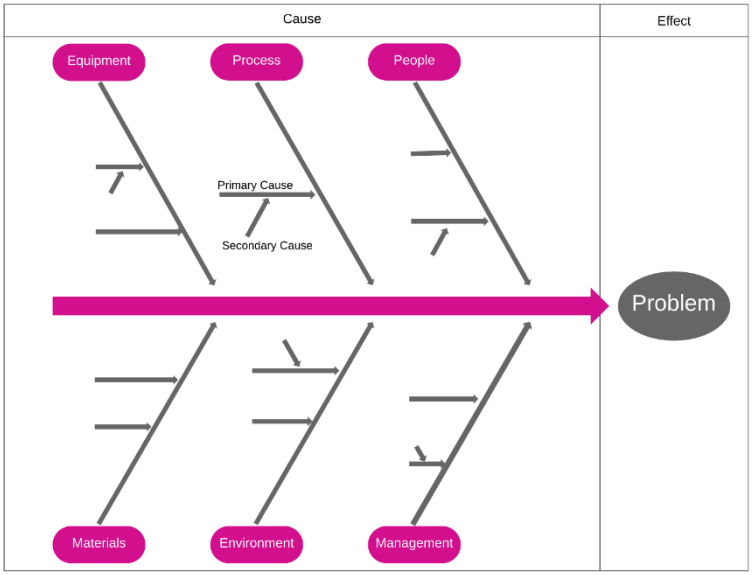

Figure 5: Fishbone diagram. Adapted from (TXMLeanSolutions, 2017)

2.1.4.6 Set Based Design

To understand set based design, it should be compared to point based design. The difference between the two is illustrated in Figure 6. Point based design develop a single design option where specified requirements are implemented at an early stage. Due to the detailed design, the initial design often requires adjustments at a later stage which can be costly.

Set based design differs from point based design by maintaining multiple alternatives for a longer time. In set based design, several initial design options, or sets, are developed, and design plans are terminated at critical points if they no longer are the best fit to reach the project goal. The concept reduces time spent on reworking as well as providing flexibility of approach, rather than locking down a single option early in the process. However, the development and maintaining of multiple designs comes at a cost, but this

cost can be kept at a minimum by simulation, modelling and prototyping. A key practice to achieve efficiency with this method is to specify requirements and interfaces, rather than design. Additionally, frequent elimination of out-of-date designs should be done to avoid wasting time. (Ballard, 2008; ScaledAgile, 2017)

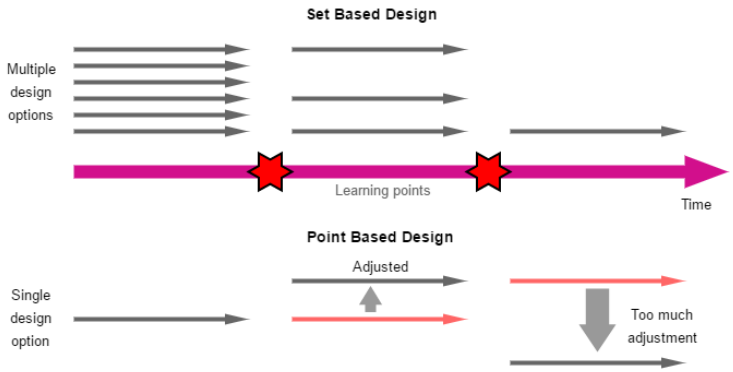

Figure 6: Set-Based Design vs. Point-Based Design. Adapted from (ScaledAgile, 2017)

2.1.4.7 Standardization

According to Ingvaldsen and Ringen (2014a), standardization is a requirement to be able to apply Womack and Jones' (2003) fifth principle, perfection. Ingvaldsen and Ringen (2014a) defines standardization as a way of dividing work per scope, schedule, time interval and quality of the output of a process. The idea behind standardization is to perform work following what is decided to be best practice. Standardization is applicable in any organization, regardless of industry, although it is easier in some industries than other.

Liker (2004) states that many organizations have misunderstood standardization, and that they think it is "to scientifically find one best way and freeze it", which does not allow for continuous improvement. However, standardization is important to stabilize a process which can then be improved. Therefore, standardization is the basis for continuous improvement and quality in a process (James P. Womack & Jones, 2003).

2.1.4.8 Hoshin Kanri

In the implementation of Lean, or in general in a company, it is crucial to prioritize the right objectives. Hoshin Kanri, or policy-deployment, is a strategic decision-making tool that allows a company to focus its resources in the right places. The tool is comprised of matrix diagrams, where some objectives are selected while others are given lower priority. The tool is typically used by management to agree on a few goals at a time, thereby allocating the people and resources for getting the projects done and establish numerical improvement targets to be achieved at a specific time. (James P. Womack & Jones, 2003)

2.1.4.9 The 5 S's

The 5 S's is comprised of five different Japanese terms which combined is utilized to create better suited a workplace for keeping visual control. Visual control means that the components of the systems should be in plain sight, so that the status of the system can be understood by the involved personnel. Visual control creates a transparency in the system which again makes it easier to identify any problems arising.

The 5 S's (James P. Womack & Jones, 2003):

1. The first S stands for Seiri, and means to separate or sort needed tools, parts, and instructions from unneeded materials and to remove unnecessary parts.
2. Seiton means to organize and identify parts, equipment and tools systematically so they easily can be put in use. All equipment should be at the location where it is most needed, and every piece of equipment should have a reserved spot.
3. Seiso means to keep the workplace clean. Equipment should always be put back in to its original location in a condition where it is ready to be used.
4. Seiketsu means to standardize work, by using the three latter terms to maintain a workplace in perfect condition. Every process and routine should be standardized to make sure that all employees know their responsibilities, and how various tasks are performed.
5. The last S is Shitsuke means to sustain and improve already implemented routines, and create the habit of always following the first four S's.

Together, the 5 S's creates a continuous process for improving the work environment and eliminating waste which might have accumulated over many years. The 5 S's is illustrated in Figure 7. (Liker, 2004)

Figure 7: The 5 S's. Adapted from (Liker, 2004)

2.1.4.10 Visual Management

Visual management makes processes, systems, progress etc. visible and easily understandable once it is observed. The purpose is to improve flow by create a common ground for all stakeholders.

The easiest form of visual management is by physically inspecting the value chain, known as visible management. Observation of work should be a clearly defined task for the management, and helps to achieve continuous dialog between manager and employees with the purpose of building trust and gaining a common understanding of the work to be done. This requires a certain technical background from the observer, and knowledge about the tasks to be observed. A problem with visual management is that employees might feel that they are under surveillance. Therefore, it is important that the observation is not perceived as a negative, but rather encourage innovation and improvements. (Ingvaldsen & Ringen, 2014b)

A common approach in visual management to create an image of the current improvement situations is by using a whiteboard. The whiteboard may contain lists of work in progress, workers on site and who is doing what. They can also communicate improvement work, progress, trends, goals, milestones, performance indices, quality and HSE. A whiteboard meeting is an arena where improvements are encouraged. A typical feature is to use post-it notes with improvement suggestions. Questions and issues from the participators may be dealt with at these meetings. The issues should be sorted, and dealt with accordingly. Some issues can be handled quickly; others require more thorough analysis before they can be dealt with, often using other Lean tools such as A3 Reports. (Ingvaldsen & Ringen, 2014b)

Whiteboards can be either electronical or manual, where both have their advantages and limitations. Electronical whiteboards have the major advantage of being automatically updated and easily documented for later use. Electronical whiteboards can also be used when people are at different geographical locations. However, a disadvantage is that the felt impact of a number on a screen may vary from employee to employee. Therefore, many experienced managers prefer manual whiteboard, as it is easier to personally relate to the information presented and how it affects a specific group of employees. (Ingvaldsen & Ringen, 2014b)

2.1.5 Lean Implementation

Implementation is the process where plans becomes actions. Regardless of the good intentions and a strong wish to succeed in a Lean implementation, many end up failing due to resistance from employees or lack of focus, among other reasons (Breit & Rolfsen, 2014a). Although the theory of Lean is fairly simple, the implementation process is usually difficult. In fact, the success rate is as low as 5-7% (Byrne & Womack, 2012).

Implementing Lean takes time to do right (Byrne & Womack, 2012). Knowing how to proceed to achieve a successful Lean implementation that lasts, and what the pitfalls might be, is essential for the company. A problem which is valid for all companies is that an idea might look good on paper and in meeting rooms, but the actual outcome of the idea might differ. Even though an idea works great in one company, does not mean that it will work in another (Breit & Rolfsen, 2014a).

In the sections below, some of the considerations when implementing Lean are explained.

2.1.5.1 Presenting Lean

Lean has been defined in many ways in books and papers, and many people have different opinions on what Lean is. Among these are the wide forms such as a philosophy, or the more specific forms such as tools. In between, there are have those who define Lean as an improvement strategy, control system or a production system. How Lean is presented in a company is very important to get the employees on board with the idea. (Modig, 2015) For a company to improve, it needs to have a common understanding of the situation which should be improved, otherwise there is nothing to improve.

The problem arises when people present Lean only as tools. The issue with presenting Lean in this way is that tools are often designed or intended to serve a specific purpose in a certain context. Therefore, employees have difficulties seeing the relevance to their own company. Toyota developed the Toyota Production System to produce many specific cars, and their methods are customized for that purpose, and that purpose only. This means that the applications of these tools are most likely limited, and the use of these tools in an organization might lead to misunderstanding of the Lean concept. The focus should not be on the means that Toyota uses, rather the understanding of why they use these means. (Modig, 2015)

It is important to note that Lean comes with a very useful toolbox. Nowadays, tools are gaining a wider perspective, which makes them applicable to more tasks. However, a

tool should only be used if the team has an underlying understanding of its purpose. Using the tools without knowing why, or how, does more bad than good in an organization. If the focus on the means is piercing in the employees, the implementation of Lean will become troublesome. The focus should rather be on goal of the implementation. Shifting this focus can be as easy as asking *why* instead of *how*. Asking why first, and then how, is a good way to understand Lean tools. (Modig, 2015) When the focus is shifted towards the goal, it is easier to alter the toolbox into one that is more suited for the right objectives and processes.

2.1.5.2 Variation

Variation is in many ways an opposing force to Lean. There will always be variations and uncertainties in a process, with an infinite number of causes. The more variation in a process, the longer lead time. The causes of variation have root in three different categories; resources, units in the process, and external factors. (Modig, 2015)

Company resources are internal factors and may be connected to equipment, employees and company facilities. Machines often have the purpose of decreasing variation and increasing efficiency. However, the machines may fail, causing delays and problems in the process, or in other words; variation. Employees is undoubtedly, and not surprisingly the greatest cause of variation. All humans solve problems and tasks differently and at a different pace, and they make mistakes. Resources also includes company facilities, and variation can be caused by complex and confusing facilities. (Modig, 2015)

The units within a process often have different needs, wishes, problems, and include many uncertainties. For instance, an entrepreneur never receives two identical projects or a customer in a retail store often have different requests. (Modig, 2015)

External factors are often the hardest to predict. One of the best examples is the weather, which causes trouble for many different industries.

Variation is taken into consideration in most workplaces, with a common understanding that new problems might occur. This also implies that the problem need to be handled using company practice as far as possible. However, as work process and methods are often designed to be situational, this makes a Lean implementation more difficult. As standardization has a major role in Lean, a company might experience that their methods are too situational to make Lean work in the company.

2.1.5.3 Management

Implementing Lean takes time, and without strong, committed leadership over time, failure is more likely. In fact, a Lean journey will never end, as it is not like other changes introduced to a company. Introducing Lean is wasteful if the focus is not maintained, and this is where good leadership work is required. A Lean manager sets an example for the rest of his or her team by being Lean and constantly insisting on the fundamental principles of Lean. (Byrne & Womack, 2012)

During a Lean implementation, it is important that leaders communicate the full content of what is expected from the employees. It is also important that the employees understand that the change is critical for the future of the company, and see why a Lean implementation is necessary. If the management is able to communicate this in a good way, it can be a good measure to get the employees to agree to the suggestions instead of opposing them. (Jacobsen, 2012)

Being a Lean manager sometimes takes courage, as risks must be taken to achieve the wanted results. Standing up the familiar and well-established, which has been common practice for a long time, and demanding change is also challenging. A Lean manager might have to challenge company- or industry rules. In a Lean implementation process, there will inevitably be setbacks and unforeseen challenges in addition to resistance from different parts of the company. Nevertheless, it is important that the leader keeps the team going forward. (Byrne & Womack, 2012)

Byrne (2012) summarized a Lean manager's standard work:

- Set the direction and build organization capabilities to solve problems at the root cause.
- Support the important processes through daily inspections and frequent reviews of the key performance indicators.
- Identify breakthrough opportunities and set stretch goals to achieve them.
- Show respect and support for all associates.

2.1.5.4 Resistance to Change

A Lean implementation is a major change to a company, affecting many employees. The employees will have various reactions to changes, some will be positive while others will be negative. In any changeover process, it is beneficial if there is a willingness to change among the employees. Resistance towards a change will often have ground in employees defending something familiar that they believe is right and good. Jacobsen

(2007) presents several reasons why resistance might occur including; fear of the unknown, loss of professional identity, new demands from employees, extra work, relations with coworkers, personal or economical loss, etc.

