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Asset Management in Oil and Gas

Possibilities related to asset management as management philosophy for offshore assets

by

Stian Berge

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Abstract

During the period 2008 – 2013, globalization and new business environments created new challenges and a more demanding business context. The oil and gas industry on the Norwegian Continental Shelf, which is one of the most asset-intensive industries in the world, faces challenges such as rising operation costs and lower productivity, along with stricter safety and environmental legislation. Developments in the oil and gas industry are showing clear signs of a paradigm shift from traditional practice to asset management practice. Good management of industrial assets has become expected best practice in modern organizations around the world. In 2014, the first formal standard of good asset management was presented as the ISO 55000 series.

Therefore, the aim of this thesis was to look at the possibilities related to asset management as a management philosophy for offshore assets in Statoil. This was done by, 1) conducting a literature review on asset management and the related ISO standard, 2) analysing whether asset management suits the oil and gas industry, 3) assessing if Integrated Operations could further optimize the asset management approach, 4) analysing whether ISO 55000 offers perspectives that are not covered well in, or are in conflict with, the PSA Regulations and ISO 9000, 5) performing a preliminary gap and SWOT analysis of Statoil's requirements in relation to ISO 55000, 6) and presenting recommendations to further develop asset management in Statoil.

The literature review has highlighted that a strength of ISO 55000 is that it broadens the management perspective, as there is a large focus on managing the assets that provide the actual income, instead of only managing the quality of the end product. Throughout the work with this thesis, it has become evident that organizations operating on the NCS truly need to consider adopting the discipline of integrated, risk-based, optimized, whole-life management of assets, as asset management could certainly assist in overcoming the current challenges on the NCS. Additionally, it is acknowledged that the Integrated Operations concept certainly has the opportunity to optimize asset management in any organization.

Regarding the Statoil case study, this thesis highlights several important management perspectives that are not covered in either ISO 9000 or the PSA Regulations. Another important finding relates to the fact that neither the PSA Regulations nor ISO 9000 acts as a barrier for the effective implementation of ISO 55000. Furthermore, the work highlights Statoil's gaps related to conforming to ISO 55000 and performing good asset management. Gaps relating to awareness, alignment and continual improvement are discussed, and recommendations are presented to how these gaps can be closed. It was also identified that even though ISO 55000 provide a good checklist and framework for performing good asset management, Statoil should seek both ISO 55000 compliance as well as implementing other asset management best practices not covered in ISO 55000.

Acknowledgements

This thesis forms the last part of an intriguing journey through the MSc in *Offshore Technology: Industrial Asset Management*. I am sincerely grateful for everything this journey has given me. The journey has been a challenging and informative effort, and new knowledge has been obtained through long hours of hard work. I have worked on my thesis with dedication and curiousness, and the thesis is an exclusive collaboration between student, professor and asset management professionals at both Statoil and Petroleum Safety Authority Norway. A large part of the success of this journey belongs to the dedicated people teaching classes in *Industrial Asset Management* and my supportive peers. Thus, I have many to thank:

I want to acknowledge Statoil for providing me with an interesting and stimulating topic, and special thanks goes to Nils Martin Rugsveen, my supervisor at Statoil, for many inspiring and constructive discussions. He has provided me with firsthand asset management knowledge, and his viewpoints were critical in this thesis work. I am grateful for your guidance and for using your valuable time when needed.

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I would also like to express my thanks to two other industrial professionals, Ole Jørgen Melleby at PSA Norway and Jan Einar Malmin at Statoil. Melleby's thoughts have been vital in the delivery of the scope, and his immense contributions regarding ISO 9000 and the PSA Regulations has been critical for the quality of the two assessments. Malmin helped me to gain access to information I needed, and he has contributed with insightful information about Statoil's management system.

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Stavanger, 15 June 2015

Stian Berge

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List of Abbreviations

AM	–	Asset Management
B2B	–	Business-to-business
CAPEX	–	Capital Expenditure
CCR	–	Central Control Room
FMEA	–	Failure Mode Effect Analysis
FR	–	Framework Regulations
HSE	–	Health, safety and the environment
IAM	–	Institute of Asset Management
IO	–	Integrated Operations
ISO	–	International Organization for Standardization
KPI	–	Key Performance Indicator
LCC	–	Life cycle Costing
MR	–	Management Regulations
NCS	–	Norwegian Continental Shelf
NPD	–	The Norwegian Petroleum Directorate
O&G	–	Oil and Gas
OHSAS	–	Occupational Health & Safety Advisory Services
OLF	–	The Norwegian Oil Industry Association
OPEX	–	Operational Expenditure
PAS	–	Publicly Available Specification
PSA	–	Petroleum Safety Authority Norway
RBI	–	Risk Based Inspection
RCM	–	Reliability Centred Maintenance
SAMP	–	Strategic Asset Management Plan
SCADA	–	Supervisory Control and Data Acquisition
SB	–	Statoil Book
TPM	–	Total Productive Maintenance

PART 1 BACKGROUND AND OBJECTIVES

Figure 1 – Industrial Asset (UiS, 2013)

Introduction

Everett and Furseth (2012) states that a good master thesis introduction should include the topic of the thesis, problem definition, methodology, main objectives and the thesis structure. This introduction conforms to Everett and Furseth's thoughts, and it should create a complete understanding of what the thesis is all about.

Chapter 1 Introduction

1.1 Background

The scope of this master thesis is developed in collaboration between Statoil ASA and the master degree programme Offshore Technology: Industrial Asset Management at the University of Stavanger. Asset management can provide substantial benefits, and the main objective of this master thesis is to look at the possibilities related to asset management as a management philosophy for offshore assets.

During the period 2008 – 2013, globalization and new business environments created new business challenges and a more demanding business context. The oil and gas industry on the Norwegian Continental Shelf (NCS) faces challenges such as rising operation costs and lower productivity, and simultaneously, the industry needs to meet harsher environmental legislation (Rugsveen, 2015). The petroleum industry, together with the manufacturing and power generation industries, are some of the most asset-intensive industries in the world. Organizations in these industries are continually being challenged to develop objectives to meet their strategic plans while simultaneously managing their industrial assets, which create the imperative business value. Success is largely dependent on the organization's capability to identify asset-related risks and adequately manage the risks in a way that minimizes the total cost of ownership throughout the asset's life cycle. However, the lack of a formal asset management standard has left the oil and gas industry on the NCS to determine their own best practices (Shea and Hollywood, 2013). Organizations assessments regarding risks, unplanned events and reliability have been left to chance. The new ISO 55000 series will change the game, and it is a privilege as a student to have the opportunity to assess how one of the largest offshore oil and gas companies in the world can approach the newly developed asset management standard. It is, as explained in the *Problem Description*, imperative for Statoil to assess how to approach the new standard. Therefore, the main objective of this thesis is to evaluate the content of ISO 55000 and assess how Statoil can address their shortcomings in relation to performing good asset management.

Good management of industrial assets has become expected best practice in modern organizations around the world (Rugsveen, 2014b). The formal documentation of good asset management is presented in the ISO 55000 series. ISO 55001 (2014, p.v) defines itself as:

This International Standard specifies the requirements for the establishment, implementation, maintenance and improvement of a management system for asset management, referred to as an "asset management system".

The ISO 55000 series provide a framework for supporting decisions and ensure a steady course. Asset management does not focus on the asset itself, but on the value the asset provides to the organization. It is an approach that maintains the "line of sight" in the organization. Furthermore, asset management is about balancing the total costs of design and build, as well as operation and replacement of the asset, against the risks that can affect the business outcome.

1.2 Problem Description

Woodhouse (2010b) states that there is no doubt that the integrated whole-life asset management approach is here to stay. There exists hard evidence of the benefits of asset management, and on the other hand, if oil and gas companies fail to use the asset management approach, it can be severe. The North Sea oil and gas industry is facing environmental, financial and regulatory pressure, and asset management is needed to face these challenges.

It is evident that the rising cost level on the NCS together with decreasing production efficiency is contributing to an increased business risk for Statoil. Statoil has recognised the need for adopting an integrated asset management approach and this thesis will mainly focus on the newly developed standard for asset management (ISO 55000). Asset management is under strong development internationally and the standard is already implemented within the energy distribution and public infrastructure in Europe, Asia and Oceania. It is expected that certification requirements will follow the gas distribution network and hit the Norwegian offshore industry within a relatively short time. This is further supported by Botha (n.d., p.4) who explains that, "*very soon insurers, regulators, clients and shareholders will start to make ISO 55000 certification a prerequisite for doing business*". The question of how this will affect Statoil's business and the way its industrial assets are operated are therefore now being raised.

1.3 Objectives and Scope of Work

The aim this master thesis is to look at the possibilities related to asset management as a management philosophy for offshore assets in Statoil, and therefore the scope includes a case study on Statoil's relation to asset management. The case study combines analyses of ISO 9000, PSA Regulatory and Statoil's governing documentation. An academic review focusing on asset management fundamentals and asset management in relation to the oil and gas industry is also included in the scope. Since asset management in relation to ISO 55000 is relatively unknown, the theory about asset management and ISO 55000 will be presented as an introduction. In addition, the scope includes an academic review of Integrated Operations (IO) in relation to asset management, since IO provide the technology that should optimize asset management fundamentals like optimized decision making.

The figure below illustrates the main scope of this master thesis, and it is created to illustrate the links between the different subjects in this thesis. It also outlines the main objectives in this master thesis.

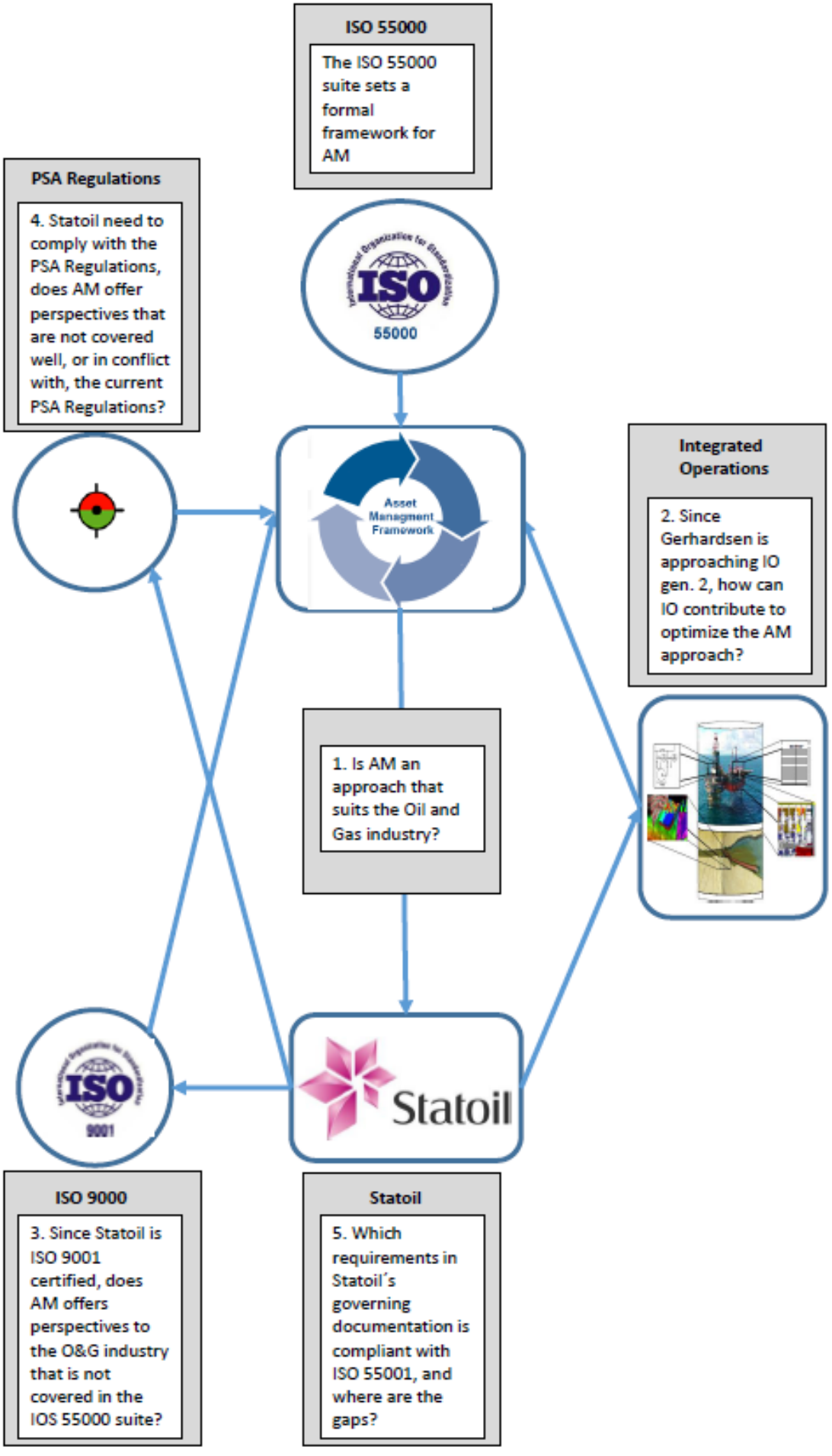
ISO 55000
The ISO 55000 suite sets a formal framework for AM
PSA Regulations
4. Statoil need to comply with the PSA Regulations, does AM offer perspectives that are not covered well, or in conflict with, the current PSA Regulations?
ISO
55000
Asset Management Framework
Integrated Operations
2. Since Gerhardsen is approaching IO gen. 2, how can IO contribute to optimize the AM approach?
1. Is AM an approach that suits the Oil and Gas industry?
ISO
9001
Statoil
ISO 9000
3. Since Statoil is ISO 9001 certified, does AM offers perspectives to the O&G industry that is not covered in the IOS 55000 suite?
Statoil
5. Which requirements in Statoil´s governing documentation is compliant with ISO 55001, and where are the gaps?

Figure 2 – Scope and objectives of the thesis

Objectives

To achieve the first objective, a comprehensive literature review on asset management (AM) will be conducted to define and describe asset management. This thesis investigates the benefits of asset management compared to traditional management approaches. Thereafter, this thesis discusses why asset management is suitable for the oil and gas industry, and how the AM approach can assist in overcoming the challenges in the oil and gas industry.

The second objective is to perform an academic review on Integrated Operations, and assess if Integrated Operations can contribute to optimizing the asset management approach.

To achieve the third objective, an analysis of the requirements in the ISO 9000 series will be performed to identify what perspectives ISO 55000 offers to the oil and gas industry that are not covered in the ISO 9000 series. ISO 9001 requirements will be compared to the requirements in ISO 55001. In addition, the overview and principle parts of the two standards will be used in the results discussion to get an overview of the fundamentals in the two standards.

The fourth objective is to conduct an analysis of the PSA Norway Regulations to identify if the PSA Regulations act as a barrier for implementing the ISO 55000 series. In addition, this analysis focuses on identifying critical (asset) management perspectives that are not covered by the PSA Regulations.

Lastly, the fifth and most important objective is to analyse Statoil's governing documentation to assess if Statoil already conforms to some of the requirements in the ISO 55000 series. In addition, a preliminary gap analysis needs to be performed to present an overview of how close Statoil is to fulfilling the requirements in ISO 55001. Ultimately, the thesis will also discuss how the gaps between Statoil's governing documentation and ISO 55001 can be closed and the possible impacts if these gaps are not closed.

1.4 Limitations

The results analysed in this master thesis are limited to some boundaries and limitations. This is a result of time constraints and the extensive amount of requirements in ISO 9001, ISO 55001, the PSA Regulations and Statoil's governing documentation. However, the main goal of this thesis is to present an overview of asset management and asset management in relation to Statoil's current practice. An in-depth case study has been conducted, however, this suffers from certain limitations. The following boundaries exist in this thesis:

The asset management approach is very broad, however, this thesis focuses on the asset management approach stated in the ISO 55000. An academic review has been performed on asset management, and the asset management main principles are formed with the basis in ISO 55000, PAS 55, the Institute of Asset Management's articles, and Chris Lloyd's book: Whole-

life Management of Physical Assets. Other literature is used to support and enhance the content of asset management. This thesis has little focus on methods supporting the effective implementation of good asset management principles and practices, and this is not explained in ISO 55000 either. This is also a result of time constraints, and it should certainly be addressed by a future thesis.

Regarding the ISO 9000 analysis, only the requirements in ISO 9001 and the fundamentals in ISO 9000 are taken into account, and ISO 9004 is excluded due to time constraints. Furthermore, as explained in Chapter 8, the PSA Regulations consist of four regulations. Only the Framework Regulations and the Management Regulations form the basis for the case study, as this is also due to time constraints and the extensive amount of requirements stated in all the four regulations.

Only Statoil's governing documentation is used in the comparison, since they specify "*what shall be expected and what is expected*" (FR20, 2015, p.9), and this is in accordance with ISO 55001, which does not specifies how to implement the requirements. Nevertheless, the result from this comparison should be good enough to answer the fifth objective. It is therefore critical to understand that if Statoil decides to implement ISO 55000, a more detailed requirement analysis is required. Only a limited number of Statoil's work processes and other requirements are taken into consideration when performing the comparison, and it is essential to include every governing document in the gap analysis. Another constraint with this case study is that it is impossible to assess if the different functions or assets within Statoil actually conform to the requirement in Statoil's governing documentation. A future study should assess if the practices on a specific asset conforms to the requirements in ISO 55001 by doing structured interviews.

Another limitation is that the case study is one-sided, as it does not take into account management perspectives covered in ISO 9000, the PSA Regulations and Statoil's governing documentation that are not covered in ISO 55000. However, it is not necessary to view the comparison from both sides to answer the objectives in this thesis.