Yukl (2013) explains that employee's attitudes towards changeover is a critical factor for success and the development of an organization. Negative attitudes tend to spread between colleagues. Parts of an organization can develop a dynamic called *group thinking* (Jacobsen & Thorsvik, 2007). Group thinking is a result of a colleagues working together over time, and might lead to a *"we-versus-them"*-attitude. Such a culture tends to shield the group from any opposition, which can cause resistance to changes and organizational development. In large organizations, there will always exist some degree of group thinking.

It is important to note that some resistance and conflicts may lead to beneficial outcomes. Resistance to changes contributes to critical thinking and reflection towards the changes, which may improve the changing process (Jacobsen, 2012). After all, Lean is about making improvements, and critical thinking can result in improvements. However, it is important that criticism is communicated in a constructive way to be taken seriously.

2.2 Lean in Projects

Lean is assumed to have the highest influence within production and manufacturing, which often include repetitive activities. This is due to the link between Lean and Toyota, which have been described in section 2.1.1. However, the focus on widening the Lean term to include other knowledge areas has caught the interest of many company managers.

This section takes forth how Lean principles can be used in other context than production, more specifically in projects. Firstly, the topic of project and project management will be presented as is it defined in *A Guide to the Project Management Body of Knowledge* (PMBOK Guide). Statoil has its own project development model which will also be described.

The investigation of Lean in projects is done through comparison of traditional- and Lean project delivery goals. Three examples are included to see how systems can be created using Lean principles.

2.2.1 Projects and Project Management

According to Project Management Institute (PMI), project management is defined as "the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements. Typical goals of a project include completing within time and budget, and meeting the requirements set by the customer" (Institute, 2013).

A project can be defined as "a temporary endeavor undertaken to create a unique product, service or result" (Institute, 2013). The main difference between a project and a manufacturing process is that a project designs a product from scratch and has a clear launching point and finish, while a manufacturing process continuously produces an already designed product.

A project has a natural life cycle, which is divided into phases. Each phase represents the main activity being conducted in that period. The phases are often comprised of smaller, more precise activities or objectives. The life cycle includes; starting the project, organizing and preparing for the execution, carrying out the work, and closing the project. Figure 8 shows a typical project life cycle where the phases are separated by vertical lines. Note that the vertical axis represents cost- and staffing resources required in the project. Executing the project requires the highest amount of resources.

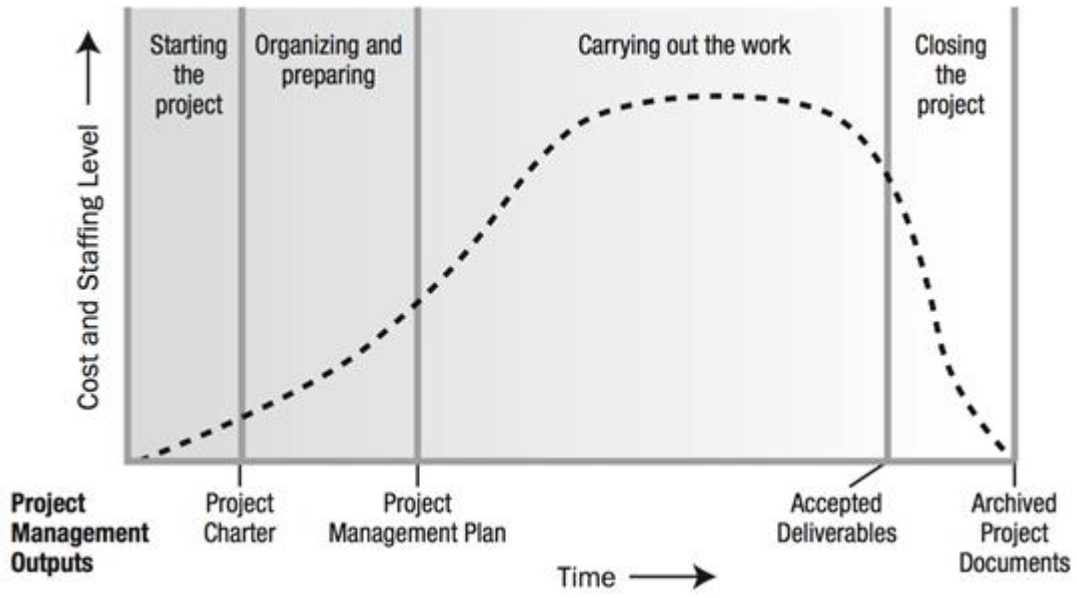

Figure 8: Project Life Cycle. Adapted from Project Management Institute (Institute, 2013).

Managing a project is unique from one project to another. However, some typical tasks include identifying requirements, addressing needs, concerns and expectations of all stakeholders, managing communication among stakeholders, and balancing constraints – steering the project towards a set goal (Institute, 2013).

Constraints are related because a change in one will most likely affect the others. A delay in time will often increase the cost when trying to get back on schedule, or a change in scope is required if the budget cannot be adjusted. Different project stakeholders have various opinions on the matter, making the job of the project delivery team challenging. (Institute, 2013)

Project management can be divided into five process groups. A process is defined as "a set of interrelated actions and activities performed to create a pre-specified product, service, or result". (Institute, 2013) The processes have the purpose of ensuring effective flow and progress of the project. The project management process groups include:

- Initiating: Define projects or new phases of an existing project.
- Planning: Establish scope, objectives, and course of action required to obtain the objectives.
- Executing: Complete the work agreed upon in the project management plan.
- Monitoring and controlling: Track, review and regulate progress and performance. Identify deviations from plan, and initiate corresponding measures.
- Closing: Finalization of all activities and formally close the project.

The project management processes should not be confused with the project phases, as the processes are relevant, and may occur during the whole project life cycle.

A project develops progressively throughout the project life which involves continuously improving and detailing plans as more information becomes available. Progressive elaboration allows the project delivery team to define work and manage the project to a greater level of detail as the project evolves. (Institute, 2013)

2.2.2 The Capital Value Process

A common practice in the oil and gas industry is The Capital Value Process, which is the structured approach to project development used in Statoil. The process starts with the first assessment of a business opportunity, and ends with the start-up of profitable operations (Statoil, 2017b).

The process uses phase gates which marks the completion of one phase and the launch of the next phase (Wysocki, 2013). A so-called *decision gate* defines the criteria which must be fulfilled to move on to the next phase. The choice on whether to proceed with the project is done at each decision gate, and this process often includes numerous meetings, documentation and quality control. The decision gates ensure that all expectations are understood for the result and that the risks involved are considered (Statoil, 2017b).

The full series of stages, separated by decision gates, is illustrated in Figure 9.

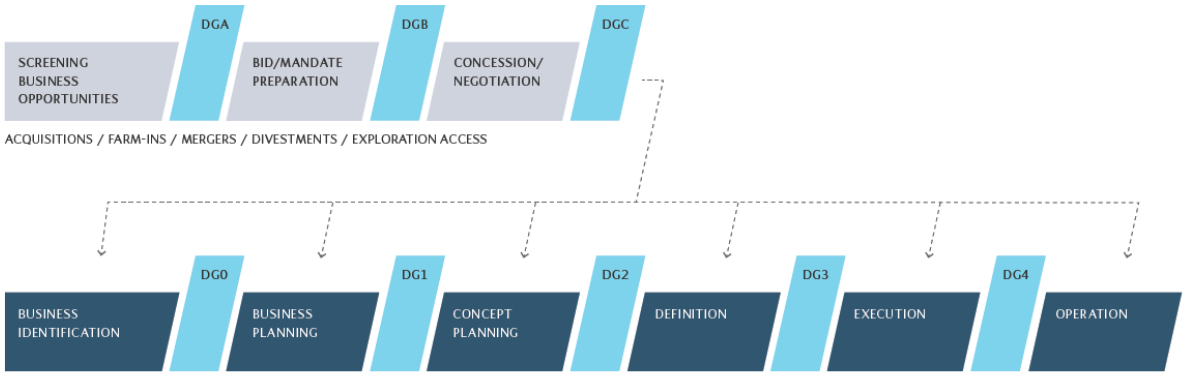

Figure 9: The Capital Value Process used for project development in Statoil. (Statoil, 2017b)

2.2.3 Earned Value Management (EVM)

The Earned Value Management method is one of the most widely used planning and reporting tools for projects, regardless of industry. The method combines scope, schedule and resource measurement to assess performance and progress in project. (Institute, 2013)

EVM helps the project delivery team to assess and measure progress and performance at a specific point in time (Institute, 2013). Creating a performance measurement baseline is essential to be able to measure the performance for the entire duration of the project.

EVM develops and monitors three key parameters; planned value, earned value and actual cost. The *planned value* defines the physical work which should have been accomplished at a specific time. The *earned value* is measurement of the work completed compared to the authorized budget for that work. By monitoring earned value, the status and long-term performance trends can be determined. The *actual cost* is the realized cost for the work performed on an activity during a specific period. (Institute, 2013)

The abovementioned parameters are used to find the variances from the approved baseline; schedule variance and cost variance. *Schedule variance* is defined as the difference between earned value and planned value, and is useful as it easily shows if the project is behind or ahead of its baseline schedule. *Cost variance* is defined as the difference between earned value and actual cost, and indicates if the project is within budget or exceeds budget. (Institute, 2013)

Both variance measurements can be represented as performance indexes which again can be compared to other projects, and helps determining the project status.

The *schedule performance index* is the ratio of earned value to planned value. If the index is lower than 1, less work than planned has been completed, which means that an index higher than 1 indicates more work completed than was planned. In combination with cost performance index and the reasons for behind or ahead of schedule, the schedule performance index can be used to estimate the completion of the project. (Institute, 2013)

The *cost performance index* is the ratio of earned value to actual cost. An index lower than 1 means a cost overrun of the work performed, and higher than 1 indicates cost underrun. The cost performance index is used to determine project status, and helps estimating project cost and schedule outcome. (Institute, 2013)

2.2.4 Lean Projects

A project can be viewed as a temporary production systems, where *production* is defined as making and designing of things. Every product starts with a project to design and create an initial version, and the production may be multiplied afterwards. When the product has been designed, copies can be made in a traditional production system. Following the above definition of production, a project is the fundamental form of a production system. (Ballard & Howell, 2003)

A project can be called Lean when the process is structured to maximize value and minimize waste. Lean project management and traditional project management often pursue different goals, the structure of the phases might vary, and the relationship between the phases and participants in each phase can also be different (Ballard & Howell, 2003).

2.2.5 Lean Projects versus Traditional Projects

As lean goals often differ from project goals, there are some differences in the desired deliverables of the project team. Table 2 presents some of the desired goals for the project team when using a Lean approach and a traditional approach. Note that the table below is not valid for all projects. Nevertheless, the table presents an overview of typical differences between Lean project delivery and non-Lean project delivery.

Lean project delivery	Traditional project delivery
Focus on the production system	Focus on transactions and contracts
Transformation, flow and value goals	Transformation goals
Downstream players are involved in upstream decisions	Decisions are made sequentially by specialists and "forced" into the project
Product and process are designed together	Product design is completed before the process design begins
All product life cycle stages are considered in the design phase	Not all product life cycle stages are considered in the design phase
Activities are performed at the last responsible moment	Activities are performed as soon as possible
Systematic efforts are made to reduce supply-chain lead times	Separate organizations link through the market and take what the market offers
Learning is incorporated into projects, form and supply-chain management	Learning occurs sporadically
Stakeholder interests are aligned	Stakeholder interests are not aligned
Buffers are sized to absorb system variability	Buffers are sized for local optimization

Table 2: Comparison of Lean and traditional project delivery goals (Ballard & Howell, 2003).

From the table compiled by Ballard and Howell (2003), it can be seen that the focus in Lean projects is towards the process in addition to the deliverable of the project. The importance of *how* the project is performed and *what* is to be created are aligned. For the traditional project, the focus is mostly towards how the project team can best use the resources to achieve the *what*. In other words, the focus in traditional projects is towards transformation of the available input into the final product that is the output of the project.

The process is important as it ensures quality in the project, and a process can often be reused. Additionally, a process can be improved further to increase the performance of the project delivery team. Furthermore, there can be recognized several other examples of Lean principles;

- By involving downstream players, the customer's opinion on value is considered.
- Systematic efforts to reduce lead times means that waste is eliminated.
- Sizing buffers is a method of achieving perfection.
- Learning is a way of continuous improvement.

It can be stated that that the project focus is different when Lean principles are used. By incorporating Lean, the traditional project development processes and project management methods have been challenged, resulting in various Lean systems.

The following three sections describe how Lean principles have been incorporated into project and planning systems. The presentations are included as examples of how Lean can help improve existing practice to create better and more efficient processes.

2.2.5.1 The Lean Project Delivery System (LPDS)

Glenn Ballard developed the Lean Project Delivery System in 2000 from theoretical and practical investigations, and the system is continuously being revised through experimenting. Ballard's latest update on the system from 2008, focuses on the first two phases of the LPDS; project definition and lean design. Therefore, the project definition- and lean design phase will be described in detailed below, while lean supply and lean assembly will be briefly explained.

The system is originally developed for the construction sector, but can also be relevant to the oil and gas sector. LPDS uses various Lean principles, and especially *target costing* and *set based design* can be traced back to the Toyota Production System. Through systematic feedback loops between supplier and customer, continuous learning can be achieved in the system.