Finally, due to limited access to documentation from the chosen offshore installation's project phase, there is little asset-specific documentation presented in the case study. Nevertheless, the offshore installation is built upon Statoil's governing documentation that governs every Statoil offshore asset, and this is clearly shown by the statement in OMC63 (Chapter 2): *"Gerhardsen will develop its operating model based on the common operating model for DPN, and on the company's IO principles."* This means that the majority of the documents used in the comparison were collected from Statoil's governing documentation.

1.5 Research Methodology

Literature Review

Part 2 of this thesis focuses on a comprehensive literature review of asset management and the newly developed asset management standard ISO 55000. This thesis attempts to address a

company need, as well as to enhance theoretical and academic learning. There exist many different definitions and approaches to asset management, however, a theoretical approach is chosen that is consistent with the new ISO 55000 series. The master thesis started with a detailed academic review through the relevant books from the University of Stavanger library, online articles, relevant standards and papers. Furthermore, discussions with thesis supervisors and the asset management academic environment at Statoil were used to establish the body of the literature review and enhance the content.

The method used in Part 3 of this thesis is employed in order to link the lessons learned in the academic review of asset management with current challenges in the offshore oil and gas industry. In addition, a limited literature review of Integrated Operations is conducted to assess how IO can optimize the asset management approach.

The Case Study

Understanding phenomena related to human and social systems demands a holistic approach, which both produces detailed descriptions and provides an in-depth understanding of the actors involved (Gagnon, 2010). Only qualitative research methods can fulfil these requirements. In particular, a case study makes it possible to investigate, observe and analyse phenomena in a single and integrated manner. Case studies are relevant when performing research where the main approach is to study systems, programs, individuals and events (Swanson and Holton, 2005). Yin (2012) further explains that case studies are most applicable when the researcher is interested in "how", "what" and "why" questions.

The case study in Part 4 is mainly interested in the "how" question, as it seeks to identify how Statoil can approach good asset management practices and how close Statoil is to fulfilling the requirements in ISO 55001. Good asset management is formalized in ISO 55000, and this standard is the main document used in Part 4. In terms of this case study, it was imperative to review Statoil's governing documentation and requirements in relation to the new asset management standard. When performing a case study on Statoil's degree of compliance with the requirements in ISO 55000, it is also natural to compare ISO 55000 with ISO 9000 and the PSA Regulations since Statoil already conforms to these. ISO 9000 and the PSA Regulations can be understood as the actors involved, and an in-depth understanding is needed of their relation to asset management. The analyses of ISO 9000 and the PSA Requirements is included in Part 4, as they are important for the Statoil case study.

The main objective of the case study is to compare ISO 55001 requirements with requirements in ISO 9001, Statoil's governing documentation and the PSA Regulations (Framework and Management Regulations). This structured comparison approach should provide a clear understanding of how asset management relates to Statoil's governing documentation and other factors involved in Statoil's current practice. Furthermore, meetings with Statoil's asset management academic environment and a PSA Norway specialist enriched the case study by providing valuable hands-on perspectives.

1.6 Gerhardsen – An Offshore Asset

To supplement the case study, this thesis uses examples from one of Statoil's offshore assets. The asset will be called "Gerhardsen" throughout this thesis, as Statoil wish to protect the identity of the asset. Traditional practice has been to choose the names of the oil fields from Norse Mythology, however after 2012, the names will be decided by the Ministry of Petroleum and Energy. There are strict rules for selecting names, and among others the name shall reflect the beliefs related to the emergence of democracy, the fight for human rights, ideals of equality and individual freedom. It may be the name of a person who has fought for such matters. Gerhardsen is selected because he was prime minister in Norway longer than any other, and his period in office is known for economic growth, harmony and NATO membership. In addition, in 1972 he received Norway's highest civilian honour.

1.7 Structure of the Report

Due to the extent of the scope and the diversity between the academic review, research and the case study, five main parts have been developed. Each part contains a small introduction of its content. Part 1 presents an introduction to the master thesis. The structure of this thesis is as follows:

The second part makes up the academic literature review of the report. Part 2, titled *State of the Art*, looks at an in-depth overview of asset management. Chapter 2 defines and describes asset management and presents the benefits of asset management compared to traditional management. Chapter 3 outlines the imperative asset management fundamental elements, and Chapter 4 provides an introduction to the newly developed ISO 55000 and the fundamental elements of an asset management system.

Part 3 forms the literature research part of the report. Chapter 5 describes the Norwegian Continental Shelf and the North Sea, along with its associated challenges. It also assesses how asset management can be used as an approach to overcoming the challenges faced by the oil and gas industry. Chapter 6 presents an overview of Integrated Operations and assesses how IO can optimize the asset management approach.

Part 4 consists of the case study on Statoil. The case study analyses ISO 9000, PSA Requirements and Statoil's governing documentation in relation to ISO 55000. Chapter 7 provides an introduction to Statoil and Statoil's current asset management practices. Chapter 8 and Chapter 9 analyse ISO 9000 and the PSA requirements respectively, while Chapter 10 analyses Statoil's governing documentation. Chapter 10 also includes a preliminary gap analysis, a SWOT analysis and recommendations for further development of asset management in Statoil.

Part 5, *Discussion, Findings and Conclusion*, sums up and pulls together the main findings of the work, together with areas for further studies. Chapter 11 is the discussion chapter, and Chapter 12 gives the final remarks of this thesis in the form of a conclusion.

PART 2 STATE OF THE ART

Figure 3 – Asset Management bridge (IAM, 2014, p.14)

Introduction

This part is the state of the art literature review on theory available on different aspects of asset management. The first chapter in Part 2 defines and describes asset management, and presents the benefits of asset management. Asset management is about providing a "bridge" between the business plan and the daily activities, and this is further discussed in Chapter 3. Chapter 3 introduces the imperative asset management fundamental elements. It is critical to understand and align these elements in order to perform good asset management. Chapter 4 presents an overview of ISO 55000, which includes the development of the standard together with a presentation of the asset management system.

Chapter 2 Asset Management

"*Asset management converts the fundamental aims of the organization into the practical implications for choosing, acquiring (or creating), utilising (operating) and looking after (maintaining) appropriate assets to deliver those aims. And it does so while seeking the best total value approach (the optimal combination of costs, risks, performance and sustainability"*

(IAM, 2014, p5)

2.1 Assets

Asset Definition

To get an extensive understanding of asset management, it is imperative to reach consensus about the definition of the term asset. ISO 55000 (2014, p13) define asset as an "*item, thing or entity that has potential or actual value to an organization*". Asset management is needed to realize this value (IAM, 2014).

The IAM (2014) states that organizations define their assets with different levels of detail. Some organizations define their individual equipment items as discrete assets, and all the maintenance, investment and spare parts are directed to this. However, these assets deliver only their functional performance in a larger system like the whole network or the production line. It is therefore essential that the organization recognise the associated inputs, costs and risks in the discrete intervention and their effects in the higher integrated system. This is why organizations often define their assets at a higher level (e.g. production line). This will provide the organization with a better value-for-money picture of the life cycle activities.

Types of Assets

PAS 55-2 (2008) states that there exists five categories of assets that needs to be managed with a holistic approach in order to achieve the organizational objectives and hence the organizational strategic plan. It is extremely important to be aware of the interdependencies between them. Organizations that are dependent on their physical assets needs to be aware that failure in the management of the other asset categories can make an impact in the long-term performance of the physical assets. Besides the obvious physical asset, the other categories are:

- *Human assets*: The motivation, communication, knowledge, responsibilities, teamwork and experience influence the workforce and hence the performance of their activities.
- *Financial assets*: Financial resources are required for investment, maintenance and operation.
- *Information assets*: Quality data and information is important for the performance of the physical assets and the opportunity to develop and optimize the asset.
- *Intangible assets*: These assets is about reputation, image, morale and social impact. Reputation and image can have huge impact on investment and associated costs.

2.2 The Evolution of Asset Management

According to Edwards (2010a), many asset management principles have existed for decades. Historically, the management of industrial assets had the main focus on capital investments, costs and returns (Liyanage, 2012). However, over the years, the industrial sector have recognised that it is essential to manage the changes in the business environment and at the centre of this development path is elements relating to quality, customer and productivity. Companies in the UK started to use the term asset management to describe their processes of optimizing management in the early 1990s. This is supported by the IAM (2014) who explains that managing assets have existed for thousands of years. Pilling (2010) provide a figure of the evolution of asset management. He states that it have evolved over a large timespan and learned from other disciplines and techniques.

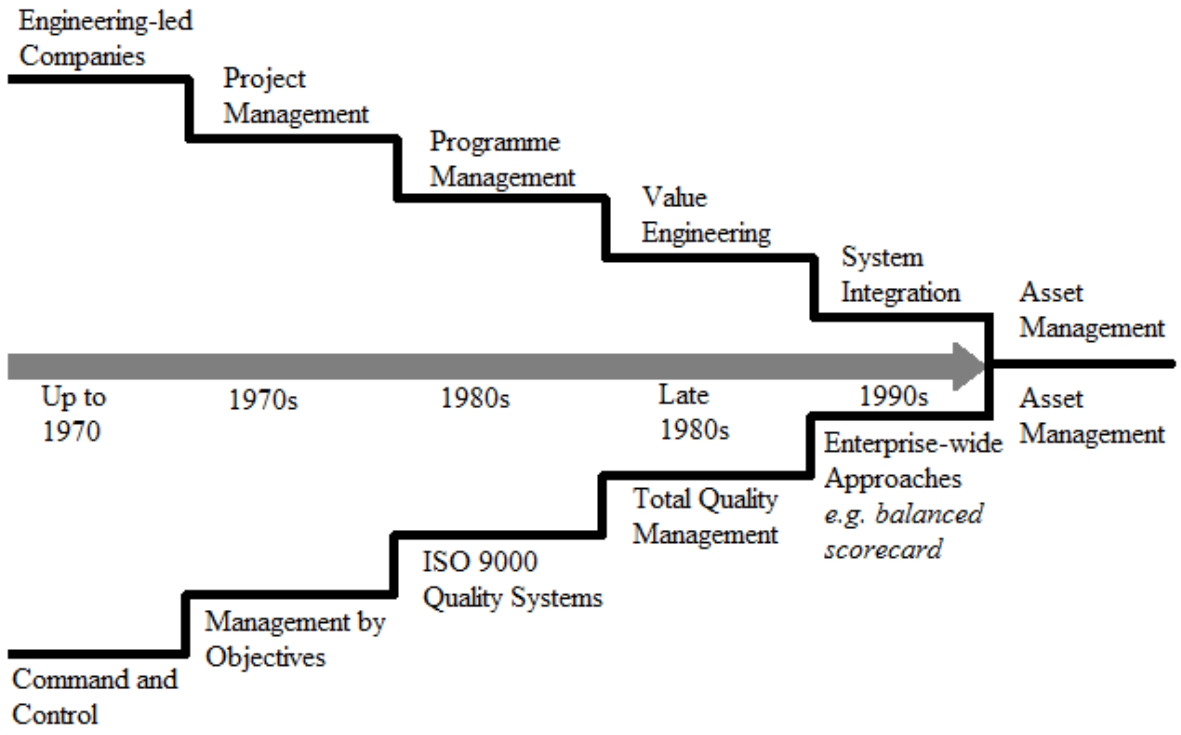

Figure 4 – The evolution of asset management (Piling, 2010, p.77)

Nowadays there have been fostered a cumulative recognition of good asset management and the benefits is provide (IAM, 2014). This have primality three origins:

- The financial sector has used the asset management term for over 100 years to optimize the risk, yield, and long-term security from stocks and cash.
- The North Sea Oil and Gas sector adopted asset management in the 1980s after the Piper Alpha disaster and the oil price crash. It was discovered that small, multi-disciplinary teams managing their own separate oil platforms created great improvements in performance, productivity and safety.

- In the same era in Australia and New Zealand, the public sector experienced poor planning and falling levels of service. This forced a radical rethink of their planning processes and value-for-money thinking.

These widely different environments learned the same lessons and formed equal conclusions. Now, these lessons have spread to electrical and water utilities, road and rail transport systems, mining, process and manufacturing industries.

2.3 Asset Management: A new way of thinking

Lloyd (2010a) states that the traditional way of managing the assets is outdated. It is not easy to earn profit when the regulatory put pressure on the prices, energy costs are raising, the government forces organizations to reduce the toxic emissions and the different stakeholders continuously create challenges. Other failure issues of traditional managing is departments working in functional silos and fighting each other over the future funds and only focuses on short-term targets. There is no clear line of sight, and improvement in one department could cause a decrease in the financial results of other departments. The result of this functional thinking is that some functions and decision levels have become superior to the others, e.g. production decisions are often weighted over maintenance interventions (Liyanage, 2012). Implementing asset management in the organization will help the organization to overcome these problems. It is a structured approach that helps the organization to define their goals and identify their stakeholders so that no surprises should occur in the future (Lloyd, 2010a). Asset management integrate management and information systems, it focus on defining the resources and capabilities needed, and creating medium-term activity needs and long-term plans instead of short-term profit targets.

A Whole Life Management Approach

Lloyd (2010a) explains that the traditional asset management approach have often been linked to financial asset management. Financial asset management is about managing the assets to achieve the highest financial returns. Physical asset management is another concept that also focus on the return of the investments, however, this concept also focus on the whole life of capital assets and the trade-offs is entails. Asset management differentiate from the traditional management of assets. Asset management is a strategic whole life management approach where the organization decide (Lloyd, 2010a, p. xiii):

- “how, where and in what to invest”
- “what assets are most critical”
- “what risks need to be managed”
- “what demands must be served”
- “what needs to be known”
- “how this knowledge should be captured and disseminated”

- “how organizations should be structured and led”
- “what types and teams of people they need”
- “how activities should be carried out”
- “how actual performance should be measured”
- “that improvement is needed”

Asset management bring these decisions and others into a framework helping the organization to achieve its intentional goals (Lloyd, 2010a). It is needed a holistic approach to manage the whole life of assets. Good asset management is characterised by a clear line of sight. This clear line of sight include that the first line maintenance workers have the same objectives and goals as the director of the organization. Good asset management should be supported by well-communicated processes, clear roles and responsibilities, and managers with the properly skills, knowledge and experience needed to contribute to the asset management policy and objectives. Furthermore, asset management require the stakeholders to be engaged in the debate of the balancing of costs, risks and performance.

What does Asset Management mean?

The IAM (2014) explains that the term asset management have matured and organizations increasingly understands that it is not about doing things to assets, instead it is about using the assets to deliver value to the organization. When googling the term asset management, one get many different hits. Financial services dominate the search results, and other results are physical asset management, strategic asset management, integrated asset management, infrastructure asset management and facilities asset management. All these different approaches are special cases of asset management, and they contain equal generic requirements for deploying asset management. The IAM (2014) explains that good asset management is strategic, enterprise wide, and relates to asset owners and managers. Asset management convert the organizations vision and values to practical implications for choosing, operating and maintaining the assets. Furthermore, asset management collects the knowledge and tools the organization needs to manage their assets. These tools (including processes and techniques) enable the organization to demonstrate their optimal management of the assets, and this is especially valuable to the different stakeholders, customers, owners and the general public. Good asset management balances cost, performance and risk, relates to both intangible and tangible assets, and applies to every organization (public, private, non-for-profit). In addition, Lloyd (2010b) explains that asset management is needed to manage the fast changing, cost-conscious, competitive environment.

2.4 Asset Management Definition

There exists numerous definitions of asset management. The IAM (2014) states that a web search for the term "Asset Management" results in a confusing range of variants. With the growing popularity on the subject, a number of organizations have created their own definition of what asset management is all about (Liyanage, 2012).

Organization	Definition
Asset Management Council (2014, p.7)	"*The life cycle management of physical assets to achieve the stated outputs of the enterprise*" *Comment:* This definition focus on the delivery of a capability where the physical asset plays a key role. The Asset Management Council's definition defines the boundaries of asset management (only include physical assets) and differentiates it from other management systems
Hastings (2014, p.4)	Hastings states that asset management is a set of activities that are associated with: - "*identifying what assets are needed,*" - "*identifying funding requirements,*" - "*acquiring assets,*" - "*providing logistic and maintenance support systems for assets,*" - "*disposing or renewing assets,*" - "*so as to effectively and efficiently meet the desired outcome*" *Comment:* Hastings states that his definition of asset management is a broader set of activities than the ones related to maintenance.
PAS 55-1 (2008, p.v)	"*Systematic and coordinated activities and practices through which an organization optimally and sustainably manages its assets and asset systems, their associated performance, risks and expenditures over their life cycles for the purpose of achieving its organizational strategic plan*" *Comment:* PAS55-2 (2008) explains that this definition covers more than just maintenance and care of physical assets, it relates more to the central purpose of the organization. Good asset management optimizes asset utilization versus asset care, it balances short-term performance versus long-term sustainability, and it optimizes capital investments against operating costs, risk and performance. Life cycle asset management is more than capital and operational costs over a predetermined life.

ISO 55000 (2014, p.14)	"*The coordinated activity of an organization to realise value from assets*" *Comment:* This definition is very general, and this enable every organization to apply asset management on their special assets (IAM, 2014). The value of the assets is also very general and can include everything from reducing risk of physical assets to optimize the financial results of financial assets.

Summary

Hastings (2014) explains that the above definitions vary, however they most say the same kind of things; asset management is concerned with using different financial and technical techniques to decide what assets are needed to meet the organizational objectives, and how to manage them throughout their entire life cycle.

2.5 Asset Management System

The Asset Management System

According to ISO 55000 (2014, p4) an asset management system is "*used by the organization to direct, coordinate and control asset management activities*". A proper asset management system will give improved risk control and assurance that the organizational objectives will be reached. The function of the asset management system is to establish an asset management policy, strategic asset management plan (SAMP) and asset management objectives.

Business processes, information systems, plans and policies should be integrated to achieve the required objectives. ISO 55000 (2014) states that when using an integrated management system approach, the asset management system will build on elements from other management systems. The asset management system can integrate with systems like Health and Safety Management (OHSAS 18000), Quality Management (ISO 9000), Environmental Management (ISO 14000), and Risk Management (ISO 31000). When building on existing system, less effort and resources is needed and the asset management system is more likely to be successful. Integration across different disciplines should also be improved. ISO 55000 (2014) states that an integrated system approach can reduce risk and costs, and improve acceptance of the new asset management system approach.

The asset management system will also ensure coordination between different functional units in the organization. It is important that everyone in the organization have a common understanding of the asset value, and the asset management system assures that every employee works toward the same organizational objectives. Below is a figure that summarise the key asset management terms.

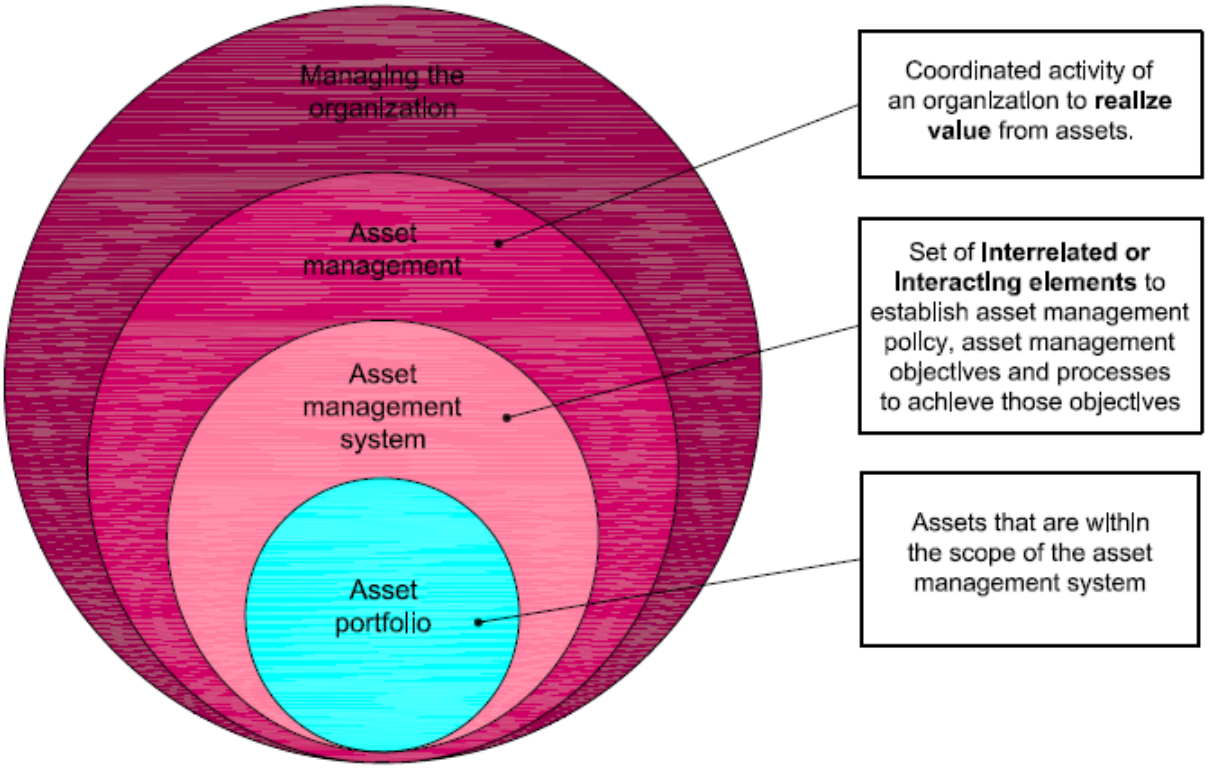

Figure 5 – Relationships between key terms (ISO 55000, 2014, p.4)

Figure 2.2 – Relationships between key terms (ISO 55000, 2014, p4)

There is several benefits of implementing an asset management system (ISO 55000, 2014). The creation of an asset management system provides benefits itself because much effort and resources are needed and this requires new and important knowledge. An asset management system can help the top management to understand the performance and risk of the assets, and use this as a baseline in decision-making. The use of the SAMP will help balancing short-term financial needs with medium-term activity needs and long-term plans. Other benefits with an asset management system is integration of data from different control systems, improvement in communication with employees, and increase in employee creativity and innovation.

The Need for an Asset Management System

An asset management system cover the life cycle management of the assets, and specifically the assets that are the main core of the organisation (PAS 55-1, 2008). These core assets may be oil and gas installations, utility networks, power stations, railway systems, buildings and manufacturing plants. The asset management system is therefore essential to organizations that are dependent on the performance of their assets. Achieving the best value for money is a complex process and involve balancing performance, risk and costs. There is many conflicting factors to manage, like long-term investment against short-term performance. In addition, there are many levels of assets to manage, ranging from single components to complex systems, sites

and portfolios. Figure 5 shows the different asset levels. The hierarchy also brings challenges as the equipment have a defined life cycle and the asset system may have infinite life cycle. Sustainability is therefore an important issue of the optimized management of assets. Organizations may also have several portfolios of assets that increases the complexity of the management. An integrated asset management system is essential to every organization in order to coordinate and optimize the performance of the complex asset system.

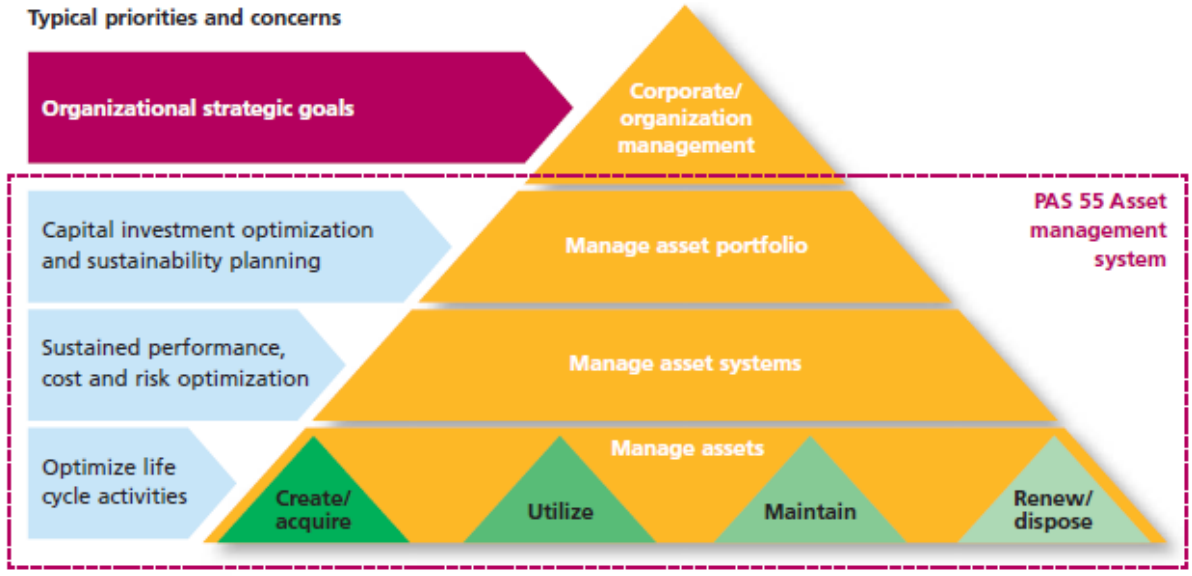

Figure 6 – Levels of assets (PAS 55:2, 2008, p.x)

Another important issue is the demanding stakeholders (customers, regulators and shareholders). The stakeholders needs assurance that the asset management system delivers safety services and financial performance. Organizations are sensitive to their stakeholders, and negative public opinion will directly affect their asset performance and hence the asset system may even fail. This is another reason why organizations "needs" to implement and maintain an asset management system.

2.6 Benefits of Good Asset Management

Benefits of Asset Management

The IAM (2014) states that there exists case studies and hard facts of companies having adopted the holistic asset management approach, and that demonstrate higher performance at lower costs, increased confidence, more satisfied customers and regulators, and more sustainable results. Organizations from different industries provide evidence of higher business performance and their improved ability to manage cost, risk and capability. The adoption of asset management require re-arrangement of the workforce, the breakdown traditional barriers and a motivated commitment to deliver better value-for-money. It is explained in ISO 55000 (2014) that organizations need effective control of the assets in order to achieve the optimum

balance of risk, cost and performance. The benefits of asset management can and should include the following (ISO 55000, 2014, p2):

- *Improved financial performance*: Cost reduction and improved returns can be achieved if implementing ISO 55000. Another benefit with asset management is that the organization may experience improved financial performance without affecting the short and long-term organizational objectives.
- *Informed asset investment decisions*: The organization should improve its decision-making, and hence optimize the balance of cost, risk, performance and opportunities.
- *Managed risk*: Proper management of risk can reduce penalties and insurance premiums. Managing risk in asset management may reduce financial losses, and improve health, safety and reputation.
- *Improved services and outputs*: Asset management can lead to improved services and hence meet and exceed the stakeholder expectations.
- *Demonstrated social responsibility*: Adopting asset management can help the organization to reduce emissions and adapt to the changing climate.
- *Demonstrated compliance*: Asset management can provide compliance to standards, policies, and legal and regulatory requirements.
- *Enhanced reputation*: Enhanced reputation is achieved through improved customer satisfaction and stakeholder awareness.
- *Improved organizational sustainability*: Asset management can improve the organizational sustainability through effective management of short and long-term performance and costs.
- *Improved efficiency and effectiveness*: Continual improvement of processes, asset performance and processes can improve efficiency and effectiveness.

Hard Evidences of Benefits

Lafraia and Hardwick (2013) states that the implementation of asset management have led to improved safety, transforming an old refinery to a world class facility, and even placing a man on the moon. Moreover, Woodhouse (2013a) states that leading organizations are removing 30% of the "total cost of ownership" and hence increases performance and asset life cycle. The outcome of the efforts to better asset management is remarkable. Woodhouse (2013a) presents some hard evidences of benefits of asset management:

- CLP Hong Kong: 90% reduction in system downtime, 40% reduction in tariff charges and 20% increase in asset portfolio
- Nuon Holland: Eliminating 30% of "total cost of ownership"
- Chilean copper mine: 3-10% increase in output with 30% reduction in maintenance cost
- New South Wales government: 11M$/year savings in the budget
- Baltimore power generation: 29% increased output without no increase in costs.

2.7 Other Literature Supporting Asset Management Thinking

As explained by Edwards (2010a), there have existed many asset management principles for decades. Several authors have addressed important asset management principles without explicitly linking them to asset management.

A good example is EFQM's Excellence Model (2003) that is created to help organizations drive performance improvement. Many parts of this model align with asset management, e.g. EFQM states that leaders in excellent organizations unite the employees and establishes a collaborative culture that focus on achieving the organizational objectives. Furthermore, excellent organizations continuously learn from the "best", and is flexible and responsive to the changing needs to customers and stakeholders.

Kaplan and Norton's (1996) Balanced Scorecard and Strategy Maps support asset management. Kaplan and Norton explains that to create value to the stakeholders and customers, it is essential to create long-term objectives within the financial, customer, internal processes, and learning and growth perspective, and these perspectives are shared by the asset management approach. Frankel (2008) further debate that successful management today is about the effective management of change in markets, technology, service, resources and regulatory developments. This is certainly in line with asset management approaches. System thinking is another aspect that support the holistic management of assets and systems. System thinking require a more holistic way of managing the processes that create organizational value (Parnell and Driscoll, 2011). There is several other authors and literature that support asset management, however, this sub-chapter is written to show that organizations supporting e.g. system thinking or uses Balanced Scorecard already conforms to some good asset management practices. Nevertheless, it is worth mention that asset management is an integration framework, and it is not enough to address asset management fundamental elements in isolation (IAM, 2014).

Chapter 3 Asset Management Fundamental Elements

"*Asset Management is best seen as an integration framework that enables organizations to achieve their explicit aims in a structured way*"

(IAM, 2014, p15)

3.1 The Fundamental Elements

Asset management is based on a set of fundamentals elements. If one of these fundamentals lacks in the management of the assets, the asset value will be reduced (Lafraia and Hardwick, 2013). However, it is not enough to implement the fundamental elements, and as stated in the quote above, asset management is about the integration of these elements. Furthermore, the asset management processes needs to be integrated with the other functional processes like human resources, information systems, financial management, logistics and operations. Effective asset management require all these key areas to be aligned with the organizational strategy and objectives, also referred to as providing a clear "line of sight" from the strategy to the daily operations (Edwards, 2010a).

The following fundamental elements align with the IAM's Conceptual Model (2014) which specifies asset management in terms of 39 subjects. The IAM's Conceptual Model align with GFMAM's Asset Management Landscape and ISO 55000. The most fundamental asset management subjects is presented in this thesis, however, to gain a more comprehensive understanding of asset management best practices it is recommended to study IAM's Conceptual Model or the Asset Management Landscape document.

3.2 Value

ISO 55000 (2014) states that assets exists to create value to the organization and its stakeholders. Asset management does not focus on the asset itself, but the value created by the asset. The asset can deliver tangible, intangible, financial and non-financial value. Furthermore, it is the establishment of the decision-making process that determine the stakeholder needs and expectations, and hence the asset value. Another important aspect is the use of a life cycle management approach to realize the asset value.

The IAM (2014) explains that value can be perceived differently since there are numerous organizations that operate within different sectors. An investor seeks high profit, while the customer wants high quality at low costs. Value can be achieved by the buy-and-sell sense, or by the performance the asset provide. The value needs to reflect all the different stakeholder expectations. This process include trade-offs, and it is essential to optimize these trade-offs between short and long term goals, between cost, risk and performance, between CAPEX and OPEX, and between asset utilization and asset care. In addition, value will consist of a combination of intangible and tangible benefits/risks.

3.3 “Line of sight”

Traditional “Silo” Management

Burns (2010) states that during the early 1980s, the origin of asset management engineering occurred, and it included acquisition, maintenance, operation and disposal of assets. Further, as the years passed by, the activities performed by accountant planners, designers and regulators was added to the asset management term. It was recognised the importance of “what is to be done” and “long term”. Up to this date, the organizations have focused on developing better tools and techniques and providing better training to the asset managers. Even though companies have developed better risk management, awareness, understanding, accountability of investments and opportunities, and resource allocation, the companies still work in functional “silos”. Results that are more effective are achieved through the development of an asset management strategy that supports the “line of sight” in the organization.

Figure 7 – Organizations working in functional silos

From the figure above, one clearly see that every single silo is working to increase their own outcome. It is hard to reach the organizational objectives when each manager is managing their silo in isolation from the others. There is no overarching consensus of resource allocation when managing in silos. Woodhouse (2010b) states that it is critical that the corporate value is reflected in the whole organization from the day-to-day activities to investment decisions and strategic prioritization. Traditional management lacks this “line of sight” and it expects improved performance in an environment of conflicting messages, risks and uncertainties. Modern asset management require a broad consensus about the organizational goals and the practical implications required. The requirement of the line of sight between the organizational strategy and the asset management activities is vital in asset management.

Line of Sight

The IAM (2014) states that the backbone of good asset management is the clear connection between the organizational business plan and the daily activities of the different departments (e.g. operation and maintenance, engineering, procurement and management). This clear connection is called "line of sight" since the front line workers needs to know the reason for their activities. "Line of sight" will stimulate creativity and innovation since the workers know what is important, and this may lead to the development of new and more creative ways of performing the work.

Woodhouse (2010, cited in Lloyd, 2010b) explains the importance of integrate the management teams with functional contributions to achieve a single shared purpose. Lloyd (2010b) further explains that it is important that everyone that can affect the asset management plan is both committed and competent to contribute to the achievement of the organizational/asset management objectives. They need to show this commitment to regulators and investors, and be proactive with regards to training, recruiting, selecting and developing people. Top-down strategic planning needs to interact with bottom-up management processes to ensure that the plans are continuously improvement and updated. A combination of assessments, requirements and development processes are needed to make sure that the employees and teams are competent and motivated to make the necessary contribution. Another aspect of "line of sight" is that the organization cannot only focus on the individuals in the organization, and multi-disciplinary teams is essential for success. These teams needs to have people with different background and their competence need to span over all the different disciplines.

3.4 Leadership

Leadership and culture are according to ISO 55000 (2014) essential elements to realize the asset value and to establish, operate and improve the asset management in the organization. Good leadership include commitment from every managerial level to achieve the organizational objectives and to ensure that the employees understand the objectives and their role in achieving them. Consultation with employees and stakeholders regarding changes and improvements in the asset management system is needed to ensure effective asset management (Lafraia and Hardwick, 2013). Competence management is another issue covered by the leaders, as it is impossible to achieve effective asset management without competent employees. Moreover, the IAM (2014) states that there are many different ways to be a good and effective leader. However, all leaders needs to:

- Give the group direction. In the context of asset management, the leaders needs a clear vision of how the organization can optimise the asset value and communicate this vision in a persuasive way.
- Make difficult decisions. Difficult asset management decisions include decisions where the problem is ill defined or non-routine and leaders need to take tough choices that both affect the organization as a whole and the individuals in the organization.

- Inspire staff to work in an effective way to achieve the organizational goals.
- Assure the stakeholders that their expectations will be achieved.

The Asset Management Council (2014) explains that effective leadership transforms the stakeholder expectations and needs into the organizational objectives. Good leadership is needed to change the behaviour and culture in the organization.