The infamous system is illustrated in Figure 10.

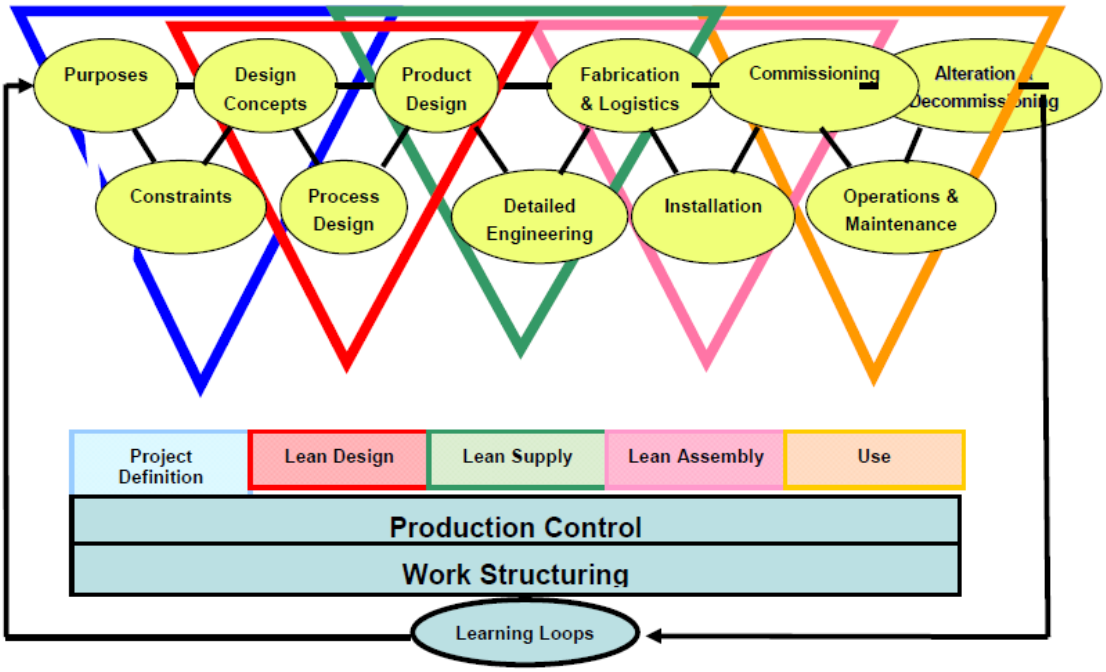

Figure 10: The Lean Project Delivery System. (Ballard, 2008)

2.2.5.1.1 Project Definition

The project definition phase is the process of aligning ends, means and constraints to optimize the product design. Ballard (2008) states that this alignment is best achieved through conversation with the end customer. The purpose (what the customer want to accomplish) and the constraints (location, cost and time) on the means for achieving the goal should be addressed properly. Putting all the facts out in the open will create transparency in the project, and further allowing for a more efficient progress. Clients should specify what they are able and willing to spend to get what they want. However, many clients do not normally reveal their financial state to the project team. (Ballard, 2008)

Ballard (2008) states that in the LPDS, the project delivery team does not just provide what the customer asks for, but assists the customer in deciding exactly what they want. The purpose is to maximize the value of the project, and create the best possible solutions for the end user. Inevitably, this will in some way change the project variables, but will benefit both the customer and the project team, creating additional value, and in some cases cut costs.

There are certain things to consider to maximize the value of the project. During the project definition, the planning should be done in the correct order so that no more, or

no less than what the user wants is being designed. Firstly, it is important to knowing how the product will be used is done before designing the product itself. Secondly, design criteria should be developed from values, from the users point of view, and values should be developed from purposes. Ballard (2008) emphasizes that involving the right people when making project decisions is vital. For instance, when the business plan is developed, it is important to engage key members of the project team to help validate and improve.

2.2.5.1.2 Lean Design

In the design phase, the goal is to design a product within the constraints given in the business plan. Ballard (2008) claims that using *set based design*, will greatly improve the efficiency of the project. The term is described in section 2.1.4.6. To effectively use set based design, all key players should be members of the design team, so that all aspects are covered. This design process involves a new mindset as well as cooperation from the team to overcome traditional working habits. In this phase, the project will benefit from colocation, which means gathering all the team members in the same room to discuss the design. The key is collaboration to solve challenges in the project, where all aspects should be considered.

Ballard (2008) describes the term *target costing* as a method for shaping product and process design for delivery of customer value within constraints. Target cost is the cost which the project team commits to deliver. Womack and Jones (2003) described this as the key to maximize value and squeeze out waste. If the set productivity target is lower than what is known as best practice, this requires reduction in the time workers spend on waiting, searching and reworking, and will thereby enhance innovation by challenging work methods, technologies, design etc. A financial buffer can be reduced in the budget to encourage innovation in system design and project management practices so that previously required contingencies are no longer needed.

2.2.5.1.3 Lean Supply

To achieve flow in the LPDS it is important that the system knows what must be made, and when is must be delivered. Therefore, the project requires a detailed product- and process design. The supply phase includes initiatives for reducing lead time for information and materials. Especially the lead times, which typically determine the pace and timing of project delivery, and can be seen as critical paths in the project. (Ballard & Howell, 2003)

2.2.5.1.4 Lean Assembly

The assembly begins with the delivery of materials and relevant information for the installation, and is completed as the customer can be start using the delivery (Ballard & Howell, 2003).

2.2.5.2 The Last Planner System (LPS)

The Last Planner System is a planning, monitoring and control system which uses Lean principles in project work, and is developed by Glenn Ballard and Greg Howell (1998). The motivation for developing the system was the finding that only about half of the weekly assignment for construction crews were completed on time. LPS is based on Koskela's (1992) work, where two important observations create a foundation for the system.

The first observation is that the traditional definition of a project from the Project Management Institute has its focus on conversion of input to output (Institute, 2013). In this conversion model, it is typical that work can be divided into parts and executed independently. What the definition lacks is the importance of flow and value generating activities, which is essential in Lean. (Koskela, 1992)

The second observation is on how projects are controlled. In traditional project management, the system is designed to detect negative project variances from the target, and then take actions to try to steer the project back on schedule. However, a project which runs behind on schedule is difficult to get back on track. (Koskela, 1992)

LPS is comprised of five design criteria (Koskela, 1999):

1. A task should not be started until every requirement for completing the task are available. Such a task is also known as a *sound activity*. The requirements include necessary information or knowledge about the task, components or raw materials, workers, equipment, space, previous work and external conditions such as licenses, rules or even weather.
2. Monitoring and measuring of number of completed assignments is done using Percent Planned Complete (PPC). PPC is the ratio of completed assignment to number of promised or planned activities within a time perspective.
3. Finding causes for non-realization of assignments, and deploying the correct countermeasures to assure that the mistake does not happen again, always focusing on continuous improvement.
4. Maintain a buffer of executable tasks to avoid wasted time or resources.

5. Prerequisites for upcoming assignments must actively be made ready. This is essentially a pull mechanism preventing too great material buffers from emerging on site.

The LPS has three levels of planning which depends on the known level of detail of the assignments in the project. The first level is the *initial planning* level, which is where the full project budget and schedule is developed. The initial budget and schedule pushes completions and deliveries into the project, keeping the course of the project. (Ballard & Howell, 1998)

The next level is the *look-ahead planning* where the time frame depends on project characteristics such as lead times for acquiring materials, information, workers or equipment. The purpose of this plan is to pull resources into the project for preparing sound activities. The look-ahead planning also assist in further adjustments and details in budget and schedule. (Ballard & Howell, 1998)

The third and final level is known as *commitment planning*, which is based on an evaluation of what can be achieved right now in the project. Typical commitment planning last for one week at a time. The decision takes the actual situation into account and compares to higher levels of planning on what is due to be done. The assignments are prepared by a team comprised of both planners and doers. When sound activities have been developed at the commitment planning level, the doers commit themselves to the plan. It is also important to note that the sequence of the assignments must be defined to avoid rework. The developed assignments must be specific enough so that it can easily be determined if the assignment is completed or not. If the assignment is not completed, an investigation of why is conducted, which encourages organizational learning and similar mistakes can be avoided in the future. (Ballard & Howell, 1998)

In Figure 11, the three levels are illustrated. Method planning involves planning of how work is supposed to be executed and is valid for all planning levels. The detail in method planning increases with lower levels in the hierarchy.

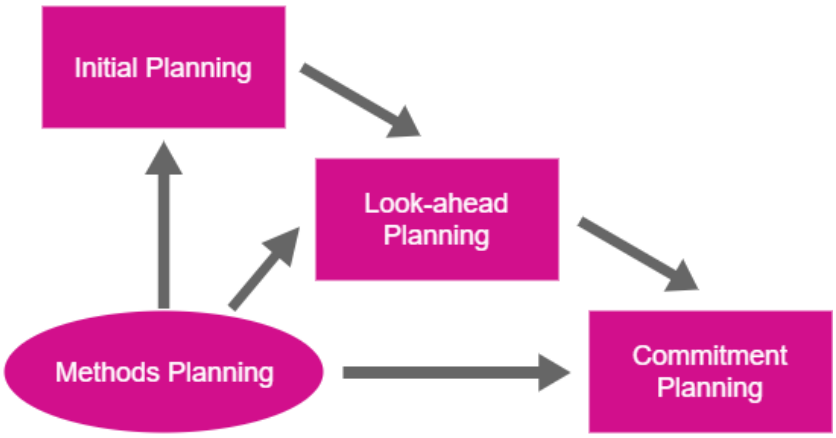

Figure 11: LPS planning levels. Adapted from (Ballard & Howell, 1998)

Emblemsvåg (2014) reviewed LPS and highlighted some differences to traditional project management:

1. Traditional methods from Project Management Insitute favors push techniques when it comes to transferring information and materials. A pull method will create flow in the system.
2. Project control in Earned Value Management (EVM) relies on variance detection after the damage is done, while in LPS project control is obtained via execution.
3. The LPS includes feedback loops to allow for rapid system adjustments in every level. Here, capacity and inventory buffers are present to absorb variation. The EVM does not encourage or include methods for adjustments.
4. LPS has ways of mitigating variation in every aspect, driving continuous improvement, and manages the remaining variation, while in EVM variation mitigation and management is not considered.

For companies using LPS, the percentage of completed assignments has greatly improved. While non-Lean processes have a PPC in the range of 35-65%, the LPS have a typical performance of 75-90%. Prior to LPS, PPCs above 70% was very rare. (Emblemsvåg, 2014)

2.2.5.3 Lean Project Planning (LPP)

Jan Emblemsvåg (2014) found that the LPS does not handle large scale issues as well as Earned Value Management (EVM), and EVM fails to assist supervisors in improving project performance as well as LPS. Besides, both approaches fail to handle advanced engineering design since it does not have a way of measuring progress in engineering.

Emblemsvåg developed a new system which is called Lean Project Planning, and is meant to incorporate the best of EVM and LPS to create a new and improved approach.

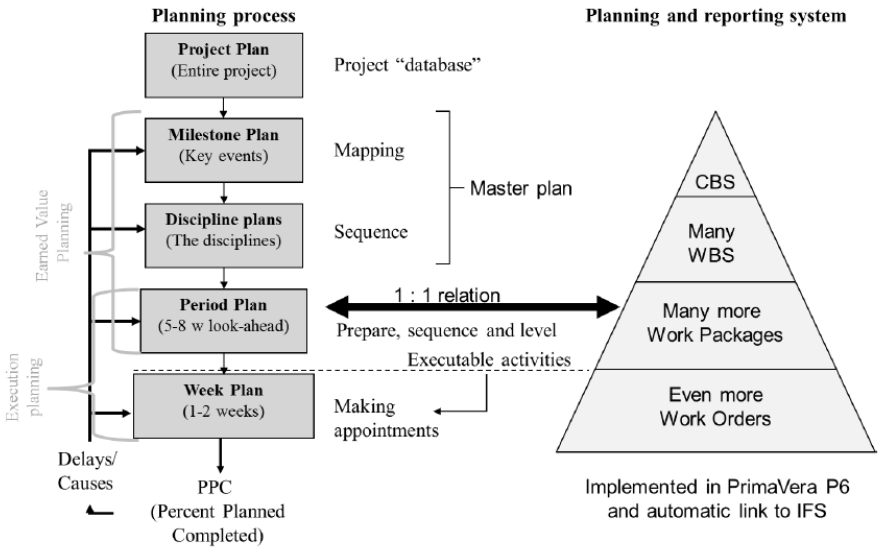

Figure 12: Lean Project Planning overview. (Emblemsvåg, 2014)

The LPP separates the system part and the planning process part. The planning process is much like LPS, with some elements from EVM. In the system part, a project management software is implemented. An overview can be seen in Figure 12.

The planning process starts with the *project plan*, which contains the entire project and creates the database for the software tool. This is only for the project planner team to see, and is not a plan which the doers in the project will have any relations to. (Emblemsvåg, 2014)

The *milestone plan* is the first plan meant as a communication tool between planners and doers. The milestone plan does as the name suggests; map out key events or milestones in the project. The milestones are defined early, and should never be more than 25 in number. (Emblemsvåg, 2014)

The *discipline plans* accounts for sequencing the activities in a logical order to work effectively and prevent rework, and remove non-value adding activities. The milestone plan and discipline plans is the two parts which together creates the master plan. The master plan helps seeing the project execution horizon, to keep a steady course towards the major project goals.