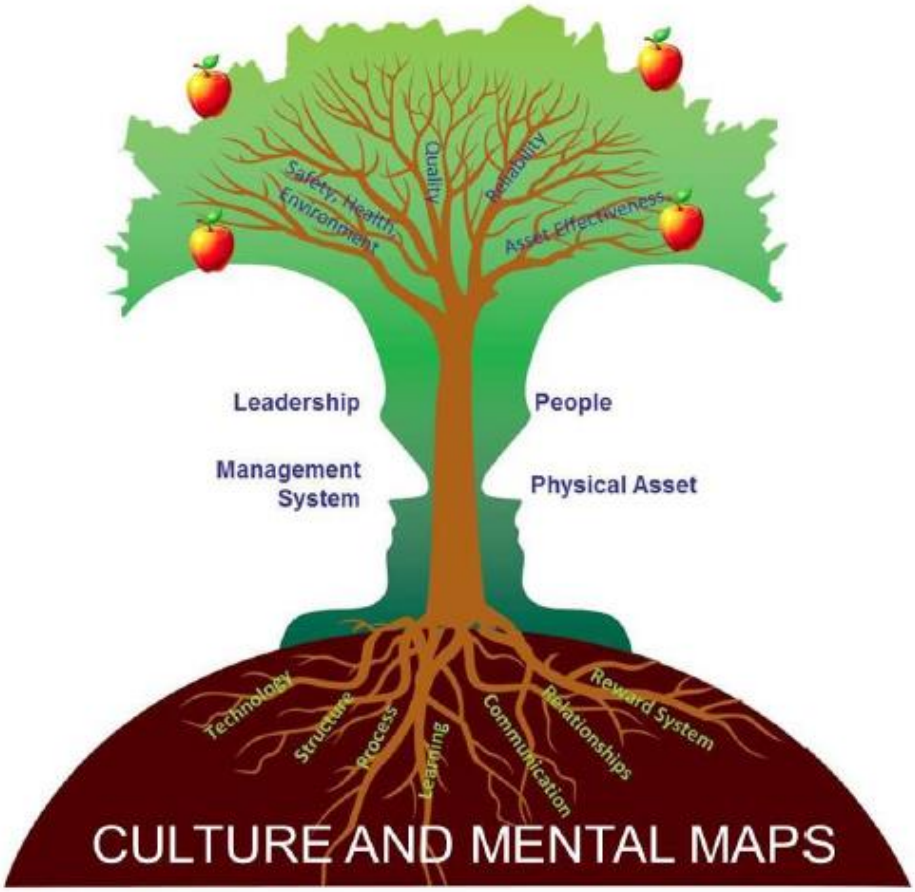

Figure 8 – Asset management needs the right environment to flourish (Asset Management Council, 2014, p.10)

Asset Management Council (2014) explains that asset management needs the right environment (leadership, culture and behaviour) to blossom. Achieving high stock prices, improving efficiency or reducing costs are all possible results from good leadership and culture within the organization. Asset management leadership is therefore crucial in an organization striving to deliver effective asset management.

3.5 Life Cycle Management

The Asset Life Cycle

Hastings (2015) explains that the first step in the asset life cycle is to identify business opportunities or business needs. The requirements of these opportunities needs to be set and the organization should perform an asset capability gap analysis to identify where they needs the asset to contribute. The next step is to perform a feasibility analysis of the preferred asset and analyse how it is going to affect the organization. The steps following is concerning the development of the asset or acquiring the asset, install and implement the asset, and further develop the required logistic support needed to manage it. It is from here the organization operate, maintain and monitor the asset and continuously review the asset to identify improvement options. The last step of the asset life cycle is disposal.

Figure 9 – Asset Life Cycle (LCE, 2013, p.2)

Life Cycle Activities

Asset management life cycle activities consumes the majority of the expenditure in an organization. It exists significant opportunities to identify efficiencies through the deployment of an asset management approach. The life cycle activities should not be considered in isolation, e.g. operation and maintenance go hand in hand. As explained by Edwards (2010a), life cycle management comprises every action taken to execute the asset management plan, and this includes the acquisition of the assets, engineering, maintenance, project management, operations, management of needed resources and disposal (see figure below). These methods are well established, however, asset management is concerned with the integration of these methods.

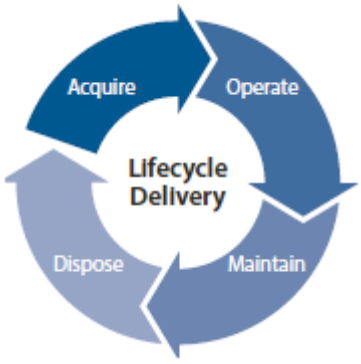

Figure 10 – Lifecycle Delivery (IAM, 2014, p.17)

Asset management would e.g. require the operation and maintenance personnel to be involved early in the planning phase to ensure that future maintenance can be done effectively. Furthermore, the IAM (2014) explains that it is easy to understand Life Cycle activities associated with assets at the lowest levels (e.g. physical equipment). However, these assets only contribute in systems that may have infinite life. Maintenance strategies, asset replacements, functional demands, modifications and other options needs to be considered to fully understand the needed life cycle activities of the asset. One also needs to understand the different periods the life cycle activities, life cycle costs and value realization occur in.

Systems Engineering

It is impossible to conduct asset management on isolated systems, one need to take into consideration the whole asset system and the interdependencies and relations of different systems (IAM, 2014). System Engineering in an asset management context covers effective planning, optimal design and performance at a system level. Furthermore, the Asset Management Council (2014) states that Systems Engineering is an interdisciplinary engineering management process that ensure an integrated, life cycle balanced set of systems. Systems engineering is based upon a "V" process and the different stages in the process is verified to ensure that the outputs of every design stage meet the requirement of the stakeholders. The "V" process consider the lowest life cycle costs as a balance of CAPEX and OPEX, and hence it is possible to achieve the optimum life cycle costs. Systems engineering also includes consideration of Reliability, Availability, Maintainability and Safety (RAMS). Hastings (2014) states that the RAMS requirements is set from technical knowledge, service condition and other requirements. Especially reliability is an important term in asset management since failure can reduce the effectiveness of the service provided, and hence affect the organizational objectives.

Maintenance

As stated earlier in the *State of the Art*, asset management is about the optimizing the trade-offs between asset utilization and asset care. Asset care is per definition maintenance. As stated by Hastings (2014), one of the fundamental elements of asset management is to take care of the assets and ensure that the asset provide the required service and performance requirements. This involves several activities at several levels, e.g. at an offshore plant it includes good housekeeping, first and second line maintenance, and operation and overhauling of the process/machine. The Asset Management Council (2014) explains that maintenance and operations is by far the longest asset life cycle activity. It begins as soon as the asset is accepted and it lasts until asset disposal. Maintenance and operations consume large parts of the costs of asset ownership.

The IAM (2014) states that maintenance can be divided into three groups; inspection, testing and monitoring, preventive maintenance, and corrective maintenance. It is not easy to decide

the right level of maintenance. The asset managers needs to be aware of the techniques available and apply them properly to achieve successful asset performance. The IAM (2014) proposes three maintenance strategy techniques to support maintenance decisions; Failure Mode and Effects Analysis (FMEA), Reliability Centred Maintenance (RCM), and Risk Based Inspection (RBI). In addition, Risk-Based Maintenance can be used to enhance RCM in order to optimize the maintenance. Asset Management Council (2014) explains that organizations needs to understand the functional requirements of the asset together with the asset failure modes in order to establish the required maintenance activities. A good starting point is to use FMEA to identify the possible failure modes and implement maintenance tasks to prevent the failure to occur. The key to a risk based approach is to understand the trade-offs between the maintenance costs and the risks associated with a deteriorating asset (IAM, 2014). If these techniques are used properly, they can support in the development of robust maintenance regimes that can be justified from both a cost and risk perspective to the stakeholders. The IAM (2014) further explains that it is imperative that the planning and delivery of maintenance is optimized to ensure that the performance and service requirements are achieved with minimum lifecycle costs.

One way of addressing the required maintenance, is to integrate asset management with PSA's maintenance management model (the figure below). This model is well known in the oil and gas sector (including Statoil) for managing and improving the maintenance activities. PSA (1998) states that one of the goals of this model is to ensure continual improvement of the activities, products and services. NORSOK Z-008 (2011) further states that the maintenance at an overall level consists of resources, management of work processes and results.

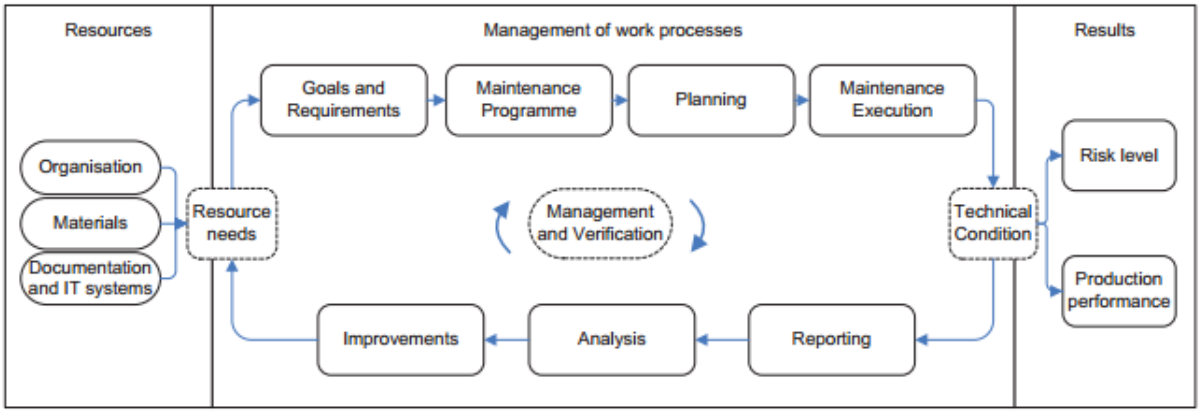

Figure 11 – Maintenance management process (NORSOK Z-008, 2011, p.14)

3.6 Optimized Decision-making

Asset Management Decision-making

As stated by Woodhouse (2010b) the holistic view of asset management will provide better value-for-money. Asset management require the consideration of all associated costs as risks, performance and duration of assets to identify the optimal balance that create the highest asset value. This optimization of costs, risks and performance is one of the most critical attributes of asset management. Furthermore, PAS 55-2 (2008) states that good decision-making require adequate information about the asset and the assets strengths, weaknesses, opportunities and threats. It is especially important to understand the asset management actions and activities, and what their effect is upon the asset in long and short term costs, risks and performance. Many asset management tools and methods are applicable to asset management decision making. These tools can be reliability centred maintenance, value engineering, and cost/risk optimization. It is however important to understand that these tools does not provide good asset management alone.

Optimized Decision-making

The IAM (2014) states that the optimized, risk-based decision-making is one of the core elements of achieving good asset management. This involves finding the optimal compromise of the conflicting issues like asset utilization versus asset care, CAPEX versus OPEX, and short-term results versus long-term sustainability. In practical terms, this often comprise the combination of the lowest risk, cost and performance losses, or it comprise the maximization of net value. One should also be proportionate, and the organization does not need to apply the same level of detail in every decision the take. Simple decisions (non-critical) can be taken with common sense, where the higher impact decisions with several inputs, options and timings require more sophisticated, systematic and optimization methods.

Edwards (2010a) explains that another important aspect of optimized decision-making is the whole-life cost justification. Whole-life cost justification is about analysing the costs and risks over the assets entire life cycle, and identify the optimal way to achieve customer/stakeholder requirements at the lowest possible costs. Whole-life cost justification is often a process integrated with strategy and planning. It is also important to include maintenance and inspection expenditure in the whole-life cost justification to identify the optimum operational expenditure. Many organizations uses Bayesian statistics to create the optimum whole-life cost. Other methods and tools for identifying the optimum operational expenditure is Reliability centred maintenance (RCM) and Risk-based maintenance (RBM).

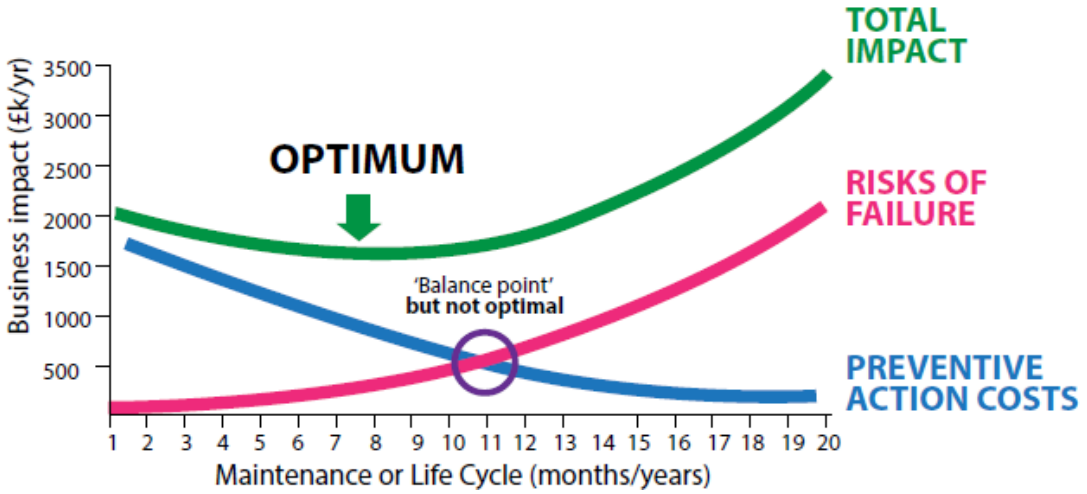

Figure 12 – Optimum value achieved by optimizing total cost/risk/performance impact (IAM, 2014, p.11)

Asset management decisions are often constrained by factors that prevent the optimum solution to be selected. These factors is often budget constraints, resources and/or regulation. The asset manager needs to understand these factors and optimize with them.

3.7 Asset Information

Asset Knowledge

The IAM (2014) explains that asset data, information and knowledge are essentials in asset-intensive organizations. Furthermore, Edwards (2010a) states that asset knowledge relates to the collection, maintaining and disposal of asset information that is in line with the asset management's objectives. The organization should develop an asset management strategy that define the organizational approach to asset information and the criticality of the asset information. Hastings (2014) explains that to achieve successful asset management it is important that the managers understands the requirements of the assets. High standards of awareness enable good asset management. Management needs to communicate to all employees the significance the asset have on the organizational objectives (IAM, 2014). Everyone in the organization should be aware of the specific asset contribution and the interrelationships between the assets. It is not easy to acquire both asset knowledge and business knowledge. Operation and maintenance personnel acquire asset knowledge through their work with the asset, and engineers have detailed asset knowledge. The ideal is to have employees who have acquired asset knowledge which also have an overall business knowledge. Organizations are increasingly using concepts like Building Information Modelling (BIM) to prevent that asset knowledge is lost at key stages in the Life Cycle of the asset.

Asset Information Systems - CMMS

Another aspect of asset information is related to the establishment of asset information systems. Asset information systems are the collection of technology, processes and applications used to support effective asset management decisions and automate asset management processes (IAM, 2014). These systems needs to describe how to manage and store the asset information, and define the quality and accuracy requirements of the asset information. Moreover, Hastings (2014) states that the Asset Management Information System is a computer based system, which helps to create and maintain asset management documents. Over the years, these specific systems have evolved to enterprise-wide asset information systems. Nowadays, these systems are often called Computerized Maintenance Management Systems (CMMS) since they had their origin in the maintenance side of the application. The CMMS are required to handle the massive amount of asset information, and perform continuous monitoring of the asset.

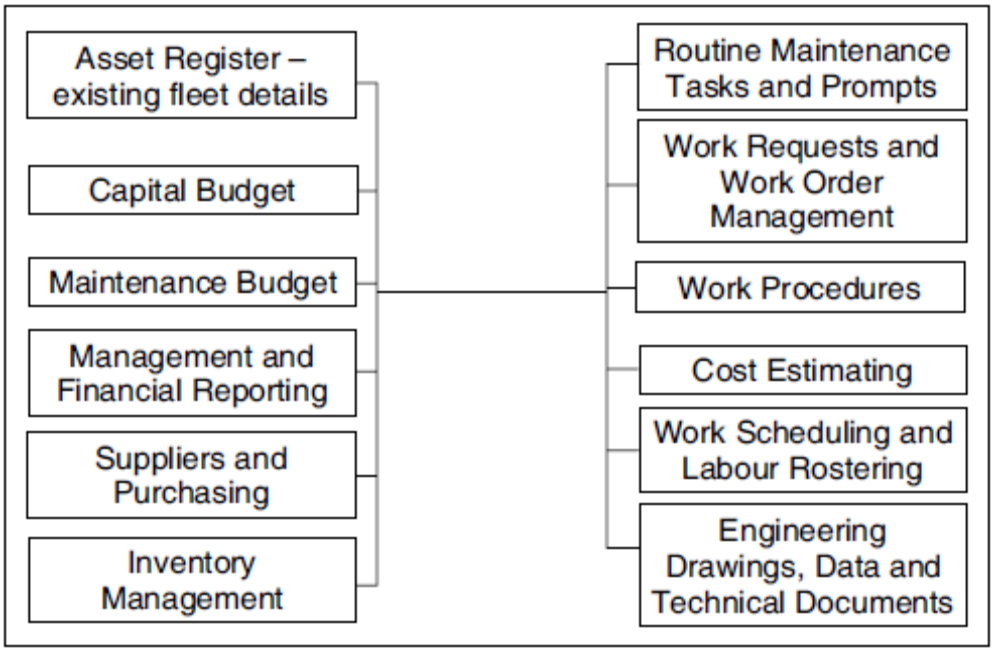

Figure 13 – Asset management information systems (Hastings, 2014, p.244)

The CMMS include work order, work requests, logging, suppliers, purchasing, spare part management, estimating and costing, maintenance procedures and lists, work history, management reports, and the asset register (ref. figure above). Plant specific structuring and coding is essential in the CMMS since when the organization buy the system the databases are empty. Another important aspect in the CMMS is that the managers should develop and maintain a list of the key assets in the organization where the assets age and condition is updated continuously (IAM, 2014). The SCADA systems provide the record of how well the asset is performing and this information should be continuously updated in the CMMS.

3.8 Stakeholders

Liyanage (2012) states that stakeholders in the traditional industrial climate included shareholders and governments, however, organizations operating in the modern industrial climate needs to take into account a wider stakeholder approach. The production and manufacturing environment today is evolving into complex business networks with shared resources and capabilities, and the result of this is a large increase in different organizations as stakeholders. The stakeholders determine the degree of an organization's success or failure, and organizations need to include stakeholders as socially, politically and economically groups in the daily management. The Asset Management Council (2014) complies with these statements as they explains that the stakeholders determine the needs of the business, and hence the stakeholders is a key issue in every asset management processes and decisions. ISO 55501 (2014) define a stakeholder as a person or organization that affects or can be affected by the organization's decisions and actions. Stakeholders can both be internal (employees, owners and board of directors) and external (investors, government organizations, local communities, customers, influencers and vendors). Each type of stakeholder group can affect the business result of an organization (IAM, 2014). Selling defect spares, shutting down operations due to strike notice, issuing penalties for regulation violations, withdrawing a licence to operate and reducing maintenance budget are but a few negative consequences a stakeholder can impose. As seen by the figure below, several influencing stakeholders need to be taken into account.

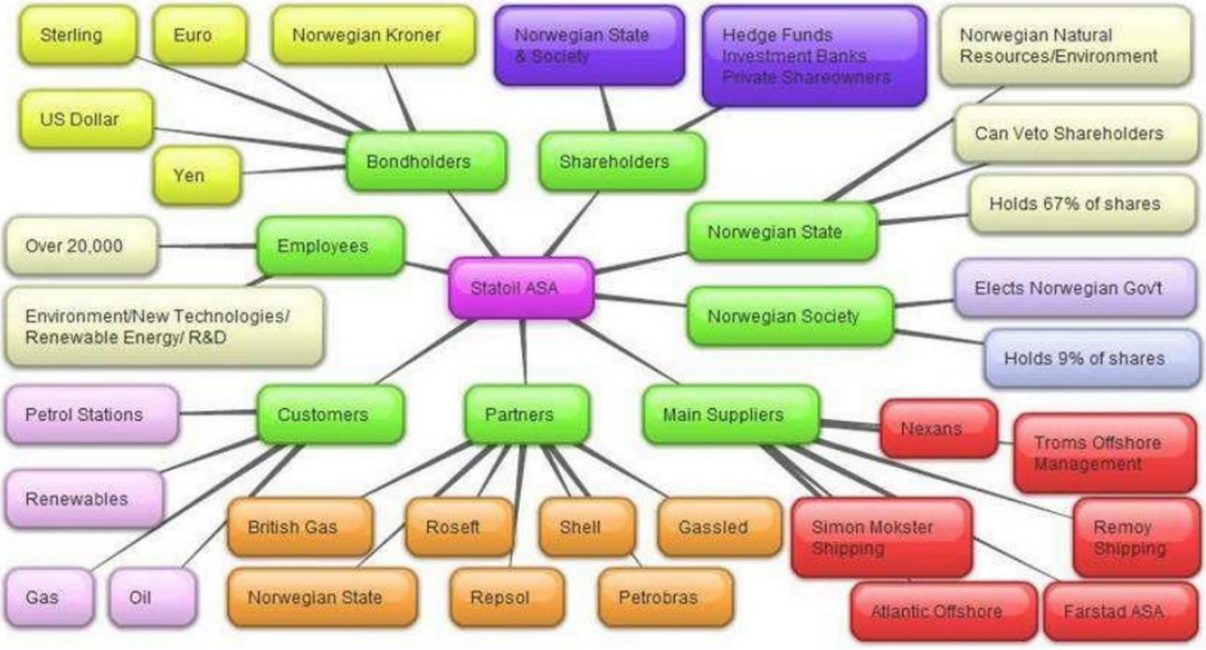

Figure 14 – A stakeholder example (Nolan et al., 2014, p.5)

The stakeholders set the requirements for the leadership needed to achieve the organizational objectives (Asset Management Council, 2014). These requirements often include general public expectations, employee's expectations, shareholder and owner's expectations, regulator expectations and customer expectations. According to ISO 55001 (2014) these expectations

should be documented and communicated. Furthermore, Asset Management Council (2014) states that the stakeholder requirements often include decision making criteria, financial needs, legal compliance, local community needs, and safety and environmental issues. To achieve a successful project, the stakeholders needs to agree on the developed plan.

3.9 Asset Management Planning and Strategy

Asset Management Policy

The asset management policy is a high-level document that specifies the principles an organization uses to manage its assets (IAM, 2014). The AM policy specifies the direction and the intentions of the organization, and it is the cornerstone of the organization's approach to asset management. The AM policy makes it possible to transform the organizational plan into asset management plans and it provide the important asset management element "line of sight". Furthermore, the AM policy needs to be consistent with the organizational strategic plan, and it needs to promote continual improvement. Additionally, the AM policy should provide a commitment to comply with all relevant regulations and laws.

The Asset Management Strategy

According to Burns (2010), the asset management strategy is new to the most of the organizations. It is about the combined decision-making of engineers and accountants taking place both before and between activities. The IAM (2014) explains that a large part of the asset management strategy is concerning the long-term requirements of the physical assets. It provide guidance on how to invest and create maintenance plans, which make it possible to put in place the resources needed to manage the assets. A key requirement of an effective asset management strategy is the development of asset management objectives that are Specific, Measureable, Achievable, Realistic and Time-bound (SMART). ISO 55000 defines the asset management strategy and objectives as the "Strategic Asset Management Plan" (SAMP). PAS 55 (IAM, 2014) states that the asset management strategy needs to have a risk-based approach, consider the Life Cycle of the asset, and it needs to include stakeholder assessments.

The asset management strategy consists of three separate and interconnected layers of decision-making (Burns, 2010). The first level is about looking outward to address the stakeholders, customers and the future of the organization. The vision of the organization should have a long-term perspective. A large effort is needed when deriving the goals and aspirations, and test these against a number of future scenarios to identify the different consequences. The second level decision-making deals with the organization itself, how it is structured and how it is going to achieve its goals. The most successful organizations ensure that there is an appropriate balance between the powers of different sectors and that a section does not dominate others. All the staff should share the corporate values and vision. The third level relates to monitoring the achievement of the organizational goals, and how to update and improve them. The core is the

anchor of the organization and it keeps the organization on track. It is in the core level the practical application of the organizational vision is performed.

Asset Management Plan

Edwards (2010a) explains that strategy and planning is about the different activities and approaches to the development, implementation and maintaining of asset management that is in line with the organization objectives. The outcome of the strategy and planning phase is often an asset management plan (AMP) that describe how the organization is going to manage their assets (individual asset or a portfolio of assets) to get the required business results. There is no set formula for what to include in the AMP, however, it is common to include maintenance and operational plans, capital investments plans, and financial and resource plans (ISO 55000, 2014). Furthermore, many organizations needs to develop planning models to help in the establishment of the AMP (Edwards, 2010a). There are often huge amounts of data and information that needs to be assessed to establish the AMP, and IT systems like planning models will help in doing this.

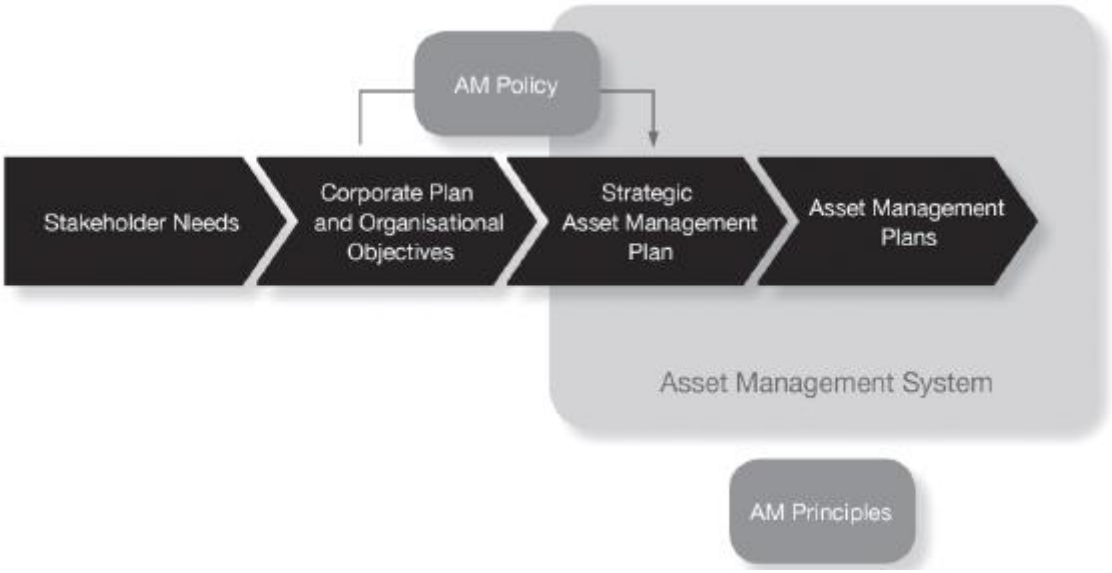

Figure 15 – Organizational alignment (Lafraia and Hardwick, 2013, p.3)

This figure shows the alignment between the stakeholder's needs and ultimately the asset management plans. It is from the corporate plan and the organizational objectives the asset management policy are created that again sets the strategic asset management plan.

3.10 Risk & Review

Risk Management

Risk Management is according to Asset Management Council (2014) one of the fundamental activities within every management system. Risk management techniques figures within both asset management and other management systems like supporting process management and financial decision-making processes. It is from the asset management perspective the risk management process is used to address risks at both an operational level and a strategic level that enable an organization to achieve its goals. This makes it possible to achieve the optimal balance between the costs of treating the risk, the resulting risk from the expenditure relating to the resources and the asset performance. Furthermore, the IAM (2014) states that risk management are a fundamental element that ensure a sustainable asset management system. Risk assessment and risk management is part of the process that enable the organization to achieve maximised value. Organizations needs to understand their tolerance to risk in term of safety, financial, performance, environmental and reputational risks to perform optimal decision making. It is essential to manage stakeholder engagement in the risk managing process, since it is the stakeholders that ultimately face the risks.

The management of risk in relation to asset management occurs at every level of the organization (Asset Management Council, 2014). The organizational risk attitude should reflect stakeholder needs and it should be stored in the risk management plan. The risk attitude should further be evidenced in the procedures and processes used in the asset management system. The evidence should consist of various types of risk tools like FMEA, HAZOP, risk registers, reliability modelling and risk matrix. Different risk management techniques have been used for decades (Edwards, 2010a). A risk matrix (with acceptable, tolerable and intolerable regions) is often used by many organizations. Figure 15 shows a typical risk matrix proposed by NORSOK Z-013 (2010):

Impact category	E					
	D					
	C					
	B					
	A					
	Likelihood	1	2	3	4	5

Figure 16 – Risk matrix (NORSOK Z-013, 2010, p.66)

Hastings (2014) states that in a risk analysis, one is concerned with identifying the risks and reducing their potential outcome through risk mitigation. The outcome of a risk can both have positive and negative consequences, e.g. a construction site may experience good or bad weather. Moreover, Edwards (2010a) states that it may be possible to remove risk in theory, however, the practice approach of removing risk is not easy. The IAM (2014) states that asset

management does not only focus on safety and operational risks, but asset management also consider social, environmental and reputational risks. Addressing these risks can be difficult sometimes since their consequences can be hard to quantify. E.g. climate changes poses different challenges and their consequences can vary from increased occurrence of harsh weather to completely new weather patterns.

Review

As explained by the IAM (2010), review and audit are needed to provide evidence to the stakeholders that the activities are performed in line with standards and procedures. It is also through audits and reviews the organization can measure its performance against the organizational objectives and identify potential improvements.

Chapter 4 ISO 55000

Figure 17 – The ISO 55000 series (Statoil, 2014a)

4.1 ISO 55000 introduction

The new standard is a series of three documents. Used together they provide expert knowledge in the asset management topic (Yates, n.d.). The ISO 55000 series is about the management system of managing assets, and the standard does not tells us how to "do" asset management, instead the ISO 55000 series describe what needs to be put in place to manage the asset. As mentioned at the start, ISO 55000 is a series that consists of these three documents:

- ISO 55000:2014 Asset Management – Overview, principles and terminology
- ISO 55001:2014 Asset Management – Management systems: Requirements
- ISO 55002:2014 Asset Management – Management systems: Guidelines for the application of ISO 55001.

ISO 55000:2014

This standard provide an overview of the principles, terminology and concepts relating to asset management (ISO 55000, 2014). Asset management and asset management system is explained and defined together with benefits of asset management. Furthermore, this standard provide a brief description of each element of an asset management system and explains how these elements integrate (Annex B in ISO 55000).

ISO 55001:2014

This standard "*specifies the requirements for the establishment, implementation, maintenance and improvement of a management system for asset management, referred to as an asset management system*" (ISO 55001, 2014, p v). ISO 55001 specifies 71 "shall" statements and these needs to be fulfilled to achieve the certification. The requirements is build up around the main elements of an asset management system:

- Context of the organization
- Leadership
- Planning
- Support
- Operation
- Performance Evaluation
- Improvement

ISO 55002:2014

This standard provide guidance and notes that should help organizations to implement ISO 55001 (ISO 55002, 2014). Since this standard is a guideline it contains more "should" statements, instead of the "shall" statements. Annex B provide a model for an asset management system together with all the clauses of ISO 55001.

4.2 The creation of ISO 55000

PAS 55 – The Basis for the new Asset Management ISO Standard

Woodhouse (2013b) states that BSI PAS 55 has until now been the formal documentation for good asset management. PAS 55 was formed by the Institute of Asset Management (IAM) in combination with 49 organizations and 15 industries. It was first published in 2004 and later updated in 2008. PAS 55 has been widely implemented by organizations in the whole world, and it have served as a tool to improve their performance and provide better consistency. PAS 55 is primary focused on physical assets, however, PAS 55 recognises that all asset types are interrelated and achieving optimal performance include the management of people, finances, information and other asset types. PAS 55 focuses on removing the traditional "silo" thinking and instead managing assets in systems. This, together with the cross-functional optimization is considered as core elements of good asset management.

Woodhouse (2013b) explains that since PAS 55 was so popular, the work started to create an International Standard. The ISO 55000 series was the result, and 31 countries was participating in the creation. Elements in PAS 55-1 were split into ISO 55000 and ISO 55001. All the terms, principles and terminology is included in ISO 55000, while ISO 55001 only contains the requirements of the asset management system. PAS 55-2 is directly linked to ISO 55002, as

they both serve as a guideline. This new ISO standard aligns and can integrate with other management standards like Environmental Management (ISO 14001), Risk Management (ISO 31000), Occupational Health and Safety Management (OHSAS 18000) and Quality Management (ISO 9001). Since ISO 55000 specifies the requirements for an asset management system and ISO 9001 specifies a quality management system, they can and should be integrated. The requirements in ISO 55000 are structured around Deming's Plan-Do-Check-Act cycle of continual improvement, and this aligns with the structures of PAS 55 and e.g. ISO 9000. ISO 55000 is closing the PDCA loop with management review and audits. The figure below shows ISO 55001 set in a PDCA context.

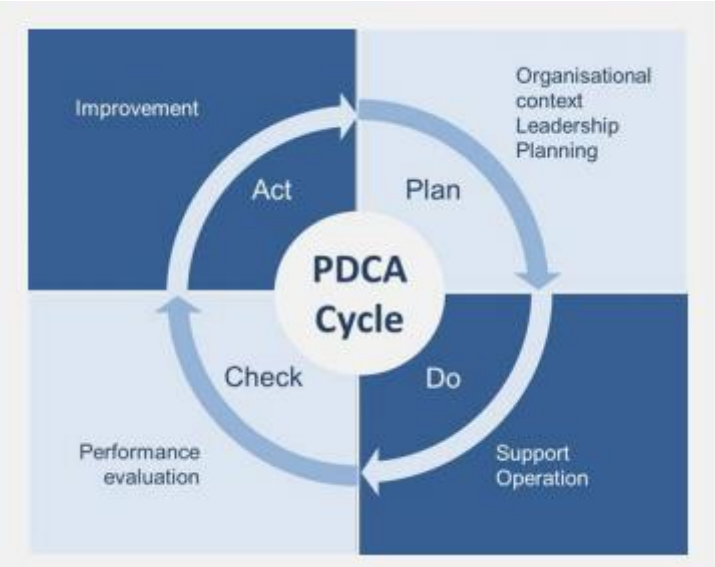

Figure 18 – The PDCA Cycle with related ISO 55000 clauses (Botha, n.d., p.3)

Alignment and Changes between PAS 55 and ISO 55000.

Woodhouse (2013b) states that the main features of PAS 55 is included and expanded in ISO 55000. Nevertheless, the structure of the standard is changed since all new ISO standards need to follow the new standardised terminology and layout specified by Joint Technical Coordination Group in "Annex SL". The structure of every new ISO standards builds upon the PDCA cycle, which is the basis for continual improvement in management systems. Furthermore, Woodhouse (2013b) states that the successful factors that made PAS 55 so popular, is included in the ISO 55000 series. This include:

- Alignment ("line of sight").
- Whole life cycle
- Risk based decision making and risk management
- The enablers for good asset management, including leadership, consultation, competency and communication.

4.3 ISO 55000: An Overview of the Asset Management System

The asset management system is an integrated part of the organizational management system and it has its own structure (ISO 55002, 2014). The asset management system results from the asset management objectives and plan. The asset management system include the asset management policy, strategy, SAMP and the asset management plan.