Emblemsvåg (2014) refers to the *period plan* as the intersection between EVM and LPS. This plan is at the look-ahead level in LPS which plans several weeks ahead, and

improves the EVM reliability. Around 8 weeks is the recommended limit by Emblemsvåg for a period plan. When planning between 5 and 8 weeks ahead, it is easier to maneuver out of previously unidentified problems. In a project setting, maneuverability is the ability to make a controlled change in direction before a problem occurs. Some procurements take more longer than the time frame of the period plan, and should therefore be planned outside of the period plan. (Emblemsvåg, 2014)

Emblemsvåg (2014) states that it should be a 1:1 relation between work packages and the period plan, and the work packages should be defined to achieve this relation. A 1:1 relation provides an easier way to track physical progress, and it gives the cost performance indexes in EVM a physical meaning to the supervisors. This also makes the EVM harder to manipulate by creating false numbers in order to show better progress than is the case. (Emblemsvåg, 2014)

The bottom level in the planning process is the *week plan* level, which is what the LPS refers to as commitment plan. The week plan works as a work list for supervisors and their teams, and like commitment plans in the LPS, they include the Percent Planned complete system. Week plans must be coordinated through all disciplines. This plan is more detailed, and the plan is pulled out of the period plan in feasible packages. Each package should be easy to find in the plan, and hence the plan works as a communication and coordination tool for the workforce. (Emblemsvåg, 2014)

Increased detail in planning closer to the moment of execution is one of the principles used in LPP, and substantially reduces the risk of rework. It also increases the maneuverability of the project because effort, and time is not wasted on frequent updating of plans. (Emblemsvåg, 2014)

Since planning unfeasible jobs is a waste of time, resources, and effort, it is important that those who know the job must be included in the planning of the task. Emblemsvåg differs between a plan and planning; a plan is a document made by the planners, but planning requires participation from all key players which are either responsible for project delivery or for doing the work. By involving all relevant personnel, the planning process itself becomes more effective, the doers know exactly what needs to be done, and hence, the execution becomes more effective. Achieving good communication within the project is considered the key for excellent planning. (Emblemsvåg, 2014)

2.3 Lean & the Oil and Gas Industry

From the next chapter and onwards, the thesis will mainly focus on Lean in Statoil. This section is included to get a better understanding of the oil and gas industry. The chapter describe industry relations, short on how oil and gas is formed, and the value chain in the industry. Additionally, the importance of the sector is described, followed by how Lean can affect the oil and gas industry.

2.3.1 Introduction to the Oil and Gas Industry

The oil and gas industry can be split into three main sectors; upstream, midstream and downstream. A high number of companies work within the different sectors, some within more than one. Companies with a connection to the oil and gas industry are often categorized as either operators or service companies. Service companies are often referred to as contractors by the operators. The operators are companies which operate an oil and/or gas field, and are in most cases indirectly or directly involved in upstream, midstream and downstream activities. Examples of operators are Statoil, ConocoPhillips and Aker BP. The service companies assist in various aspects of the sectors, and supply resources to accomplish the goals of the operation. Examples of service companies are Aker Solutions, Aibel, Schlumberger, Baker Hughes and Halliburton. Put in a simplified manner it can be said that the operators get their income from production of hydrocarbons, while the service companies get their income by performing work for the operators.

2.3.2 How Oil and Gas is Formed

There is especially one aspect to the oil and gas industry that is unique. The uniqueness of the industry lies in the uncertainty which comes with dealing with a *reservoir*. The reservoir is where oil and gas is stored, or trapped, underground. The reservoir contains oil and gas molecules which have migrated from what is known as a source rock, which is a rock containing high amounts of organic matter. The source rock gained its content of organic material mainly from dead plants or marine algae and animals. Through millions of years, the source rock has been exposed to conditions with high pressure and high temperature and the organic matter has transformed into what is known as crude oil and natural gas. Crude oil and natural gas are known under the collective term *hydrocarbons*. The hydrocarbons have migrated from a source rock and been trapped beneath a dense cap rock, inside a porous reservoir rocks. Every reservoir is unique as the pressure, temperature, depth, rock formation, content and size varies. (Fantini & Haderer, 2013; Speight, 2011)

2.3.3 The Oil and Gas Value Chain

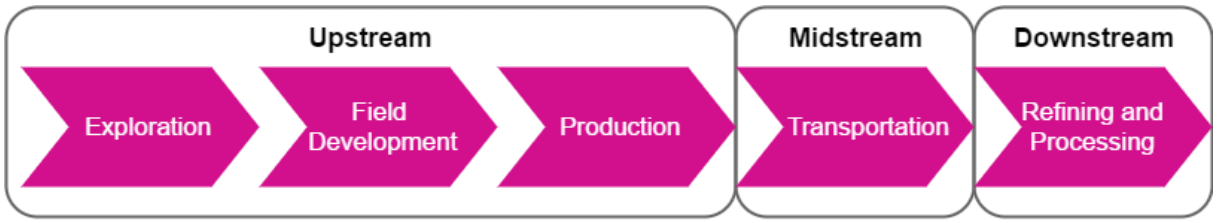

Figure 13: The Oil and Gas Value Chain

2.3.3.1 Exploration

The value chain starts by finding the abovementioned reservoirs, and the process is better known as *exploration*. The first step in exploration is usually seismic logging. For offshore oil, the seismic logging is done by large seismic vessels transmitting sonic waves through the rock layers below sea bed, and when the receivers pick up the signals from the waves, and interpretation of the content of the rocks can be made. However, these seismic logs never give an absolute answer to whether the rocks contain hydrocarbons. Therefore, the next step in the exploration process is to drill exploration wells. To access the hydrocarbon, a hole must be drilled through the above rock layers. If hydrocarbons are not found, this is referred to as a dry well, and further evaluation must be done to develop the next step. If, however, hydrocarbons are found, an appraisal of the size of the field is the next in line. Once the content of the reservoir, and all the relevant parameters have been established, the best way to extract the resources must be developed. (Devold, 2013; Speight, 2011; Tordo, Tracy, & Arfaa, 2011)

2.3.3.2 Field Development

Field development is the next step in the value chain, where the entire life of field must be considered. This involves selecting the optimal concept for a specific reservoir, and typical considerations includes; types of installations, how and where the hydrocarbons are transported to shore, where to place wells to achieve the highest production, and most importantly; how to secure safety for employees and the environment. The field development requires precise engineering and many companies actively participate in achieving the best solutions. Due to the uniqueness of the reservoirs, there is no full standard solution to solve the challenges for all reservoirs, as every concept must be tailored for a single reservoir.

Every field development comes with a breakeven oil price, which is the oil price required to make the field profitable. Breakeven prices in Norway have traditionally been

higher compared to many other regions, as offshore operations are expensive. (Speight, 2011; Tordo et al., 2011)

2.3.3.3 Production

Once the field has been developed, wells have been drilled and completed, the field can start the *production*. Production means that the hydrocarbons in the reservoir rock can flow to the surface through long pipes, known as tubing, extending all the way to the surface. The flow occurs due to the pressure difference between surface and reservoir. When the hydrocarbons reach the surface, they are separated from each other in a separator, while also removing water from the mix. The production is the true source of income for the operators, and what gathers the raw material which is sold at a later stage. (Devold, 2013; Speight, 2011; Tordo et al., 2011)

2.3.3.4 Transportation

Further on, the hydrocarbons are *transported* to shore, which is the next step in the value chain. The distance between the offshore installation and onshore facility is often long, and the transportation can be done in two ways; by pipeline or large tanker vessels. Whether the choice is one or the other must be decided in the field development phase. Gas is often liquefied before transportation. When the hydrocarbons have been brought to shore, the raw materials are either stored or distributed for further processing. (Speight, 2011)

2.3.3.5 Refining and Processing

As for most raw material, a process is required to purify the crude oil into a variety of useful products which can be sold to the market. This is done at a refinery, which is a separate business that buys crude oil from the operators. Crude oil comes in varying quality, and without processing, it is rarely useful for any industrial applications. The crude oil is categorized into different benchmark crudes which is used as a quality reference for buyers and sold in *barrels* (1 barrel = 159 liters). (Melton, Hudson, & Ladislaw, 2015) (Speight, 2011) A typical example is the Brent Blend, which is a blend of several crude oils from fields in the North Sea region (Fantini & Haderer, 2013). The output from the refineries include gasoline, diesel fuel, asphalt, jet fuel etc., and are consumed by residential and commercial users, industrial users, and electric utilities (Melton et al., 2015). In fact, many of everyday items such as clothes, shampoo, deodorants, toothpaste, cameras, phones, and computers are made from oil or are dependent on oil for their production (Fantini & Haderer, 2013).

Natural gas, however, undergoes a process at dedicated plants to be suitable for pipeline transportation, and is not refined in the same way as crude oil. The gas is processed, often liquefied, and after impurities are removed, the gas can be sold to the market (Tordo et al., 2011).

2.3.4 The Impact of Oil and Gas

Today, oil and gas have been very important for hundreds of years, and will continue to be important for a long time into the future. Without oil and gas, people would not be able to live by today's standard. Oil and gas is also important in the growth of developing countries, as they become more industrialized and the average person's energy consume increases. Statoil claims in their yearly analysis of energy perspectives that the energy demand will increase globally until 2040 (which is the horizon of the analysis) (Statoil, 2016). It is expected that some of the growing energy demand will be covered by other forms of energy, where new renewable energy solutions will have the highest percentage increase. However, the larger fraction will still be covered by oil and gas. The report concludes that investments in all parts of the energy sector is needed in the future, including in the oil and gas sector.

2.3.5 Lean and the Oil and Gas Industry

Statoil is not a typical manufacturing company, which is where the Lean principles originally come from. The delivery is not the same in any project, hence there cannot be one standard solution. What defines the oil and gas industry is that the projects are always dependent on a reservoir. Statoil must adapt to the circumstances of the natural resources to exploit the resources to its fullest. This is valid for all parts of the value chain. For instance, when building a platform, the platform must match the reservoir, and the drilling target must be the exact spot where the oil and gas is located in the reservoir. The reservoir will always add this uncertainty to the oil and gas industry.

The top priority in the oil and gas industry is safety. Most importantly to secure a safe workplace for all employees, but also with regards to environmental problems which can be a result of an operational mistake. Having this ground laying principle affect how Lean can be used in the industry, as no shortcut or assumed efficiency improvement should ever put the safety at risk. The industry is responsible for many fatalities. To find an examples, one does not have to look further than to May 1st 2017, where six workers were killed in South Korea during the construction of Total's platform, Martin Linge. (Hole & Taraldsen, 2017)

In October 2016, Statoil experienced six serious incidents were deaths could have occurred and was accused of de-prioritizing safety to cut costs. The corporate management in Statoil denied the accusations, saying that "nothing indicates that our cuts in costs influences the safety" (Barstad, 2016). It is important that the safety focus is maintained, even though there is a higher focus on improvements, efficiency and cutting costs.

3 Lean in Statoil

3.1 Methodology

3.1.1 Gathering Information

The methodology used in this thesis is *semi-structured qualitative interviewing*. The purpose of the interviews is to establish how Statoil has implemented Lean and if the implementation seems to be effective and show results. The second purpose is to investigate how Statoil uses Lean in practice to improve their processes and ensure continuous improvement in projects.

The analysis of the thesis is based on five interviews of Statoil employees with different positions within the organization. The shared feature is that they all have experience with Lean implementation in one way or another. The interviewees were chosen by Tor Livar Halvorsen and André Henning Aspedal after discussions of which employees had experience with Lean, and a focus was put on having interviewees with different backgrounds in Statoil. The five chosen interviewees are listed below in chronological order of the interviews.

- **Magne Otterå:** Implementation leader of Lean for all projects of various sizes within Statoil with a main responsibility towards investment projects. The interview was conducted on May 8th, 2017.
- **Kristian Sirevaag:** Lean expert within Drilling and Well in Statoil. Kristian has 30 year experience the Drilling and Well-discipline. Started working with Lean in late summer 2016. The interview was conducted on May 8th, 2017.
- **Cecilie Bekkeheien:** Chief engineer for Project Development in Statoil. Cecilie recently started in this position, and her Lean experience is mainly from the previous position in Top Side Modifications on the Utgard project. The Utgard project was one of the Lean pilots in Statoil. The interview was conducted on May 9th, 2017.
- **Edvin Håvik:** Leading Advisor Planning and Analysis at Statoil. Worked 10 years in Statoil. The role means that Edvin is responsible for all processes within planning of projects in Statoil. Started working with Lean in January 2017. The interview was conducted on May 10th, 2017.
- **Arild Gjerstad:** Head of Construction, hookup and commissioning sector in Statoil. Started using Lean about two and half years ago in his previous position within Statoil. The interview was conducted on May 10th, 2017.

The interviews have been conducted both face-to-face and through Skype voice call, all one by one. The three first interviews were done at Statoil's office, Vassbotten, at Forus in Stavanger. These interviews were recorded using a cellphone as a recording device, and later stored to a computer. The last two interviews were done through virtual communication using Skype voice call and recorded using a software called Amolto Call Recorder. This was because Edvin Håvik is located at Statoil's office in Oslo, and Arild Gjerstad at Statoil's office in Bergen.

The interviews have been performed in Norwegian and translated to English in the author's best effort. Hopefully, the translation process has been done correctly, including technical terms.

The purpose of a qualitative research interview is to find the interviewee's experiences and understanding of the topic of the interview. (Dalland, 2012) As mentioned above, the methodology used in this thesis is semi-structured interviewing. The method of interviewing is most likely the most employed qualitative research method. While structured *quantitative* interviews are mostly used in surveys, the semi-structured interview or unstructured interview is used in qualitative research. Qualitative interviews are characterized by a higher level of flexibility and less structure in the questions. (Edwards & Holland, 2013)

In the research, a list of questions was used, and acted as a template for the theme of the conversation. The list was given to the five selected interviewees at least two days before the interview took place. As for semi-structured interviews, the interview was flexible and the questions did not necessary follow a specific order, although in most cases the questions made a natural course in the interviews. The dialogue between the interviewer and the interviewee often had digressions which touched into the topic of other questions or personal experiences. The questions acted as a thread through the interview, keeping on track while still allowing space for the interviewee to answer on their own terms. Using the same questions for all the interviews helped keeping the topic of the different interviews comparable to one another. (Edwards & Holland, 2013)

All interviews gave the impression of a regular conversation, and allowed for follow-up questions which drove the conversation onwards. The interviewees were always free to elaborate onto topics outside the scope of the question, thereby adding interesting elements to the interviews which would otherwise not be considered.

The initial list of questions which was given to each of the interviewees is presented below. The questions have been translated from Norwegian to English.

Part 1: Implementation of Lean

1. What is the reason for the implementation of Lean in Statoil?
2. Have the leaders and employees received training within Lean, and how?
3. Describe the approach when trying to implement Lean.
4. Has there been any noticeable progress after the implementation was carried out?
5. How was the reaction among the employees at the beginning of the implementation, and how are they at this point?
6. Have there been any negative consequences?
7. What barriers and obstructions within Statoil may be relevant with regards to the implementation of Lean?
8. Working across organizational boundaries, with contractors or other service providers should ideally run as smooth as within an organization itself. How is your experience with Lean towards other companies?

Part 2: Lean in practice

9. What part of a project life cycle do you think have the highest potential of benefiting from Lean principles?
10. Have you used Lean principles to follow up, control and ensure quality in projects? If so, how?
11. How do you use Lean in Engineering?
12. Standardization of work tasks and processes is important in Lean. How are processes standardized as of now, and how can Lean influence the standardization?
13. How to ensure continuous improvement throughout the whole organization? How can experiences be transferred?

3.1.2 Using the Obtained Information

The analysis will be structured based on the major topics discussed in the interviews. The interviews have been reviewed and the essence of the information received is stated in the section 3.2.

The discussion found in chapter 4 will be based on the information obtained through the literature study of Lean and from the interviews. Important topics brought up in the interviews will be discussed in detail in addition to challenges which Statoil is facing with the Lean implementation.

3.1.2.1 Citing the Interviews

Further on in this thesis, any statement made by the various interviewees will be cited. The interviewees will be referred to by last name wherever necessary (for instance: *Otterå* said), and statements by the different persons will be cited with their last name in a parenthesis (for instance: With a common company-wide tool, the cultural change is obtainable (*Bekkeheien*).). When whole sections are based on what the interviewees expressed, the name will be cited at the end of the section. This type of citation was suggested by the internal supervisor for this thesis.

3.2 Analysis

3.2.1 Introduction to Lean in Statoil

The implementation of Lean in Statoil is a planned initiative from corporate management. The initiative is a reaction to the high costs which has developed in the oil and gas industry, as well as the sudden drop in oil price (Otterå). The high costs were reflected on many Statoil projects, and the two main contributors were; high payments to contractors (sometimes a cause of the requirements set by Statoil) and high internal management costs within the projects (Bekkeheien). In 2014, when the oil price began to drop, the rise of the industry had been lengthy over several years. The management saw the need to change the culture within the company to be able to stay competitive, and thereby get the best business cases. It has been expressed that such a change was long overdue in Statoil, and that the way the industry was run was not sustainable (Sirevaag).

This is not the first time in history that the framework for the whole industry has changed, and most likely not the last (Sirevaag). During the previous downturns, there has also been a need to adapt to the changing circumstances. When the oil price has been low, all-out efforts have been made within Statoil to improve the business to survive in the market. The problem, however, have been to achieve long lasting changes in the organization. The tendency has been that when the oil price went back up, the routines have bounced back to how they were before the improvements were implemented. This is assumed to be a cultural issue, where the culture has been set around campaign-based improvement efforts (Håvik).

To start the journey of changing the company culture, Statoil needed a tool which could be incorporated across all units. With a common company-wide tool, the cultural change is obtainable (Bekkeheien). Jacobsen and Thorsvik (2007) refer to such a tool as an important element when going through a planned change. Once the goal has been set, and the need for a change is evident, the next step is to find the solutions to the problems which the organization is facing.

Gjerstad said that it was obvious that improvements were needed. He used an example from his unit. Even though it was clear that the unit should improve, it was known where in the system the improvements were needed, and who had to go through with the changes, there was a missing link. It became evident that the industry lacked tools and methods to operationalize the improvements effectively and systematically. In

Gjerstad's situation, Lean turned out to be able to assist this operationalization issue, and was thereby an enabler of the improvement agenda.

3.2.1.1 The Statoil Lean Wheel

The Lean wheel (see Figure 14) is the backbone of how Statoil addresses Lean, and how it is related to the basic Statoil values and principles. Standardized and stable processes, which can be found to the bottom left of the wheel creates the fundament on how Statoil works with Lean. Standardization involves developing work processes which makes it possible to work across unit boundaries. Through quality tested standardized processes, the purpose is to have processes with an outcome that is *right the first time*, thereby avoiding rework. It is inconvenient if different units establish several different ways of working, making it very difficult to extract any learnings across the organization. When this framework has been created, systematic continuous improvement of the processes can commence. On top of this, the Customer-Driven Flow principle is used to optimize the processes, and visual management to follow-up on the improvements. (Gjerstad)

Figure 14: The Statoil Lean Wheel.

3.2.1.2 The Lean Implementation Process in Statoil

The Lean implementation is achieved through what Statoil refers to as *waves*. This is a systematic approach which target different units at different times. When a wave hits a unit, a structured and in-depth effort on implementing Lean is put into effect within that unit. The purpose is that the employees shall understand the Lean principles, and learn tools which may assist in improving everyday work (Otterå). Before the waves started, there were different pilots within Statoil, where extra attention was put on getting feedback on the implementation process and opinions on using Lean. Statoil does not implement Lean to a unit until the unit has a well-defined project, with a well-defined project team.

A wave involves about 16 intensive weeks of implementation within a single unit. There are some set roles regarding the implementation which are called *Lean coaches* and *Lean experts*. The Lean coach is an external part and has the role of assisting the unit, especially with the use of Lean tools. The Lean coaches provide training when needed and continuous observation of the unit (Otterå). In Statoil, the Lean coaches are brought in by Accenture, which is a global consulting company. Accenture have developed a professional program of how the Lean implementation is to be rolled out.

The Lean expert is a person which is a part of the respective Statoil unit, and provides an internal perspective on the implementation process. This role has an extra responsibility in the Lean implementation, and is the outwards contact from the unit to the Lean administration (Sirevaag). Feedbacks have shown that having internal Lean expertise from a Statoil employee is preferred to external consultants when the team starts to understand the basic principles of Lean (Bekkeheien).

Leading by example is a familiar term in many contexts. Byrne (2012) states that Lean leaders have to lead from the front in a hands-on way. Using a leader's personal features in the Lean implementation is very important. Employees tend to pay attention to how leaders act when changes come along, which makes the Lean expert role and other leader roles very important in this process. Leaders who actively use Lean tools in their work will reflect onto the employees within his or her unit (Sirevaag). In addition, the drive and focus on continuous improvement and Lean from corporate management is motivating for all employees, and is vital to a successful Lean implementation.

The managers in the units receive a concise 2-day crash course in Lean, comprised of theory and practical training. The course involves using various Lean tools including VSM, A3, Fishbone, 5S, visual management using whiteboard, TIMWOODY and 5 Why's. The tools are described in section 2.1.4. The tools have been selected as they are believed to cover the needs in Statoil. Tools are introduced stepwise to achieve a constant learning curve, and even more tools might be added later in the process if needed. (Otterå, 2017)

When the managers have been through their training, the employees within the unit receive a similar course packed into two hours. The learning process continuous with on-the-job-training, meaning that when a tool is to be used, the team involved will receive training just before the process is started, or underway in the process. The Lean coaches have an active role in this training (Otterå). The purpose is to avoid having to teach the tool more than necessary by having the knowledge fresh in mind when doing the work.

The retention rate of practice by doing is documented to be significantly higher than for lecturing and demonstrations (Edgar Dale's Cone of Learning) (Lalley & Miller, 2007).

When making radical changes in an organization it is important that the basic, ground laying principles are not forgotten. An important part of the implementation process is to build on top of the most central principles in Statoil. Changes should not in any way contradict these principles. In the oil and gas industry, there is especially one principle which is above all, and that is safety. Safety is important in projects and operationally, and the Lean implementation should support these overriding principles (Otterå).

Otterå views the implementation process in a perspective of at least five year. Due to the complexity of Statoil, a long-term commitment is important to fully incorporate Lean principles into the Statoil management system. A typical characteristic of many companies is that they usually follow a 3-year-cycle before changes occur in management. This might be a challenge with regards to the Lean implementation, since invested efforts might fade. If the organization and management can keep pressure on implementing Lean, the higher is the possibility of a sustainable success.

3.2.2 Examples using Lean in Statoil

Naturally, some examples of the usage of Lean came up during the interviews. The examples are interesting as they show problems that have been faced, and how they have been dealt with. They also show how improvements can be made.

The first Lean initiative in Statoil was an initiative from a smaller group of employees, and started independently of corporate management in late 2014 (Gjerstad). The respective unit, which was responsible for parts of Statoil's project portfolio on the Norwegian continental shelf, recognized that the cost in many of the projects was sky rocketing, and that improvements had to be made. One of the employees within the unit had experience with Lean from another industry, and suggested using Lean to operationalize the improvements. It was agreed in the unit that Lean should be considered carefully, and the benefits to the oil and gas industry should be studied. At this point, no one in Statoil could assist with Lean tools and implementation. The initiative had support from the management, which saw the value this could bring to the unit if it turned out successful. Some tools which could help to kick off the Lean implementation were selected by Statoil and various contractors, which also had a role in the Lean initiative. The tools used at first were VSM, A3 and TIMWOODY (Gjerstad).

As this was an independent initiative, there was no professional framework for implementing the tools into various project. However, it was decided that Lean was to be tested in some specific projects, and therefore some project managers and leaders acting as Lean experts were hand-picked. The tools were firmly implemented into the project in a top-down-effort to anchor Lean in the lower levels in the both Statoil and the involved contractors. Results were evident after barely six months, as there had been considerable cuts in costs. After eight or nine months, there was a noticeable change in the culture in the project team, where the involved members naturally sought out improvements in projects, using Lean tools. The improvements involved simplifications of work processes, cutting costs, or challenging problems and find how they can be eliminates (Gjerstad).

Bekkeheien was responsible for Top Side Modification on the Utgard project, which was one of the Lean pilots in Statoil. Utgard was selected as a pilot since the timing of the project was a good fit with the corporate controlled Lean initiative in Statoil. The purpose of the pilot was to test Accenture's implementation model, and of course implement Lean.

In Bekkeheien's project, there were some start-up difficulties as it was unclear how to best fit the implementation to the specific unit. Some tools had been presented to the employees, but the process of starting to use them was not straight forward. As meetings is very common in Statoil, it was decided that short, mandatory whiteboard meetings, with a focus on improvements, should be a regularity. Having the Lean managers in these meetings is important to create an engagement in the implementation process. The participants used post-it notes to submit their improvement suggestions, and the bar was low when accepting suggestions. The purpose was to get the employees more self-motored in their Lean work. Early in the process, there were many improvement notes, which Bekkeheien referred to as the *low hanging fruits*, which where problems that have been around for a while and can be dealt with easily. The subjects of the suggestions were mainly about internal meetings and cross-unit interaction within Statoil. For instance, it was brought up that a lot of time was wasted preparing and moving to and from meetings. Movement, which is one of the eight wastes, was avoided by cutting the number of meetings and having just one multipurpose meeting. This freed up a lot of time for the employees every week.

Another example was found in a procurement process, where the discovery was that two teams were pursuing the same goal independent of each other. The first team was comprised of engineers and the second of economists. By putting the teams together, creating a more qualified team, they managed to cut costs and speed up the process.

A few months into the Lean implementation process, Bekkeheien noticed that the improvements notes stopped. Many of the quick-fix issues had been dealt with, leaving more demanding improvements for the employees. To take on one of these improvements would result in what the employees saw as extra work. Gjerstad also noticed that early in the implementation, there was easy to make improvements. However, the remaining improvements required more from more employees to actualize, and they would therefore be reluctant to initiating these improvements.