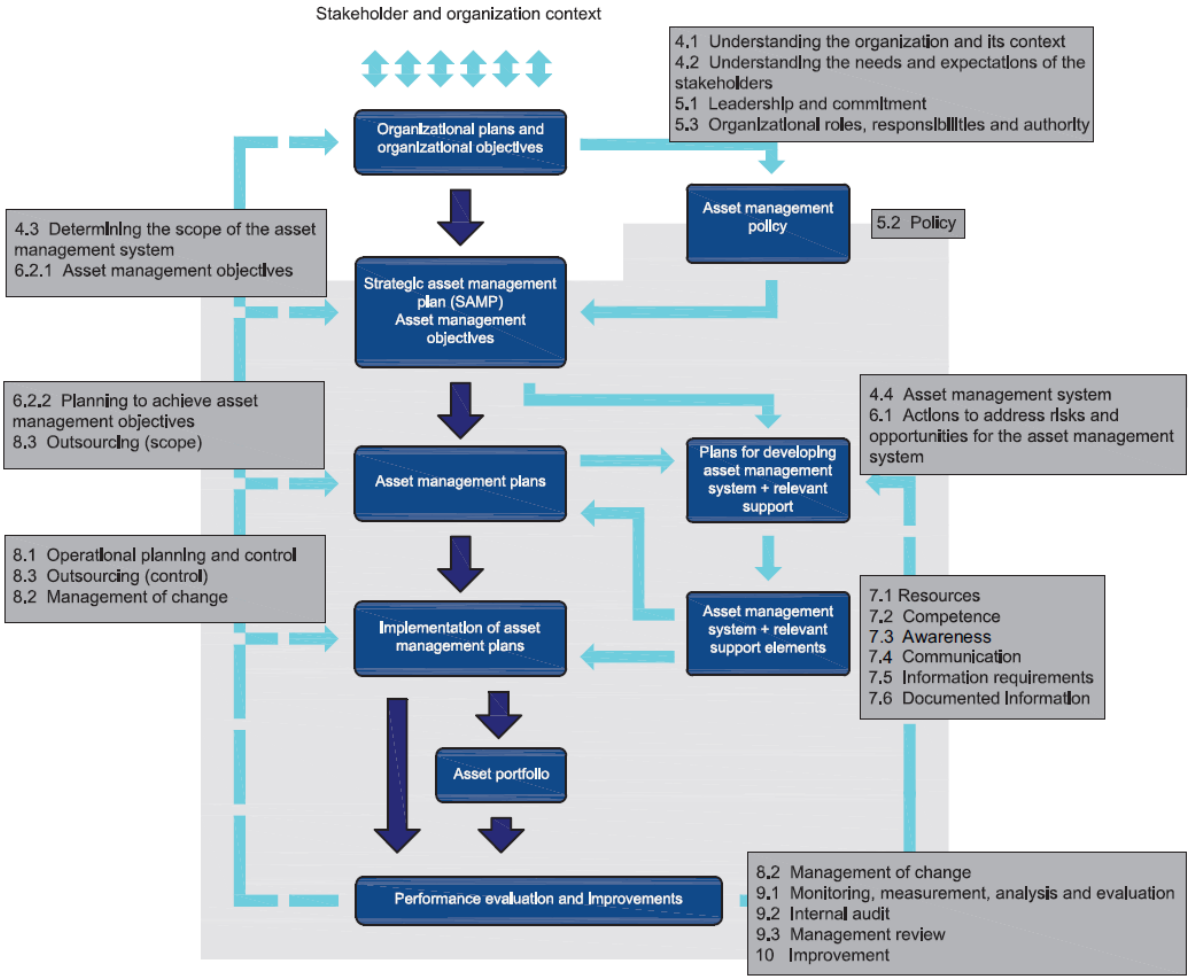

Figure 19 – Relationship between key elements of an asset management system (ISO 55002, 2008, p.30)

It is explained in ISO 55002 (2014) that the scope of the asset management system together with the outputs from the asset management activities enables the organization to reach its organizational objectives. The organizational objectives (stored in the organizational plan) provides the overarching directions of the organization, and hence the asset management activities. The asset management principles that the organization will use to achieve their organizational goals are stated in the asset management policy. The strategic asset management plan (SAMP) documents the approach to implement the principles stored in the policy. The SAMP also documents the connection between the organizational objectives and the asset management objectives. The organizational plan and the SAMP should be developed together in an iterative process. The outputs from asset management activities (e.g. asset management

plans) is key inputs to enable achievable organizational objectives. When developing the SAMP the organization needs to take into account stakeholder requirements and expectations. The SAMP include the asset management objectives, and therefore the SAMP is used to create the asset management plans where all the asset management activities are set. Further, the asset management plans is implemented and the asset management activities are carried out on a daily basis. One of the important elements of the asset management system is performance evaluation and improvements. The organization continually evaluate and identifies potential improvements of the asset management system and implementing the changes.

4.4 ISO 55000: The Main Elements of an Asset Management System

ISO 55000 (2014) states that when developing and implementing an asset management system, the organization needs to have an extensive understanding of the asset management elements and the policies, procedures and plans that integrate them. These elements are explained below, and their detailed requirements is explained in ISO 55001 (2014).

Context of the Organization (Clause 4)

When creating or reviewing an asset management system, the organization needs to take into account the internal and external context (ISO 55000, 2014). Cultural, social and physical environments, together with regulatory and financial aspects is included in the external context, while the internal context comprises organizational culture and environment, and the organizational mission and values. It is also important to account for stakeholder inputs and expectations, as this is also a part of the context of the organization. The organization needs to create, implement and continually improve the asset management system, and the strategic asset management plan (SAMP) needs to be developed.

Leadership (Clause 5)

Managers at all levels are involved in the planning, implementation and operation of the asset management system (ISO 55000, 2014). However, it is the top management's task to develop the asset management policy and objectives. The asset management policy and objectives shall support the organizational policies and objectives. Top management also have the responsibility to create the vision and values, so that every employee in the organization have the same understanding of what values are needed to use the asset management system as effectively and efficient as possible. According to ISO 55000 (2014), the creation of strategies, responsibilities and accountabilities, together with resource allocation, are also top management's responsibility. At last, all managers are responsible to communicating the asset management objectives to every employee, suppliers, stakeholders and customers.

Planning (Clause 6)

The organizational objectives puts out the direction of the organizational and asset management activities (ISO 55000, 2014). The principles that lay as a foundation for asset management in achieving the organizational objectives should be documented in the asset management policy. The implementation of these principles should be written in the SAMP. When creating the objectives it is very important to assess risks and opportunities, and actions needed to address them. The asset management objectives needs to comply regulatory and stakeholder demands, as well as other issues like financial requirements. The SAMP should be used as a guide when setting the asset management objectives and the SAMP also need to describe the role of the asset management system in achieving these objectives. The objectives shall be continually monitored and updated.

Support (Clause 7)

Collaboration, like sharing of resources, is essential to the asset management system (ISO 55000, 2014). Coordination of these resources, together with verifying and improving the resources, should be objectives in the asset management system. It is also important to control and document the asset data and transform it to asset information. The organization needs to define the competence requirements for each person working with the asset. Communication is another important aspect in ISO 55001 (2014) and the organization needs to agree on what, how, when and with whom they shall communicate. Every employees needs to be aware of the asset management policy and their own contribution to the performance of the asset. Information requirements is the last issue in the support clause and there are strict requirements to the creation, updating and the control of the information.

Operation (Clause 8)

With the use of the asset management system the organization shall plan, implement and control the processes to achieve the required asset management objectives (ISO 55000, 2014). If a change is planned or and going to be implemented, the risk associated with it needs to be assessed. Even the outsourced activities needs to be a part of the asset management system, and the risks associated needs to be treated the same way as the internal activities.

Performance Evaluation (Clause 9)

The organization needs to evaluate the performance of the asset management system, asset management and the asset itself (ISO 55001, 2014). The measures can be financial, non-financial, direct and non-direct. Therefore, the organization needs to agree on how and what needs to be monitored and measured. These measures and the analysis, results, and evaluation needs to be documented. How often to monitor and where to store the result are other key issues.

The effective transformation of asset data to asset information is a key to measure the asset performance. Trends should be created with reference to nonconformities and corrective actions. Monitoring, measuring, evaluation and analysing should be a continuous process in the organization. To assess the asset management system, internal audits is needed at planned intervals. These internal audits evaluate if the asset management system reaches the asset management objectives. This is done to evaluate if the asset management system effectively supports the asset management. It is also important to measure the outsourced assets. If the asset management performance does not meet its objectives, evaluation is especially important and new measures needs to be taken.

Improvement (Clause 10)

When a nonconformity or incident occurs, it is important that the management take action and correct the problem, and it is equally important to eliminate the cause of the nonconformity (ISO 55001, 2014). Nonconformities require corrective action, potential nonconformities require preventive action, and these needs to be identified through internal/external audits and management reviews. Continuous improvement of the effectiveness and sustainability of the asset management system is essential, and opportunities for improvement can be identified through monitoring the asset performance. The opportunities need to be risk assessed before implemented. Asset incidents and emergencies needs to be investigated and reviewed to identify opportunities to prevent them in the future.

4.5 ISO 55000 Compliance and Certification

PAS 55 and ISO 55000 Certification

Woodhouse (2013b) explains that organizations that are certified against PAS 55 will not find it difficult to achieve certification to the new ISO 55000 series. However, the clause requirements are not 1-to-1, and effort is needed to understand ISO 55000 and potentially restructure some of the management system elements. Appendix A shows a correlation table that link the requirements in PAS 55 with the requirements in ISO 55001. An organization who already is compliant with PAS 55, and seeks ISO 55001 compliance, could use this table to identify their main gaps. The table is created with reference to Honert, Schoeman and Vlok's (2013) correlation table (with a few adjustments).

The benefits of better asset management are proven in many industries. ISO 55000 is the first international standard specifying the requirements of an asset management system. However, ISO 55000 does not specify how to implement the requirements, and Woodhouse (2013b) expect an unlimited range of future asset management guidance materials, helping the organizations to implement asset management. PAS 55 will therefore continue to be a popular as a guide on the management of physical assets.

ISO 55000 Compliance

Pilling (2010) states that businesses are under constant pressure from demanding customers, stakeholders and regulators to provide higher value of the services without increasing costs and risks associated. A good start for an organization to understand the asset management fundamentals is to start with PAS 55 (and now ISO 5500). Moreover, the leading asset management organization have taken asset management further than the requirements in the PSA 55, as they benchmark their results against others and continually strive to learn the best practices around the world. Compliance is to someone linked to costly affairs. However, compliance can also be viewed as risk mitigation. The requirements in ISO 55000 can help companies from possible losses, loss of reputation and decreased marked confidence. Successful asset management seek compliance against legal obligations, requirements and standards to ensure that the customers and stakeholders are satisfied.

The ISO 55000 series is important when implementing the asset management approach. However, it is not necessary to achieve compliance with ISO 55001 to perform good asset management. The IAM (2014) explains that organizations need to learn the whole asset management approach and not only seek ISO 55000 compliance. The documented policies, strategies and procedures are not essential to perform good asset management, however, organization that seek compliance with ISO 55001 needs these documents, and if done properly it will provide great asset management benefits. The aim of ISO 55001 is that the documents creates value and is fit for its purpose. Bottom line, the ISO 55001 provide a good framework and checklist of the asset management approach, however, it is not sufficient to only use the ISO 55000 standard when approaching asset management.

An interesting final remark is stated by Pilling (2010), who explains that organizations considering ISO 55001 compliance should not ask: “what benefits could we get with ISO 55000 compliance?”, and instead ask: “what are the potential financial benefits of asset management?”

PART 3 ASSET MANAGEMENT, INTEGRATED OPERATIONS AND THE NORWEGIAN OIL AND GAS SECTOR

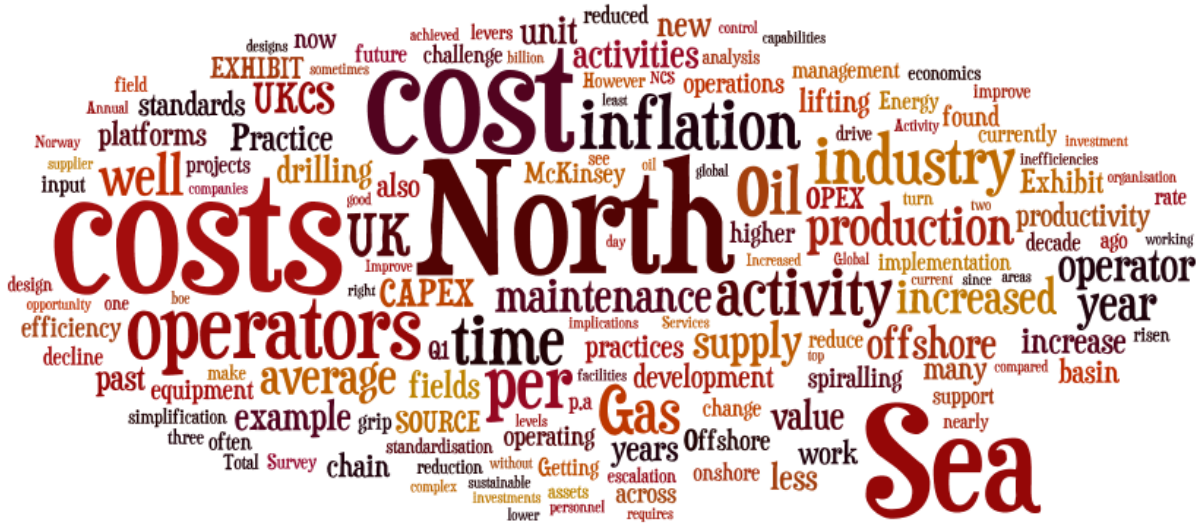

Figure 20 – Common words related to the Oil and Gas Sector (wordle.net)

Introduction

The third part of this thesis is about asset management and the Norwegian oil and gas sector. Chapter 5 begins with an introduction to the Norwegian Continental Shelf and the North Sea. This chapter includes the cost challenges that the oil and gas industry faces, as illustrated in the figure above. Lastly, Chapter 5 elaborates on how asset management as a management philosophy can overcome the current challenges. Chapter 6 presents a brief overview of Integrated Operations, and it outlines seven asset management aspects that should be optimized with the implementation of IO.

Chapter 5 Asset Management and the Norwegian Oil and Gas Sector

5.1 The Norwegian Oil and Gas Sector

The North Sea

Odland (2013) states that in 1959, the large land gas field Groningen was discovered in the Netherlands. Geologists estimated that the same rock formation could be found south in the North Sea. This led to the discovery of a gas field off the English East Coast in the 1960s. In the early 1960s, the oil and gas exploration was without success, however, in 1969 oil was discovered. The subsequent development of the North Sea is one of the world's greatest investment projects. The North Sea is shared between the UK, Norway, Denmark, Germany, Netherlands, Belgium and France.

Figure 21 – The North Sea (Odland, 2013, p.5)

The Norwegian Continental Shelf (NCS)

History

The NCS comprises 2,039,951 square kilometres and it is nearly three times larger than mainland Norway (NPD, 2014). The NCS is divided into three ocean areas, the North Sea, Norwegian Sea and Barents Sea. The North Sea is still the ocean with most active fields in Norway. There is a total of 60 production fields in the North Sea, only 16 in the Norwegian Sea and one producing field in the Barents Sea. See appendix E for a detailed map of the NCS.

The Norwegian oil era started in 1969 with the discovery of Ekofisk. The production started on 15 June 1971 and from this year several large discoveries were made in the North Sea. The following world-class discoveries include Statfjord, Gullfaks, Oseberg and Troll, and until today the NCS have been dominated by these "elephant" fields. Petroleum activities started in the North Sea and have gradually moved north as the technology develops. A large part of the North Sea is now mature and large discoveries are less likely to be found.

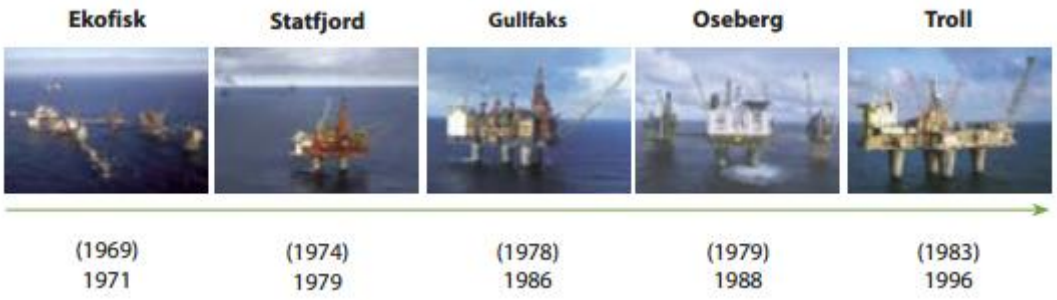

Figure 22 – Historical timeline (NPD, 2014, p.10)

In the early days of exploration, development and production on the NCS, the authorities used a model where foreign companies conducted a large part of the petroleum activities. Norwegian participation increased with the involvement of Norsk Hydro and Saga Petroleum. Statoil was first established in 1972 with the State as the owner. Norsk Hydro purchased Saga in 1999, and in 2001, Statoil was partially privatised. Furthermore, in 2007 Statoil merged with Norsk Hydro. Today, there are about 50 active Norwegian and foreign companies on the NCS.

Current situation

Since production started on the NCS in 1971, petroleum has been produced from 91 fields, contributing to the Norwegian GDP with approximately 11,000 billion NOK. In 2012, Norway was the tenth-largest oil exporter and the third-largest gas exporter in the world. Furthermore, in 2012, Norway was ranked as the fifteenth-largest oil producer and the sixth-largest gas producer. NPD (2014) states that the petroleum activities have been a key factor in the development of Norway's current welfare state. The petroleum industry is still the largest sector of Norway's economy, measured in value creation. Revenue from the petroleum sector constitutes 29% of the State's revenues. It is also worth mentioning that the Government Pension Fund reached 5,000 billion NOK in 2013. Nevertheless, there are still considerable petroleum resources in the NCS.