Sirevaag experienced the same problem when implementing Lean in his unit. Especially in stressful periods when a lot of work should be done, and the employees already feel overworked, working with Lean might seem forced upon the unit. Sirevaag emphasizes that it is import to be honest in the Lean implementation process, and realize that Lean *is* work. The extra work might be more intense in the starting phase, and deadlines with Lean work should yield to other duties in some situation. It has also been observed that when employees are travelling or located in the field (for example on an offshore rig), it is difficult to follow-up on Lean tasks. Sirevaag have also seen examples of people who used Lean work as an excuse to not follow-up on other duties. Otterå experienced tension between Lean work and regular work as well. He states that it is important that Lean becomes an integrated part of the duties, and not come on top of everything else. Bekkeheien, who also experienced trouble when the employees were very busy, said that it is important to prioritize both normal task and Lean tasks, which will improve the normal tasks in the long run.

"With an extra effort today, the benefits will come tomorrow."

(Bekkeheien)

Håvik experienced an increase in specific improvement-related actions, creating momentum in improvement work. After implementing Lean, the unit has received more muscle when it comes to improving their processes. The greatest effect has been on the systematic documentation of the improvement potentials, and a higher focus on closing the ongoing initiatives. This can be related to the principle of one-piece flow found in Lean. His team also uses virtual whiteboard in Lean meetings, which is a common software that everyone can access from their own devices. A typical meeting involves personnel from four to five different locations, making the virtual tools useful.

3.2.3 Reactions to Change

Otterå stated that in a large organization, there will always be some resistance to changes. Therefore, resistance must always be taken into consideration when performing a management-driven change.

Sirevaag said that generally, most employees are positive when they are introduced to Lean. Although, he sometimes feels as he must sell the idea of Lean to get people on board. He characterizes the employee reaction into three main pools:

- The first category includes those who have trouble understanding what Lean is. These employees do not see the purpose of implementing a new way of working as they believe that Lean is the way they have been working all their lives; as they have always strived to simplify their duties. However, it usually does not take long until this group realize that Lean is a wider term which affects everyone in the unit.
- The second category are those who are positive to the change, and believes that it was about time that a change was made. This group is usually very enthusiastic about sharing their improvement suggestions, and actively participate in meeting and learn to use the new tools.
- The third category are those with a negative view. Sirevaag said that they often have been through changing processes before, and have a "more-of-this-stuff"-attitude. They see changes as a disturbance to how they work, and want to continue as before without the involvement of the management. Typical behavior is that they try to avoid meetings and participation in Lean exercises.

Sirevaag tries to deal with the employees by staying positive and try to have fun when having Lean meetings and using tools. He recognizes that an implementation from corporate management requires active support from leaders at all levels, and adding an element of fun into the implementation makes the process less formal and scary.

Bekkeheien also noticed that having a sense of humor when implementing Lean was beneficial. In beginning, the employees joked about using Lean tools, in a way admitting that they had no idea what they were doing. On the bright side, this was a sign that the employees were doing an effort to implement Lean methods into their tasks. Another discovery was that taking an active part of the implementation, by attending all meetings and demanding that everyone else did the same, was motivating for the employees.

Håvik experienced that it was difficult to gain a great enthusiasm from employees when it was decided that Lean was to be implemented. The typical reaction was expectancy, and the employees waited patiently to see what would happen. Generally, people accepted that it was a decision from the management, and are willing to make an effort to see the outcome. Many thought it was difficult to get started, and that the work load in the beginning were larger than expected.

Furthermore, Gjerstad has observed skepticism towards Lean implementation because the employees believe that Lean tools would become a theoretical practice which would not benefit the organization. This is a risk that must be considered in the implementation process. In addition, some resistance was seen due to the uncertainty that comes with a change, such as how it affects current jobs and future jobs. People like stability and fear for their jobs, especially with a low oil price.

A general agreement is that employees are motivated when they are presented with successful stories where Lean have been used to improve projects. Bringing up the good examples makes it easier to convince employees that the methods are working (Sirevaag).

Otterå said that due to the downturn in the industry, people see the reality and realize that changes are necessary. The whole industry has seen colleagues being let go, and many have feared that they will lose their own jobs. This also helps shifting the view on a Lean implementation to something positive, and see that Lean can be a great tool to increase Statoil's opportunities in the current market. Most people also see the potential which Lean has when it comes to reducing costs, which gives the opportunity to initiate more projects. A lower breakeven price (the oil price which makes the project profitable) makes it more likely that a project will be executed. The entire industry is better served with a higher number of projects since there are typically many involved companies in every project. Otterå emphasizes that nobody makes money when projects are put on hold, or from unprofitable projects.

3.2.4 Lean Crossing Formal Boundaries

3.2.4.1 Crossing Company Boundaries

Cooperating with contractors is essential for Statoil. Contractors is important in many aspects in both projects and operations. Otterå states that the entire industry is in the same boat, and if the companies cannot actualize the projects, none of them will have a job.

Many companies, both operators and service companies, have seen the potential of using Lean as a way of working. Some of the service companies using Lean are Aker Solutions, Wood Group Mustang and Aibel. Otterå said that working with contractors which are also using Lean is preferred to those who does not use Lean. If the contractor has experience with Lean, a cooperation with regards to tools and methodology can be established. An example is joint whiteboard meetings.

Sirevaag expressed that it is much easier to work with contractors which has experience with Lean, and that some challenges occur when dealing with those which does not have any experience. Working with contractors with more Lean experience than the Statoil employees has been useful, as employees could learn from the contractors as well as from internal training (Bekkeheien).

Having a good interaction with contractors can be challenging, and a hold-up in a project might be due to the dependency of contractors (Bekkeheien). However, to achieve the best possible solutions, it is important that all external parts are involved in the continuous improvement work, and the use of Lean tools. Even though the operator and contractors work together to find the optimal answers, there will always be a different agenda due to the contractual relationship between the two parts. The contractors often want to achieve other things than the operator and vice versa. The activities where the contractor makes money is often the same activities that the operator want to cut their costs, resulting in a very competitive market for obtaining contracts. Bekkeheien has experienced that working with a contractor over many years leads to an understanding of how they make money, and what parts of the business that is important to the contractor.

Håvik shared this view, and believe that a barrier for creating flow is contact with contractors. Since contractors does not always have the same drivers as operators and does not necessarily want to share information on how they make money, the communication between the parts should be planned in detail and considered at all times.

As an operator, Statoil is dependent on other external players than contractors. For instance: the Government, Norwegian Petroleum Directorate (NPD), Petroleum Safety Authority (PTIL), and various partners. Bekkeheien pointed out that the relationship towards any external player often require time consuming work for Statoil employees. Examples are explaining operational decisions, and authorization of exception from requirements and standards. The latter often requires intensive follow-up on external processes.

3.2.4.2 Crossing Unit Boundaries

For a large company, such as Statoil, interaction between units is very important in the process of generating value. Both in cooperation towards a shared goal in a project, and during hand-overs of work from one unit to another, it is important that things run smoothly, and that processes are familiar to everyone involved.

Lean has shown to be very useful when working with other units in Statoil where all units has experience with Lean (Sirevaag). Bekkeheien said that getting a common tool for continuous improvement brings along its own lingo. Sharing the same lingo throughout Statoil makes it easier to implement improvements.

3.2.5 Standardization

Statoil's approach to Lean is built on standardized processes. This makes the common control system in Statoil, *ARIS*, very important for the continuous improvement work currently rolling out in the company.

Statoil has over many years developed a process model which is available to all employees and has the intention of standardizing the way people work. The processes are described in detail and have both technical requirements and guidelines. This system exists to avoid that employees in different units have different approaches in their work, so that a work process is always familiar to all colleagues. For example, when transferring persons from one project to another it is important that those it concerns recognizes how things are done. Therefore, standardized processes are important to achieve organizational efficiency (Håvik). The major problem with the control system is that it looks great on paper, but does not work ideally in practice (Otterå). This results in processes which are independent of the control system, or that employees work the way they always have.

Bekkeheien said that the processes are not used by everyone throughout the company, and some employees does not even know where to find them. Gjerstad shares her opinion,

and said that working on simplifying the processes, so that they can be understood more easily, is the key to getting people to start using them. Sirevaag suggested that the problems with ARIS should be discussed in detail in a plenary assembly to find the flaws which can then be improved.

Statoil is in the process of transforming ARIS using digital tools to make the system more user-friendly and specified towards various projects where simple requirements are meant to replace heavy documentation (Bekkeheien).

3.2.6 Transferring Experiences

Transferring experiences throughout a large organization is a complex process. Many communication tools are used with varying degree of success, and transferring a procedure across the organization takes time. Therefore, the result is that smaller improvements is kept within a project team, and builds competence within that team, instead of supporting other units with the same improvements. The larger improvements, which affects the whole organizations or departments, are usually management driven. (Gjerstad)

The goal of experience transfer is that everyone should have access to information which may improve their work. This include both positive experiences such as new, innovative solutions, and negative experiences such as HSE incidents.

> *"If only Statoil knew what Statoil knows."*
> *(Bekkeheien)*

One of the tools used in Statoil is lessons learned. However, the lessons learned database contains an enormous amount of information, making it difficult to orient and find the needed information. Another tool used is Best Practice documents, which are based on experience from the latest projects and operations. These documents have a great potential, and could be very useful, if they were continuously updated. The problem, however, is that routines are more at random than they probably should be. Updating the documents often depends on whether the one responsible has available time to do so (Bekkeheien). Håvik emphasizes that collecting experiences require a lot of work. What makes it more challenging now than before is that the rate of improvement suggestions is increasing (because of Lean). The increased number of improvements makes it more difficult to coordinate these improvements across project boundaries. The risk is that projects take off their own direction without sharing their improvements.

Sirevaag have experienced that the most effective way to transfer experience is by rotation in personnel. That means to move employees between projects and units, which exposes entire teams to direct learning from each other. Regular cooperation with different teams with similar goals is also proven to be useful as one team might have a solution which might be relevant to the other team. Otterå said that there are some demands, including having meetings across projects to share experiences relevant to both projects. In such meetings, one of the projects are often further behind the other in the Capital Value Process, and may benefit from the information which the other project provides.

Sirevaag also stated that a cultural issue in Norway is that it is frowned upon to share your success, meaning that good experiences and good work is difficult to spread out in the organization. In other cultures, it is more common to publicly state your achievements, without having to receive negative comments for doing so.

Bekkeheien agreed with Sirevaag that Statoil is not good enough at sharing quality and good work. However, the company is excellent at sharing HSE experiences to avoid similar problems in different parts of the organization. As safety is the highest priority, sharing HSE incidents is a natural reaction. Bekkeheien said that digitalization could become important for transferring experience in the future. Although digital tools already have a central role in Statoil, digitalization can open for new opportunities in Statoil. Bekkeheien said that Statoil's internal IT systems has never been given a high priority in the past. However, she mentioned that a new roadmap for digitalization in Statoil was on the way, and was going to be announced within the next few weeks of the interview.

3.2.7 Engineering and Lean

One of the most vital resources in Statoil are the engineers. Håvik said that "attacking" engineering is difficult since the cost of doing engineering work wrong, and making mistakes, is enormous. Therefore, it can be argued that engineers should continue using the same work processes as they always have, and spend extra time to ensure that things are done right the first time. Additionally, knowing who the customer of the engineer is, exactly what an engineer produces, and measuring an engineer's performance of engineers, is difficult.

"Engineers are the core of the operations in Statoil."

(Otterå)

Sirevaag said that using regular Lean exercise with engineers can be challenging, as engineers tend to be solution-oriented and jump ahead to instantly find a solution to a

problem. It is difficult to find root causes, and the associated lasting solution, when someone claim to have the answer right away, and jump to conclusions. Sirevaag said that the key is to timeout and jump back to the brainstorming part, and have an open discussion with all participants.

Bekkeheien said that engineers should use Lean to go through how they spend their time. Lean for engineers is no different than for anyone else, as an analysis of their work can identify which activities that is value-adding, and thereby eliminate waste. Fully understanding the unit's responsibility, and how the responsibility is divided throughout the team can help in this process. An issue is that engineers often end up doing the activities they are good at and like doing. This means that some aspects of their work could be over processed while others are not handled satisfactory.

Gjerstad claimed that engineering in the oil and gas industry have become inefficient over time. An engineer often strives to achieve the perfect solution and have their own preferred way of working. This makes standardization difficult as they often apply their own changes and improvements to work processes unless they are controlled. However, if engineering can be measured and controlled more effectively, the costs of engineering may be cut (Gjerstad).

3.2.8 Improvement Potential in Statoil's Projects

Lean will operate under different frameworks depending on the phase of the project. For instance, the early phases of a project require creativity to come up with the best solutions. By using Lean principles, it is possible to develop a better selection process and find the best concept (Otterå). It is early in the project that the decisions have the highest influence on the outcome with regards to time, cost, quality, and achieving the goal. Investing sufficient time in making the correct decisions is very important to avoid changes in the execution phase. Making changes in the definition phase is simple, and cheap, but making the same change during construction might cost a lot. (Otterå)

Håvik said that Lean can be used in the process of *design to cost*, which involves developing a design with the cheapest possible solution and still use the full potential of the reservoir. Gjerstad states that the highest value can be actualized in the early phases, as the solutions are decided along with the cost of these solutions. Using Lean to find ways to cut costs in the final design while still selecting the best solution, can help Statoil reduce costs substantially.

Bekkeheien thinks that the highest improvement potential is after decision gate 2, where the definition of the project takes place, and further on in the project life cycle. She said that making business cases and selecting concepts tend to run efficiently as these activites mostly involves internal resources. However, later, when interacting with contractors there are still many elements that can become better. Additionally, there are typically more clearly defined work processes after decision gate 2, which can be improved.

Bekkeheien also said that there is much room for improvement in the decision-making processes, as it is too extensive. When passing a decision gate, Statoil has very high requirements and demands in order to get a go-decision, and the process can take up to two or three months. The process is very complex as many external actors needs to be involved. Sirevaag said that one of the problems is the production of extensive decision gate documentation. He claimed that the large decision gate documentation might be the result of too much time in hand for the employees. Especially now, when there are less projects than a few years ago, employees spend more time on a single project, thereby generating more documentation.

The problem is relevant in other contexts as well, as written processes grow out of proportion. Documentation tend to grow until it is no longer useful due to the level of detail and the magnitude of the described processes. If a report is too extensive, too much time have been spent on making it, and less people will take the time to read it. Lean has much potential in these types of situation. For instance, identifying what the recipient needs, which is most likely less than they get, can eliminate time used to over process these types of tasks. (Sirevaag)

4 Summary and Discussion

Statoil is the largest operator on the Norwegian continental shelf, and the decisions Statoil makes will affect many other companies. Statoil can, due to its position, make a larger impact on the oil and gas industry in Norway than any other company. This also includes the implementation of Lean which will affect all of Statoil's 20000 employees in addition to thousands of employees working for various contractors. People claim that Statoil has a responsibility in Norway since the company create many jobs throughout the country. Additionally, in a bigger picture, the company directly and indirectly generate a huge income to the Norwegian state and contributes to the welfare of the entire country. If Lean proves to have a positive effect on the company, which many of the interviewees believe it will, the choice of a Lean implementation will add great values the oil and gas industry in Norway.

This is not the first time the oil and gas industry is experiencing a downturn, and probably not the last. There should not be an industry which has to go through a new, destructive crisis every few years with appurtenant downsizing and unemployment. For countries, such as Norway, the situation in the oil and gas industry affects the entire country and its economy. Although Statoil's use of Lean only can contribute to a certain extent, it can help to create a stability in the industry which is highly needed.

It can be argued that the timing of the Lean implementation is good for several reasons, the first and foremost being the need for a change in the oil and gas industry. Since costs have run out of proportions, some projects and operations have become too expensive to be profitable. As the initial purpose of any business is to make profit, running a company with loss is not sustainable in the long run. Otterå said that the whole industry benefits from continuing with the initiation of new projects and maintaining operational activity. Finding a solution to develop profitable projects and cost effective operations is therefore vital to keep the oil and gas industry going. Additionally, the need for change leads to extra motivation for all employees, making the implementation process easier.

The second reason why the timing is good is that due to the downturn in the industry, projects have been put on hold or cancelled, and operational activity has dropped. Although it is argued in the section above that this is undesirable, there is one positive outcome of less projects and operation. Lower activity frees up time which can be used for other purposes. With generally more available time for Statoil employees, it is easier to make room for a Lean implementation without interfering with other work. Even though

the activity level is lower than it used to be, it was mentioned during the interviews that employees did not always have time to do Lean work, and that it was considered extra work. This is not unusual early in a Lean implementation process (Byrne & Womack, 2012). However, if the activity level was high, Lean would most likely get a lower priority, and the chance of success would have been substantially lower. Matching the Lean implementation with a period of lower utilization of resources is therefore very beneficial.

The Lean implementation takes time, and it obviously comes at a cost. The oil and gas industry is an industry of high wages, meaning that time spend on Lean will cost Statoil a considerable amount. The average salary in Statoil in 2014 was about 1 million NOK (Løvås & Bertelsen, 2014), although it can be assumed a lower average in 2017. A rough estimate can be made to see that a two-hour Lean course involving 20000 employees comes at total of 21 million NOK, which is only the introduction process. In addition, there are Lean exercises, meetings, training, etc., which will cost a lot more. Lean implementation will also have an alternative cost which is the work which could have been performed while working with Lean. In Statoil, there is no tracking of costs that comes with the Lean implementation, and the costs is registered to each unit as normal hours (Sirevaag).

Therefore, it is hard to identify the exact amount spent on the Lean implementation, but it can be assumed to be extensive. Additionally, it is difficult to track the progress of the implementation, and see the absolute results. For projects, tracking the performance is one of the easiest ways to see the effects of the Lean implementation, but there will always be a delay in the results. However, the improvement of everyday work processes is done in small steps by using Lean tools, and can therefore be difficult to trace. The tools assist in tracking the implementation of improvements, but usually not the outcome. In the end, the improvements will be noticeable in the amount of resources required in the project to follow up (Bekkeheien). If these costs are reduced, the improvements can be seen. Without knowing the costs nor the savings, it is hard to say whether the effect of Lean have generated any value up until now.

However, the costs of a project can rise to tens of billion NOK. For example, the first out of two phases in Johan Sverdrup field (a major ongoing Statoil's project) has an estimated cost of 97 billion NOK. The first phase has a breakeven price below $20/barrel (Statoil, 2017a). It should be noted that the estimated costs of Johan Sverdrup has already been reduced substantially (Lorentzen, 2016). Even though the field is comprised of many smaller projects, this gives an idea of the enormous amounts invested in an oil field. Therefore, it can be argued that if Lean helps to achieve minor cost reductions in projects,

it can quickly justify the resources spent on the Lean implementation. Only a few percent lower costs in a few projects will make the implementation process worthwhile.

The Lean implementation model used by Statoil has its advantages and disadvantages. Statoil uses Accenture, an external consultant company, to implement Lean. In the analysis, the consultants are referred to as Lean coaches. Having an external consultant can be advantageous as the consultant provide expert knowledge on the subject (Breit & Rolfsen, 2014b). The consultant may have knowledge of how Lean has been successfully implemented in other companies within the oil and gas industry, which can make the process easier for Statoil. Presenting Lean in a correct manner is important, as described in section 2.1.5.1, and a consultant would most likely have the experience to do it right. Breit and Rolfsen (2014b) said that a consultant's expert knowledge does not only transfer knowledge to the company, but a high level of knowledge among the employees also encourage innovation.

The *organizational position* of a consultant comes with some advantages. As an external part, the consultant has not developed the same thoughts on organizational structure and norms as the employees in Statoil, and can use this to see new opportunities for the company. For instance, the consultant may see improvements to what has previously been considered as industry norms in the oil and gas industry. Additionally, consultants often have a legitimacy as they are considered professional, knowledgeable and rational, which is important when introducing Lean to a company (Breit & Rolfsen, 2014b). The professional relationship gives the consultant an authority which could be harder to get for an internal part due to social relationships.

A disadvantage with external consultants is that their processes can be viewed as bureaucratic and unsuited for a specific unit within Statoil (Sirevaag). The consultant will never have the same insight in the company as a Statoil employee, and therefore, the employees might view the consultant with skepticism, and question how things are done (Breit & Rolfsen, 2014b). When an external part is making changes to the company, it might be easier to develop group thinking (described in section 2.1.5.4), compared to when an integrated part does the same thing. It is generally more accepted to criticize and badmouth someone that nobody knows, rather than someone that fellow employees relate to.

However, this problem is partially dealt with by having a Lean expert internally within the unit. The Lean expert knows the group dynamics and can, in cooperation with the external consultant and the Lean administration, develop the best possible

implementation process for the specific unit. The Lean expert is given most of the control of the process, while still receiving assistance from the consultant. The relation between the employees and the Lean expert is different to the one with the consultant, as it is likely that the employees feel more comfortable around someone within their own unit. This opens opportunities for continuous improvement of the implementation process, as the bar for "complaining" and feedbacks is most likely lower to a Lean expert.

The Lean experts have a responsibility to use Lean properly and customize the approaches to comply with the tasks of the employees. Adapting Lean into everyday tasks will defuse the tension towards the changing process. On-the-job training is an important element in the implementation to get relevant experience with Lean. This will also reduce the risk of Lean becoming a theoretical approach. When the employee can observe how Lean can be used in their improvement agenda, it is easier to fully understand the purpose of Lean. If the employees understand the purpose, there is higher chance of goodwill towards the changes. It is important that all employees are on board with the Lean implementation since the best ideas always come from the lower levels of an organization, and making them feel heard will bring these ideas into life (Sirevaag).

The Lean wheel presents standardization as one of the fundamentals of Lean in Statoil, and standardization is important to have operational efficiency (Håvik). Many processes in Statoil are standardized in ARIS, Statoil's control system, but they are not followed by everyone on a regular basis (Bekkeheien). The reason why some employees choose not to use the processes might be due to the lack of optimization, and that they think that their way of doing it is more effective. Additionally, it was mentioned by Bekkeheien that the system is complex and hard to use. ARIS is now up for revision as a part of Statoil's digitalization campaign, which will be discussed further. However, the combination of Lean tools open an opportunity to collaborate on finding the best processes, based on the already standardized processes. Using processes which have been quality tested and agreed upon by several employees ensures that things are done right the first time. Many companies stop the improvement process at this point, and claims to be satisfied with the result. However, what characterizes a Lean company is that there is always room for improvement. Statoil has included the improvement principle in the Lean wheel by striving to continuously improve their processes. Continuous improvement is achievable if there is a focus on following through with the improvement activities, and always keeping an eye out for waste. This is what Statoil seeks to achieve; a culture where

it is allowed and encouraged to act when something can be improved, and Lean can function as a mean to accomplish this goal.

Statoil practices a handful of Lean tools which is a part of the implementation model. The incorporated tools are namely TIMWOODY, VSM, A3 Reports, Fishbone, 5 Why's and visual management through whiteboard meetings (see section 2.1.4 for review of tools). Additionally, some divisions create matrices to prioritize objectives (Gjerstad), which is the idea behind Hoshin Kanri (see section 2.1.4.8). If used correctly, this line of tools in combination covers all of Womack and Jones' (2003) five principles. TIMWOODY is used to recognize waste in the unit's activities, and thereby identify the value-adding activities. This practice will also help seeing waste elsewhere in the organization, and after a while people in Statoil could start noticing waste unconsciously (Gjerstad). VSM will identify the value stream, and help categorizing the activities in a process. When *value-adding*, *non-value-adding* and *non-value adding but necessary activities* have been found, Fishbone, 5 Why's and A3 Reports can be used to make improvements to the process.

One of the challenges with regards to the Lean wheel, and implementing Lean in Statoil, is the Customer-Driven Flow principle. The purpose of Customer-Driven Flow is to optimize processes by creating a continuous flow of activities in the value stream, using the pull principle. However, creating flow in Statoil's projects is challenging due to the content of the work processes and the variation of the work. Every project is unique and will involve different people from different companies. The team is given a task to design and execute a project which might require completely new solutions, or at least a unique combination of standard solution. There is no way to be fully prepared for the issues that must be solved. Even though projects are unique, there is a set of objectives which are similar. This means that the purpose of the projects can be compared to other projects. For instance, the objective of two different project can be to build offshore platforms, but two platforms are often very different from each other. However, the technology used to accomplish the goals of the projects are often standardized to some degree. A good example is the Johan Sverdrup field which is based on standard technology used in previous projects and standard processes for development (Statoil, 2017c).

As projects are unique, it is difficult to predict how much time an activity requires. This uncertainty makes it difficult to achieve a constant flow of work in a project. If the person performing a task does not know when the task will be finished, the next person cannot prepare to receive it and be ready to start the next activity. It might be difficult to know exactly what is required in a certain activity, therefore, another problem arises when

assistance is needed from someone outside the project. The external person does not know that he or she will be needed in a project, and might not be available to handle any requests. These types of situation must be considered in a planning process, and a priority must be put towards the critical activities, which are activities that will delay the project.

In Ballard's Last Planner System (LPS) and Emblemsvåg's Lean Project Planner (LPP) system (see section 2.2.5.2 and 2.2.5.3, respectively), the key to good project planning is good communication and involvement of all key members of the project. Thorough planning and transparency can help create flow and remove waste in the project throughout the project, as Ballard and Emblemsvåg experienced. Using ideas from LPS and LPP could help Statoil using Lean in their project. More specifically, by using the planning levels found in LPS and LPP, it is easier to pull resources into the project.

Statoil's work processes often require key persons from other departments in Statoil, or from various contractors. As stated in the interviews, one of the challenges when working with Lean is to work across unit boundaries. Statoil's projects include value-adding activities which are conducted by other units or contractors. Dependency on external parts (in the perspective of the single unit) can often cause waiting and thereby interrupts the flow of the process. Sirevaag and Bekkeheien had good experiences working with units in Statoil which had been through Lean training. However, some conflicts occurred when the other unit did not have any experience with Lean. For example, it would be difficult for someone lacking Lean experience to attend whiteboard meetings when the majority of the room speaks a lingo which the person does not understand. Naturally, there will be some confusion if one unit work differently than the other, and the two have to cooperate. Eventually, this problem will disappear when all Lean waves are finished, which means that all units in Statoil have implemented Lean.