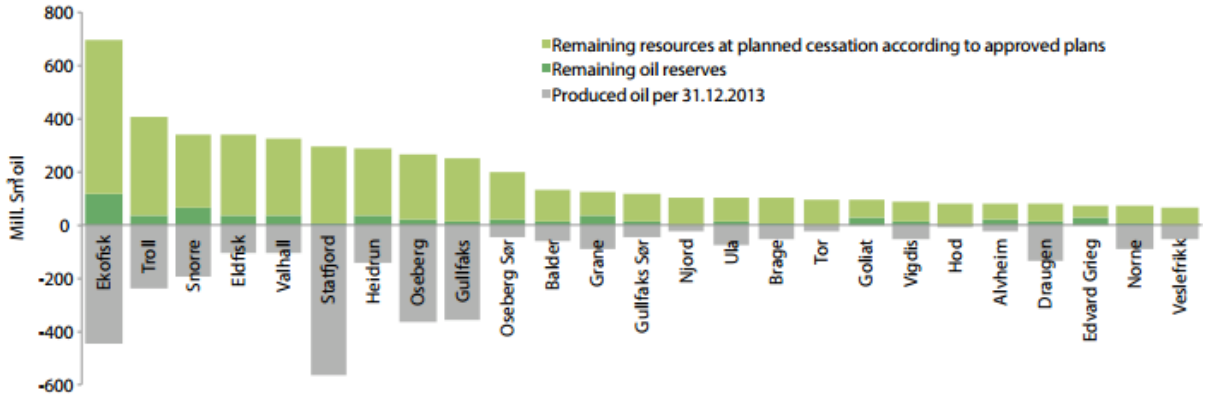

Figure 23 – Distribution of oil resources and oil reserves in fields (NPD, 2014, p.39)

So far, about 44% of the total recoverable resources have been produced on the NCS. The focus for the coming years will be on improving the recovery rate in producing fields and making fields more effective (NPD, 2014). From the figure above, one can see that vast resources will stay in the ground after field shutdown. Several measures need to be taken to produce more of the resources on the NCS. These measures can be divided into two groups; those that increase effectiveness and those that increase resource recovery.

5.2 The Current Challenges in the Norwegian Oil and Gas Sector

The Increasing North Sea Costs

Kar et al. (2014) state that historically, the North Sea was one of the most cost-effective oil and gas sectors in the world. However, nowadays in the North Sea region, the oil and gas costs (especially the operating and development costs) have risen faster than any other industrial sectors in the same region. This has caused projects and activities to be postponed and cancelled, and hence the long-term sustainability of the North Sea oil and gas sector is threatened. The North Sea is becoming uncompetitive compared to other global opportunities. About fifteen years ago, the operating fields had a lifting cost of £ 3-5/boe and development costs of about £4-5/boe. After that, a poor trend of increasing costs have emerged. The average lifting costs was £17/boe in the UK sector in 2013. With this increasing trend, which is a combination the inflation rate and the declining production rate, one will probably get a graph like this:

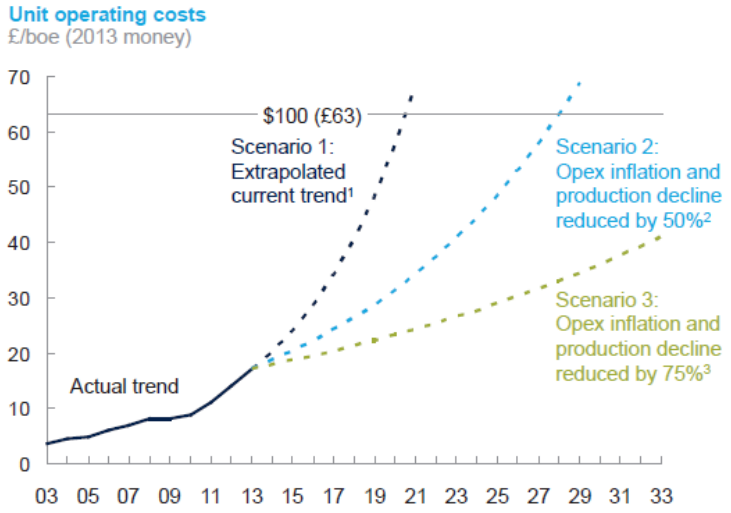

Figure 24 – Continued inflation will affect the future profitability of the basin (Kar et at., 2014, p.3)

One can clearly see that if the inflation rate continues to be at approximately 10% and the production rate declines with 7%, the lifting costs will reach $100 within 6 years from 2015. Even if the cost inflation and the production decline rate are reduced by 50%, the lifting costs will reach $100 before 2030.

Factors behind the increasing costs

The North Sea is becoming a mature basin with many operators, fields and platforms (Kar et al., 2014). The reservoirs are becoming more complex, as all the "easy" oil has already been produced. Another cost-increasing factor is that more safety and environmental regulations are now in place than before. Kar et al. (2014) have identified other cost-increasing factors such as higher activity levels, increased input costs per unit and lower efficiency.

The Declining North Sea Asset Production Efficiency

Cole et al. (2014) state that the asset production efficiency in the North Sea has fallen to a record low value, resulting in billions lost in revenue for the governments. Historically, the North Sea has delivered enormous amounts of oil, and with the help of "elephant" fields like Ekofisk, Norway has produced 39 billion boe. However, Cole et al. (2014) demonstrates that the production efficiency declined from 81% in 2004 to just 60% in 2012. The graph below also shows that the production efficiency of both NCS and the United Kingdom Continental Shelf (UKCS) has declined with 1% per year over the past decade.

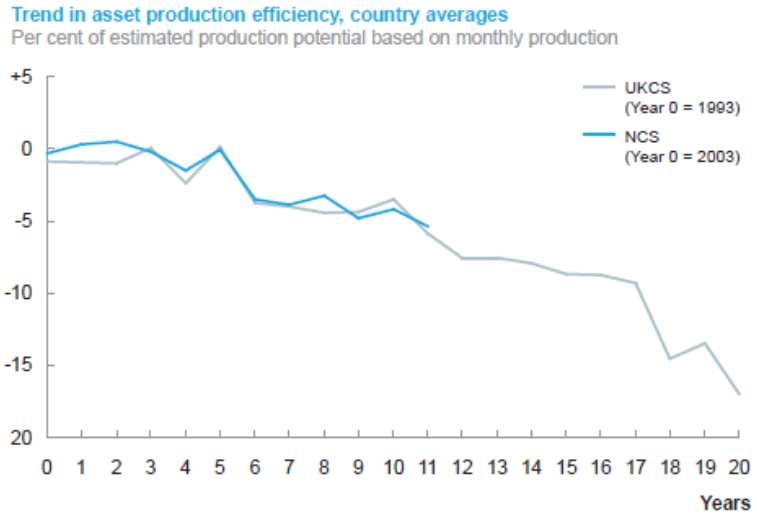

Figure 25 – Asset production efficiency trends in the UK and on NCS (Cole et al., 2014, p.2)

This decrease in production efficiency has cost the North Sea industry over 900 million boe and $60 billion in revenue since 2005.

Factors behind the declining production efficiency

There exists a common belief that the increasing age of the production plant is the main reason for the production efficiency decline. This is however, wrong, and as explained by Cole et al. (2014), the production plants that are 30 – 34 years old have equal production efficiency as the ones that are only 5-9 years old. Some of the main reasons for the production efficiency decline are plant equipment failure and unexpected shutdowns, along with third-party export hubs. However, there is another factor that is equally important and it differentiates the high-performing operators from the poor. The operator maintenance and reliability practices and approaches have huge impacts on the decreasing production efficiency. From their research, Cole et al. (2014) revealed that within maintenance and reliability, there were three practices in particular that differentiated the high performing organizations from the others. The high performing operators where "better" in (Cole et al., 2014, p6):

- "*Challenging and minimising planned downtime*"
- "*Continually improving reliability by learning from failures*"
- "*Creating a culture of responsibility in operations*"

Meeting the Challenge of Increasing Costs and Decreasing Production Efficiency

Handscomb (2014) states that the organizations should shift from managing volume to managing value instead. Leaders that execute on value will quickly adapt to the complex operational environment and have higher probability of creating a sustainable future. Furthermore, Cole et al. (2014) state that the organizations should focus on fixing the basics of

maintenance and reliability. This requires the top management to be committed to change, front-line workers to improve their competences and capabilities, the establishment of a "one-team" culture, and the creation of clear performance goals of the asset. Another focus area should be in the establishment of standards for common operating tasks. Kar et al. (2014) states that the organizations should communicate the cost drivers throughout the organization, creating a clear "line of sight" that enable every employee to understand how his/her decisions affects the costs in the organization. As explained later in this chapter, Statoil and other offshore organizations have acknowledged these challenges and started to implement Asset Management as a response.

5.3 Asset Management in the Oil and Gas Sector

Woodhouse (2010a) states the integrated asset management concept has been developed and used with a varying degree of success in different sectors. One of the most successful sectors in using the asset management approach is the oil and gas sector. It was from the oil and gas sector that modern asset management developed and this is clearly reflected in the PAS 55 structure. However, organizations in the "downstream" oil industry, like petrochemical organizations, have been some of the slowest to apply asset management approaches and techniques. Moreover, even though many of the manufacturing companies have adopted good practices, such as total quality and lean, they lack the overarching structure that balances long term values with short-term results and actions. Shea and Hollywood (2013) explain that it is surprising that the "downstream" offshore oil and gas industry is not very familiar with asset management and the newly-developed asset management standard, ISO 55000. The offshore oil and gas industry have an asset-demanding nature of fixed platforms, floating platforms and subsea production units, and these assets need to be managed with reference to HSE risk management and productivity.

Asset Management History in the Oil and Gas Sector

Woodhouse (2010a) states that it was the North Sea oil and gas industry that developed many of the core principles of integrated, optimized and lifecycle physical asset management. The asset management model emerged from a series of serious events in the 1980s that threatened the whole existence of the oil and gas industry. In the 1980s, the oil price fell below the production cost, all the easy oil was produced and finally the Pipe Alpha disaster killed 167 people. BP and Shell discovered that, despite their extensive technical competence, smaller oil companies were delivering much better production margins. BP created the BP MAST experiment, where the sole purpose was to maximise the value of declining reservoirs. The multi-disciplinary members of BP MAST were given free roles in what to decide and do, and finally the experiment was a huge success and BP implemented the model in every BP

production facility. BP went from being a middle-ranked performer in the North Sea to a top-ranked performer in the whole world. Shell did a similar project and as a result enjoyed radical improvements in their performance. One of the reasons for the successful projects was the approach to lifecycle asset management. Another result from the experiments/projects showed that both Shell and BP were in need of radical changes in the culture, processes, roles, decision-making processes, performance measures and risk management processes.

An Asset Management Business Model for the North Sea Oil and Gas Sector

The North Sea Oil and Gas Asset

The obvious physical equipment assets are only a part of the systems needed to achieve the organizational goals (Woodhouse, 2010a). To survive in the oil and gas business, one needs to find an oil reservoir, construct extraction platforms, operate and maintain the platforms and finally dispose of the platform. These operations require physical infrastructure as well as different personnel, knowledge, support systems, logistic systems, data information, and supplier relationships. To achieve the maximum value from the North Sea asset, all the elements need to be combined to provide the optimum lifecycle value to the whole system. An offshore production infrastructure is a very complex system and it has several complex production assets like a gas-treatment unit, a power station, a heliport, a hotel, and so on. It is all these different asset types, together with operational processes and the skills/requirements of personnel that define the required resources. Asset management recognises that the total output of all these systems and processes represent the North Sea asset performance.

The Asset Manager

Woodhouse (2010a) states that each North Sea asset requires a specific asset manager who is concerned with inputs, outputs, sustainability, service and safety, and who is responsible for the asset lifecycle costs. The asset manager needs to have clear accountability for the performance results of the asset. The asset manager needs to have not only extensive asset (e.g. platform) knowledge, he/she also needs excellent communication skills, risk management skills and leadership skills. The asset manager's task is to optimize CAPEX and OPEX, short and long-term production benefits, regulatory compliance and risk management processes.

The Asset Management Team

The asset manager holds the mandate that defines his/her freedom in managing the assets and the asset objectives (Woodhouse, 2010a). Representatives from each department support the asset manager and form the asset management team. In a North Sea asset, the departments would include production, drilling, human resources, reservoir development, maintenance,

transport, energy and finance. The asset management team is a multi-disciplinary team with shared responsibilities.

The Strategic Asset Management Plan (SAMP)

The SAMP has many different names as it also may be called the asset reference plan or whole-life asset management plan (Woodhouse, 2010a). Nevertheless, regardless of the different names, the content is the same and it is imperative for an offshore asset to create a SAMP. The SAMP is a cross-functional picture that considers long-term and short-term risks and opportunities, how they affect performance, cash flow, resource management and SWOT analyses. Furthermore, the SAMP contains key information such as asset life predictions, the asset strategy, how the asset management principles will be implemented, and references to detailed information sources such as production forecasts, resource requirements, and main assumptions and uncertainties. Finally, one of the most important functions of the SAMP is the translation of business objectives into asset-specific realities, opportunities and plans.

5.4 Asset Management as an Approach to Overcoming the Challenges in the North Sea

As explained by Shea and Hollywood (2013), the North Sea oil and gas industry has an asset-demanding nature of fixed and floating platforms, including subsea production units that needs to be managed with reference to HSE and production. Furthermore, Woodhouse (2010a) states that offshore production infrastructure is very complex and several complex production assets exist within these production facilities. To achieve high value from the North Sea asset, all the elements and processes need to be combined to provide the optimum life cycle value to the whole system. A holistic approach is required to manage assets throughout their life cycle. Asset management suits the oil and gas industry since it is about optimizing the whole life cycle of the assets and balance the associated costs, risks, and performance. The lack of a formal asset management standard has left the North Sea oil and gas companies to determine their own best practices (Shea and Hollywood, 2013). Without a formal asset management standard, the organizations' assessments regarding risks, reliability and unplanned events have been more arbitrary. The new ISO 55000 standard will change the game, and it should at the least be used as a guide to adopting the asset management approach.

An organization that has adopted good asset management practices will achieve results that are different from their competitors (Hawkins, 2013). One of the most obvious characteristics is that the organization will have a clear understanding of how their assets (tangible/non-tangible or physical/non-physical) will contribute towards achieving their organizational goals and objectives. Furthermore, there will be a clear "line of sight" between the organizational objectives and the daily operations and activities performed by every employee in the organization. This "line of sight" will enable every function to understand how they contribute

to the business results, and hence help them to avoid decisions that would sub-optimize their function at the expense of others. Furthermore, "line of sight" will stimulate creativity and innovation since the front line workers know what is important, and this can lead to the development of new and more creative ways of performing the work, which again can lead to increased production effectiveness and lower costs. If several processes break down at an offshore asset, the managers would immediately know which process is most critical regarding the achievement of the business results. Today, this "line of sight" between the business results and asset performance results is lacking, and there is not always a focus on the processes that contribute most to the business results.

Another asset management characteristic (of an ISO 55000-compliant organization) is that the ownership and accountability will remain at a top management level (Hawkins, 2013). Moreover, they continually ensure that the organization values asset management at the same level as quality, safety, environmental and other considerations. Top management performs reviews to ensure that the asset management system performs its function, as well ensuring that corrective and preventive actions are taken when required. In addition, top management ensures that employees working with the asset management system have the necessary competence, authorities and responsibilities. Lloyd (2010b) states that asset management is a response to the fast-changing, competitive and cost-conscious business environment, and knowledge and learning are key factors to ensuring success. The organization needs to demonstrate the necessary competence in every function that is related to the asset, which includes competence in design, operation, maintenance, installation and disposal (Statoil, 2014a). In other words, the organization will demonstrate competences in the whole life cycle of the asset. In addition, there will be a clear understanding of every risk and opportunity that exists in relation to the asset (Hawkins, 2013). Understanding the opportunities is essential, as it enables the organization to deploy capital where it produces the highest value.

The asset management approach will provide the managers with a mutual framework for supporting the asset decisions and ensuring the direction of the organization (Rugsveen, 2014b). The managers will get an overview of the assets, the asset value and their value contribution, including where the money is spent and where it contributes most to optimising the value creation. In addition, the management will conduct stakeholder analyses where all the needs and expectations of both internal and external stakeholders are identified. This will help in the establishment of communication procedures with the stakeholders, as their perception of the organization is vital for future success. Furthermore, the employees will speak of value instead of costs and clearly understand how the different assets produce value. Their actions will be based on a "whole life" view of the assets instead of a short-term approach, and hence the life cycle costs will be lower.

Woodhouse (2010b) explains that there is no doubt the discipline of integrated, risk-based, optimized, whole-life management of assets is here to stay. The North Sea oil and gas industry is facing environmental, financial and demographic pressure and asset management is needed to do things right. It is not possible to buy cheap solutions and or "do things the easy way",

nowadays the organizations need to get smarter. A North Sea asset as a viable business contributor needs to comprise the best combination of personnel, knowledge, data, licences, relationships and logistic systems to enable the maximum life cycle value. Moreover, to achieve the optimum allocation of costs and resources, the asset boundaries need to be as clear as possible. These issues are important in the asset management approach and the newly-developed ISO 55000 (clause 4.3 – Asset boundaries, clause 7.1 – Resources). The benefits of performing asset management are substantial, and the consequences of not adopting the asset management approach could be severe. Woodhouse (2010a) states that asset management includes some well-proven methods such as Reliability Centred Maintenance (RCM), Risk Based Inspection (RBI), Life Cycle Costing (LCC), Total productive maintenance (TPM), Root cause analysis, and Systems Engineering/RAMS Engineering. These methods have the potential to increase the asset value, e.g. lower the costs and increase production effectiveness. Appropriately targeting RCM to critical assets has proven to both reduce maintenance costs (by 20-40%) and improve system reliability. Woodhouse (2013a) presents evidence of the effectiveness of asset management with CLP Hong Kong, that had a 90% reduction in system downtime, and Chilean copper mine, that had a 30% maintenance cost reduction. Additionally, the Norwegian transport group NSB have improved their performance significantly by implementing RAMS Engineering and RCM (Rehman, 2013). NSB have experienced a reduction of around 50% in stopping errors across their whole fleet and a doubling in their MTTF. RCM has contributed to increasing their fleet utilization and reduced the total maintenance costs.