Sirevaag and Bekkeheien had similar experiences cooperating with contractors with and without Lean experience. The interviewees have found that it is easier to keep a focus on cutting costs and improving their professional relationship with companies with Lean experience. Although Statoil cannot force their contractors to implement Lean, there are some additional advantages for contractors that has chosen to do this. Firstly, they will most likely cut their cost and be preferred from a financial point of view. Secondly, if Statoil see additional value in using Lean in cooperation with a contractor, the contractor might seem more desirable. It should be noted that working as a contractor does in some way require adapting to the operator's work processes.

Another issue which surfaced during the interviews was that contractors have different agenda than Statoil. This will always be an issue, regardless of using Lean, but a few additional problems come up when adding Lean to the equation. As stated in the interviews, the areas where Statoil want to cut their costs is often where the contractor makes money. Generally, a commercial intention with external companies, regulates the relationship between the two parts, and achieving full transparency is nearly impossible. For instance, for any project it is desirable to complete as fast as possible, using as few resources as possible, and still achieving a high-quality result. Dependent on the contract, it will typically cost Statoil more if extra personnel are involved and the time spent on the project increases, and will therefore increase the income of the contractor. Therefore, there are contradicting intentions between operators and contractors, which are difficult to avoid.

Principles such as *target costing* and *lowering the river*, can be used to achieve cheaper and faster projects. As described in section 2.1.3.1 (James P. Womack & Jones, 2003) and in 2.2.6.2 (Ballard, 2008), the target cost can assist in finding new, innovative solutions, as the target cost is set lower than the expected cost using best practice. Lowering the river (Ballard, 2008) can be used to reveal problems by reducing the resources, so that the problem can be dealt with. However, there are some issues when using these principles in the oil and gas industry. First, there is the superior principle of safety which must not be compromised. When working with Lean, the importance of safety comes at an infinite value. This means that no unnecessary risks should be taken. Second, the cost of making mistakes is enormous. With extremely high costs, the bar for taking risks, and deliberately destabilize processes, is very low. Although high costs are often related to contingency solutions, the alternative cost of not having contingencies when something fails is much higher.

Due to these problems, it is difficult to try to improve processes in the oil and gas industry with an iterative approach, as the outcome might be catastrophic. However, being able to increase the flow and remove the hold-ups in operator-contractor interaction is one way Lean can contribute to better efficiency and cutting costs. Bekkeheien expressed during the interview that external parts should be involved in the improvement work, and use the Lean tools. Communication and interaction though Lean tools with the sole purpose of removing the impairments in the relationship between the parts could benefit both Statoil and the contractor(s) involved.

Better efficiency can be established through a more standardized engineering phase. Gjerstad said that engineering in the oil and gas industry have become inefficient, and that other industries have managed to cut their engineering costs dramatically. Engineering costs can potentially be lowered if engineers focus on the delivery and systematically goes through how they spend their time getting there. The trend has been that engineers spend time on the things they are good at, and create deliverables which are more extensive than what is needed. One of the problems which Sirevaag mentioned during the interviews was too large documentation produced by the engineers. He suggested that this might be due to a low activity level in the industry, and that the engineers had too much time available. However, it is important that the engineers focus on what is needed instead of doing unnecessary work. The engineers need to know what is *good enough* in a task, so that wasteful documentation is avoided.

By using Lean tools, a lower engineering cost can be achieved collaboratively, and result in improved and new standard processes that can be incorporated by every engineer in a unit. Problems occur when engineers come up with new ways and take off on their own, or when the processes changes too often. Working with familiar processes throughout the unit makes handovers and cooperation easier. Although processes should be improved and revised, frequent changes can be damaging as they create confusion in the unit. The result can be that different employees follow different processes, which contradicts the purpose of standardization. If changes are to be made, they should be made in a mutual agreement.

One of the highlighted improvement potentials in Statoil's projects was the selection process of concepts, which is before decision gate 2 in the Capital Value Process (see section 2.2.2). Selecting the right solutions will keep the costs low and avoid designing concepts which are not needed. The early decisions in projects have high influence on the cost, time, quality and scope at a later stage. This also means that any errors early in the project can become costly for Statoil, which is why it is important to invest sufficient time to reduce the possibility of making mistakes. Otterå said that Lean principles could be used in the development of an improved selection process to find the best concepts for a specific project.

Ballard (2008) states in the Lean Project Delivery System that good communication with the end customer is important when defining what is needed in a project. The end customer in Statoil's project will in many cases be those who will operate the deliverable of the project. Ballard (2008) also emphasizes that the project delivery team should assist

in maximizing the value of the project when defining the project. Asking the right questions in the right order will help finding the purpose of the deliverable. The purpose can help determine what would be valuable in the project, and further on decide on the design criteria for the project. It is important to involve all key member when these decisions are made, to get all aspects of the problem.

Bekkeheien mentioned that a new roadmap for digitalization was soon to be announced. On May 22nd 2017, Statoil made the announcement that they will invest one to two billion NOK towards 2020 on digitalizing the company (Ånestad, 2017). The roadmap for digitalization includes three major areas; digitalization of work processes, advanced data analysis, and robotization and remote control. Due to the timing of the announcement, the digitalization issue was not addressed in the interview. However, for the sake of the thesis, digitalization in Statoil will be discussed further.

Digitalization and information technology has become a strategic part of most businesses (Applegate, Austin, & McFarlan, 2007). Lean and digitalization are two terms which goes hand in hand, as digitalization also assist in creating more effective processes. Lean and digitalization have the possibility to create a synergic effect, where Lean can help improve digitalization, and digitalization can help improve the potential of Lean. Bekkeheien mentioned that digital tools already have a central role in Statoil. However, digitalization can open for new opportunities in Statoil.

As a large company, Statoil is dependent on digital tools to effectively transfer experiences throughout the company. The investment in digitalization can help realize better tools so that experience from one part of the organization can be used in another. Bekkeheien mentioned an ongoing project to create an engineering tool which can generate blocks of experiences from similar project, thereby creating a basis for a project. This basis acts as a template which must be customized to the current project. The system will additionally make it easier to access and use historic data on project; which have been hard to find.

Digitalization can help Statoil towards the goal of a continuous improvement culture, as it could reveal a whole new range of improvements which can be discovered through Lean. Digital tools and new technology does in most cases improve efficiency in a company. Finding the areas where digitalization can improve Statoil's work processes will require innovative thinking. Digitalization have the potential to increase the effect of Lean work, as new improvement possibilities becomes available, including new digital tools.

Lean in combination with digitalization can also assist in finding solutions for the improvement potential which is highlighted in the analysis. It was mentioned that decision-making processes are very lengthy processes due to involvement of external parts and the high requirements from Statoil. However, standardizing these processes with digital tools can make the process run smoother. Knowing exactly what information is needed in the decision-making processes and presenting them in a standardized manner can speed up the process. Having a joint digital tool for all key decision-makers and the rest of the project team can create an overview of the project which makes it easier to decide whether the project is ready to go further, or need more work.

Through information platforms across company borders a more efficient communication can be achieved. By developing a shared platform for Statoil and contractors for a specific project, it can be easier to achieve transparency and a more valuable communication. Although digital project management tools already exist and are being continuously improved, Lean principles can be used as a basis in the process of developing and improving such tools, fitting the tools to the exact purpose.

All interviewees, as well as the corporate management in Statoil, have said that Statoil is trying to shape a *culture for continuous improvement*. Continuous, in the essence of the word, means an everlasting initiative and a permanent change to the company. Lean can be used as a strategic tool to achieve this culture, as it encourages continuous improvement. However, changing the culture is an extensive process, and to do so, the people must be willing to change. From the interviews, it came forth that not everyone was positive to a Lean implementation, and many were expectant to see what happens, which is natural. Some even actively opposed the implementation (Sirevaag). The resistance which has been seen may have many reasons. Some of which have been described in section 2.1.5.4. A possible reason for opposing Lean is that employees feel like the changes does not create any value to how they work, and believe that the work they do is performed in the best possible way. Statoil employees tend to have wide experience in their job, especially those who have been with the company for many years, and the way they are working is a result of many years of experience. However, as Lean can be viewed as a bottom-up improvement system, the Lean tools open a channel where it is easier, and encouraged, to influence how the organization operates. More importantly, for some, is that the Lean tools can influence his or her work situation. Realizing this opportunity might change some minds.

As Lean is meant to create effective processes, there is a possibility that people think the increased efficiency would make their jobs redundant. Many people value stability and secure jobs above all other aspects of their job, and anything which might affect this will seem frightening (Byrne & Womack, 2012). Therefore, it is important that managers make the employees feel safe, and if possible, ensure that their positions are not in danger. The managers should communicate to the employees that such a change is critical for the future of the company, and therefore contribute to the exact opposite of what the employees fear. If the company is not profitable, there will be less jobs.

Due to the size of Statoil, it is highly likely that Lean implementation will be more successful in some units compared to others. This could be due to group dynamic, leadership, opposing individuals or complexity of the unit. However, it is the manager's responsibility to keep the unit on the right track to a successful Lean implementation. If this is not working, it is vital to have the Lean administration assist the manager and the rest of the unit when needed. Additionally, it is important that the Lean implementation initiative is anchored in the corporate management, which has made the policy that Lean shall be used by all units. This will contribute to maintain a focus on the Lean implementation throughout all of Statoil's units, and not let any units independently decide that they will not use Lean.

What is important to understand for the employees is that the Lean implementation is something that Statoil has put a lot of effort and resources into, and the company has every intention of achieving lasting effect, regardless of oil price and activity in the industry. Maintaining focus on Lean over the next years is one of the major challenges Statoil will be facing in the future. If the involvement and attention from the management fades, it would be easier to relapse into old routines. However, maintaining Lean thinking in Statoil, also in times with a higher oil price, will increase the competitiveness of the company. A large responsibility is on the Lean managers in the different units to maintain a continuous effort towards a true transformation. It is important that all employees are involved as it is important that everyone needs to think and act in the new way (Byrne & Womack, 2012). The new mindset must be towards what is good for the company, the unit, and the external- and internal customer needs, instead of what is best for the lone employee. Only then can the implementation be considered a true success.

Onwards, it will be interesting to see what transpires if the oil price increases towards a state of above $100/barrel. The interviewees have described that Statoil have had a

campaign-based improvement culture, where the improvements made during downturns has tended to be forgotten as soon as the oil price has increased. For a decreasing or stable oil price, it will come more natural for Statoil to maintain a focus on Lean, since any company will always strive for growth. However, in a case with increasing oil price, Statoil will experience growth regardless of how the company is run, and it is easier to lose focus on Lean.

The risk is that the Lean implementation will become another one of Statoil's improvement campaigns, and will be forgotten when the oil price increases. It is in this scenario that it can be concluded on whether the culture in Statoil has permanently changed. If cost increase proportional to the oil price, and the focus on cutting costs and working Lean has been forgotten, and there will be a similar crisis the next time the oil price drops. The downturn would again cause a vicious circle, where the companies would yet again have to go through downsizing and adaption processes.

In a scenario with increased profitability, the key question is; how will the extra profit be managed? In other words, what will Statoil do with the extra money?

A reasonable suggestion is that costs will increase accordingly, as contractors also require a share of the profit. However, if all players hold on to Lean, the costs will remain relatively low compared to the profit. In this case, the profitability could be high, which would provide Statoil with many opportunities. The increased income would allow investments in new oil and gas projects, new technology, or alternative energy solutions. New sustainable energy solutions are a segment of the energy market which will be important for Statoil to stay competitive in the long run.

5 Conclusion

Based on the interviews and the situation in the oil and gas industry, it is necessary to change the way Statoil is working, as industry cost are too high. Statoil's goal is to develop a continuous improvement culture, and Lean is one of the means to achieve this goal. Implementing Lean in Statoil can be a way to prepare, or avoid, the next oil crisis, while staying competitive in an industry with many powerful companies. The interviewees believe that Lean implementation is a step in the right direction for Statoil to stay competitive.

The Lean implementation model require a responsibility from the managers in every unit, as they must deal with all the everyday problems. Additionally, the managers must keep the focus towards Lean and encourage all employees to work on improving their processes. As the goal is a continuous improvement culture, the required attention from the management would eventually fade, given that the implementation process is successful.

Some key findings in this thesis are presented below:

Lean implementation in Statoil have seen the following challenges:

- Difficulty understanding and start working with Lean.
- Resistance from employees.
- Keeping up the focus on Lean.
- Working with units or contractors without Lean experience.

The timing of the Lean implementation in Statoil is good for two reasons:

- The Lean implementation is a necessary response to the need for change in the oil and gas industry.
- Relatively low activity in Statoil frees up time for the Lean implementation process.

Three main factors limit the potential of Lean in Statoil:

- Uncertainty and uniqueness of a reservoir.
- High costs of mistakes.
- High focus on safety.

What Lean can help actualize in Statoil:

- Improve interaction with contractors.
- Increase the efficiency of the employees' time at work.
- Improve and standardize work processes.
- Create a synergy between Lean and digitalization.
- Shift the mindset of the employees to what is beneficial for the company, the unit, and the external- and internal customer needs.

A minor decrease in project costs because of Lean could justify the implementation as it would have a positive financial effect on Statoil. Cutting costs will increase the profitability of projects and operation, and will create an opportunity for new investments to prepare for the future energy market.

Maintaining the focus through the Lean implementation process is important to achieve a continuous improvement culture. This involves using Lean even though the immediate need to improve is no longer necessary.

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