Chapter 6 Asset Management Optimization through IO Implementation

6.1 Introduction to Integrated Operations

The Norwegian Oil Industry Association (OLF) was already in the mid-90s concerned about the different challenges that were emerging in the NCS (Liyanage and Langeland, 2008). As discussed in Chapter 5.3 - *Asset Management in the Oil and Gas Sector*, it has become clear that the lifting costs are rising, and the production efficiency and oil price is decreasing. In addition, a large part of the Norwegian oil and gas portfolio has reached maturity, and hence the production profile is declining. This indicates that the Norwegian oil and gas sector will experience a great number of challenges in the future regarding risk reduction and increasing the value of their assets. One way of tackling these challenges is the adoption of a smarter and more integrated operational environment (Liyanage, Herbert and Harestad, 2006). This concept was introduced by the Norwegian oil and gas industry, and it was the development of high-speed communication networks through optical fibre cable between the platforms on NCS, that kick-started the development of Integrated Operations (Statoil, 2015b). This made it possible to increase the collaboration between the offshore platforms and the onshore organization.

Different concepts have been developed to handle the emerging challenges and they have been named among others: Integrated Operations (Statoil and OLF), Smart Field (Shell), eField (Hydro), Intelligent Plant (TOTAL), Digital Age Operation (Halliburton) and Intelligent Field (BP). However, the key elements are the same (Resource, 2010; Statoil, 2010), and include:

- use of advanced information and communication technology (ICT) and real time data,
- advances in automation and sensor technology,
- evolution of new work processes and operational concepts,
- organizational change; the mitigation of functions from costly offshore sites to onshore locations

Since this thesis is written in collaboration with Statoil, the term Integrated Operations will be used, and this term is consistent with the recommendation from OLF (2003). Moreover, Statoil's definition of Integrated Operation is:

"*IO is a method based on the interaction between man, technology, organization (MTO) focused on effective interaction and utilization of data, competence and experience across the organization and disciplines regardless of location*" (Statoil, 2015b).

The concept of MTO shows that Integrated Operations is concerned with more than just technological steps. Statoil, as one of the leading producers in the North Sea, has recognised the potential of Integrated Operations to increase oil recovery through new process frameworks that link real-time data to collaborative and analytical resources across organizational boundaries (Resource, 2010). The Integrated Operations solution will contribute to increased recovery rate and hence Statoil and other operators on the NCS will prolong the life span of the

fields and increase the economical revenues. Moreover, the OLF (2007a) has estimated that the potential value of Integrated Operations is about 300 billion NOK.

6.2 The Integrated Operations Concept

Integrated Operations is about gathering all the different systems, suppliers and workers into a common platform. IO expands the system boundaries, and integrates people across geographical, organizational and disciplinary boundaries (Filstad and Hepsø, 2009). Moreover, IO requires the integration of new business processes and advanced technology that is supported by the organization (Resource, 2010). The integration of people, processes and technology define Integrated Operations. The focus of Integrated Operations is to enable efficient exploration of both mature and marginal fields, and to develop effective ways to manage operational risk together with economical exposure. Other focus areas include the use of advanced application technology and joint industry competence to enable efficient and effective work processes and offshore activities (Liyanage, Herbert and Harestad, 2006).

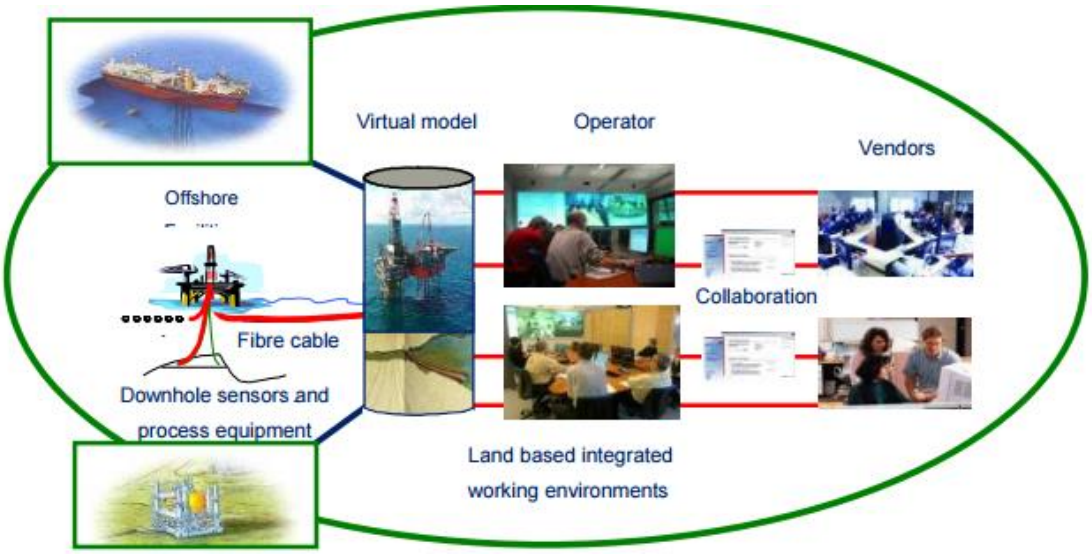

Figure 26 – Integrated Operations (Filstad and Hepsø, 2009)

Integrated Operations uses people and technology to remotely monitor, model and control the offshore asset processes regarding safety and the environment in a way that maximizes the life cycle and value of a field (Filstad and Hepsø, 2009). Real-time data and information is available from the offshore asset through the high-speed fibre optical cable. This offers great flexibility, as it is not necessary for experts to travel offshore to address production problems; the experts can collaborate with both the onshore and offshore operation team from his/her own workstation anywhere in the world. Vendors can monitor their equipment and collaborate with the operator, as shown in the figure above. Different experts with multidisciplinary backgrounds, inside or outside the organization, can analyse the information in virtual collaborative environments to support and optimize the production of oil and gas. When for example drilling a well, a team of geologists on land receive real-time data and information

from the operation, which they can analyse to identify if the drilling is on track (IS Partner, 2008). They closely communicate with the drilling operators offshore to make adjustments on the drilling path or to optimize the drilling operation.

On a large proportion of the offshore platforms, a huge amount of data is generated (IS Partner, 2008). The wealth of data is often not utilized optimally since the offshore teams are focused on the day-to-day operations and maintenance activities. The sensors offshore create large amounts of raw data that needs to be interpreted and analysed before it becomes useful. Integrated Operations ensure that all this data is provided in real-time to dedicated functional teams onshore that analyse and process the data to extract the useful information. This useful information is fed back continuously to the offshore platform, e.g. if the temperature in a bearing is rising fast, the onshore team notifies the offshore team and they can replace it before breakdown.

If an organization decides to implement Integrated Operations, there is a need for large organizational changes (OLF, 2003; Statoil, 2015b). A key element of IO is the evolution of new work processes and operational concepts, and the organization needs to change their existing work processes and implement the use of new technology like smart sensors and video conference systems. In order to successful implement the new work processes, the organization needs to be flexible and, as stated in Resource (2010), the organization needs to ensure that their people have the same mentality of being present in this new work culture. Moreover, OLF (2003) states that the largest organizational challenges are the conflict of interest and willingness to change work processes. Strong leadership is required to meet these challenges. Below is a summary of the IO work processes against the conventional work processes:

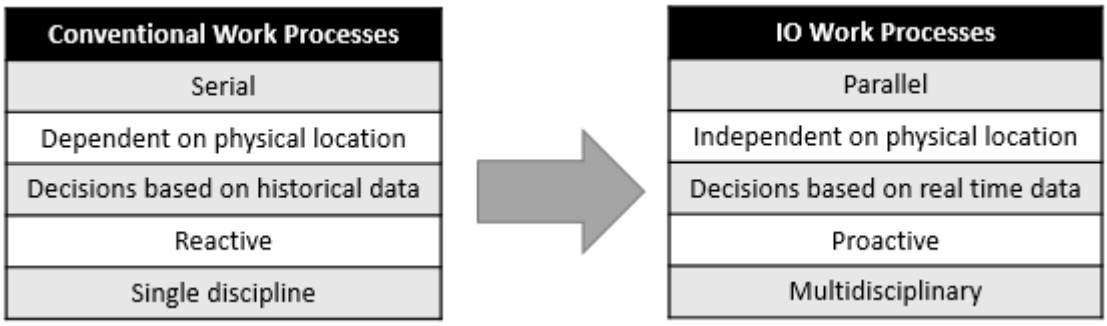

Figure 27 – IO Work Processes vs Conventional Processes (created with reference to OLF, 2007b)

Integrated Work Processes

In 2004, OLF initiated a value creation program for the NCS through the implementation of Integrated Operations (OLF, 2005). The program's main task was to describe the future work processes for drilling, reservoir, production management, and operation and maintenance. The OLF program predicted that there would be two generations of future integrated work processes. Both generations would/will improve the speed and quality of decisions and value

creation on the NCS. OLF believed that, in 2005, they stood on the verge between traditional practices and the first generation of IO.

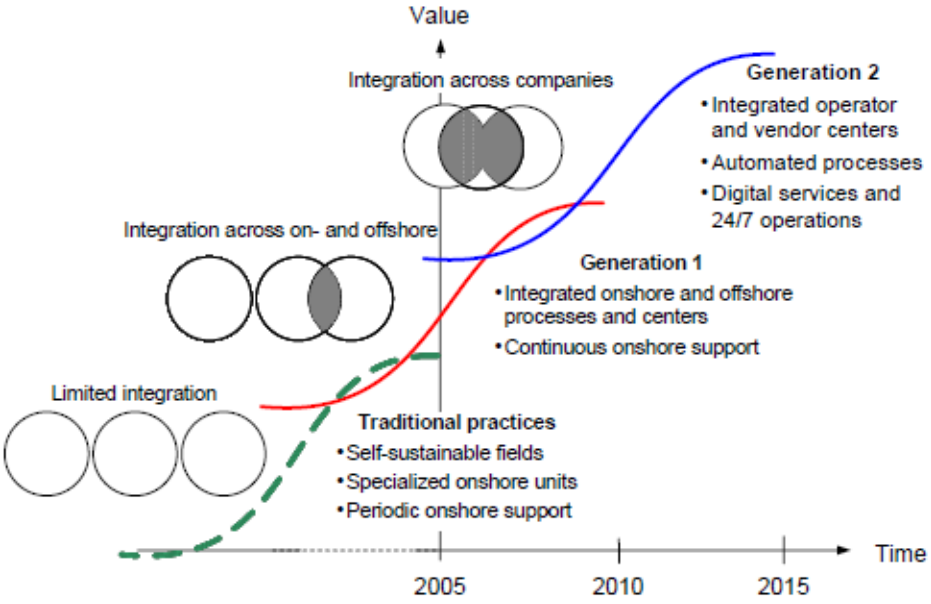

Figure 28 – Integrated work process development (OLF, 2005, p.9)

The first generation of Integrated Operations is characterised by the development of onshore centres that are integrated with the offshore operations through collaboration facilities (OLF, 2005). These collaboration facilities ensure that personnel both offshore and onshore receive the same information at the same time. The onshore centres consist of professionals of different backgrounds that have the competencies required to make the necessary decisions. In some areas, like drilling, the onshore centres provide 24/7 support to the offshore drilling operation. Furthermore, the professionals at the onshore centre can perform "what-if" analyses, elaborate on different consequences, integrate activity plans and communicate with the offshore personnel through video/conference rooms that are established for communication, monitoring and sharing of real-time data. Both onshore and offshore personnel from different departments gather in these rooms and work together to optimize e.g. the production.

The second generation of IO will lead to closer integration of the work processes between the vendors and the operators, and equally importantly, lead to the development of digital services. These digital services are operational concepts that are based on several services needed to control and operate an offshore platform via the fibre optical cables. A typical offshore oil and gas field will be controlled by an onshore operation centre, which consists of both operators and vendors. The vendors will lead some of the daily work and decision-making processes that were previously carried out by the operators. These onshore centres will provide 24/7 support and will make use of extensive filtering of information to avoid information overload. Another important aspect within the maintenance area is that the use of CBM methods and "roving teams" will replace the traditional practices and improve maintenance efficiency.

Integrated Operations and a Specific Offshore Asset

Statoil's Gerhardsen is a low manned installation controlled from the central control room (CCR). Gerhardsen's strategy is to approach IO Generation 2. This includes, compared to the traditional approach, that additional data is gathered from the field due to advances in technology (automation and sensor). This data is converted to additional information that is communicated to the offshore CCR and the onshore support centre, consisting of operators and vendors (Statoil, 2010). This information constitute the foundations for real time decisions from the onshore support centre. In addition, Gerhardsen will implement new work processes and operational concepts.

Gerhardsen's IO strategy states that IO should not be considered to be a separate subsystem, discipline or data storage (Statoil, 2010). IO shall rather focus on integrating the other disciplines (especially data). The main objective for IO at Gerhardsen is to make quicker and more informed decisions based on the right information, which is available to every relevant discipline, independent of location. The main goal is not IO itself; it is a means to improve HSE performance, increased production, improved drilling, and reduction in operation costs. Other IO considerations is the implementation of an Information Management System, establishing monitoring for all safety and production critical equipment, development of workspaces, and development of collaboration rooms located both onshore and offshore.

6.3 Optimizing Asset Management through Integrated Operations

Liyanage (2012) states that advances in asset management are often seen through new technology and application developments, and much focus has been placed on information and communication technologies, e-maintenance, e-operations and sensor technology. However, one should not only rely on these advances, and there is a critical need for integrating these technology efforts. Integrating the technology efforts requires a number of crucial elements to be in place, including among others an integrated work management, collaborative operational risk management, B2B communication, shared decision processes and assurance processes (Liyanage, 2012, p12). The business environment in the industrial sector can be seen as complex, interconnected, vulnerable and uncertain. It is critical that the assets face and adapt to new opportunities to remain competitive. The different industries need to adapt to smart and integrated solutions to manage their assets in order to reduce business risks (Liyanage and Bjerkebæk, 2007). Advanced technologies and robust data management techniques are often the basis of innovative solutions. Furthermore, Liyanage (2012) states that effective management of the industrial assets (asset management) relies on six critical factors. These factors are shown in the figure below.

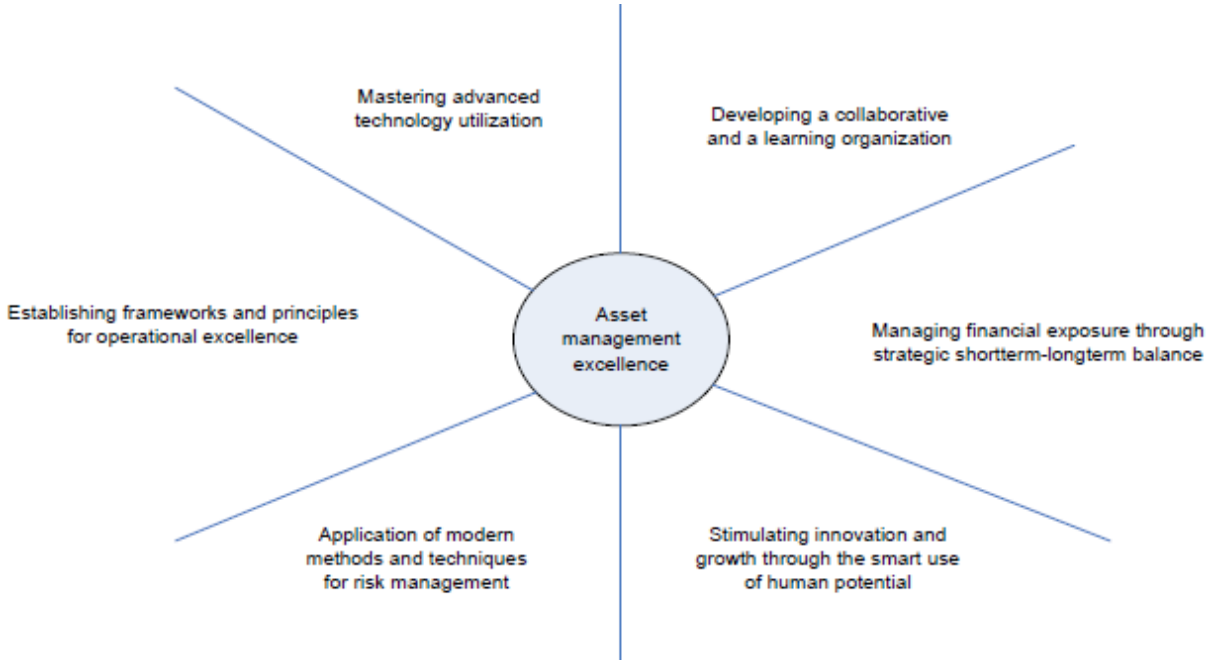

Figure 29 – Critical factors for asset management excellence (Liyanage, 2012, p.13)

"Mastering advanced technology" and the "Application of modern methods and techniques for risk management" clearly shows the need for Integrated Operations. The interface technologies will provide opportunities to utilize enormous capabilities like collaborative decision-making and real time online data assessment. Integrated Operations, eDrift and other similar technical platforms have already shown its benefits and it offers a large variety of features that should optimize asset management. It is worth mention that the new Asset management system standard (ISO 55000) focuses on one single organization, while IO is about the collaboration of several organizations, vendors and suppliers. However, the figure below shows some of the identified Asset Management and Asset Management system (ISO 55000) aspects that should be optimized by the implementation of Integrated Operations.

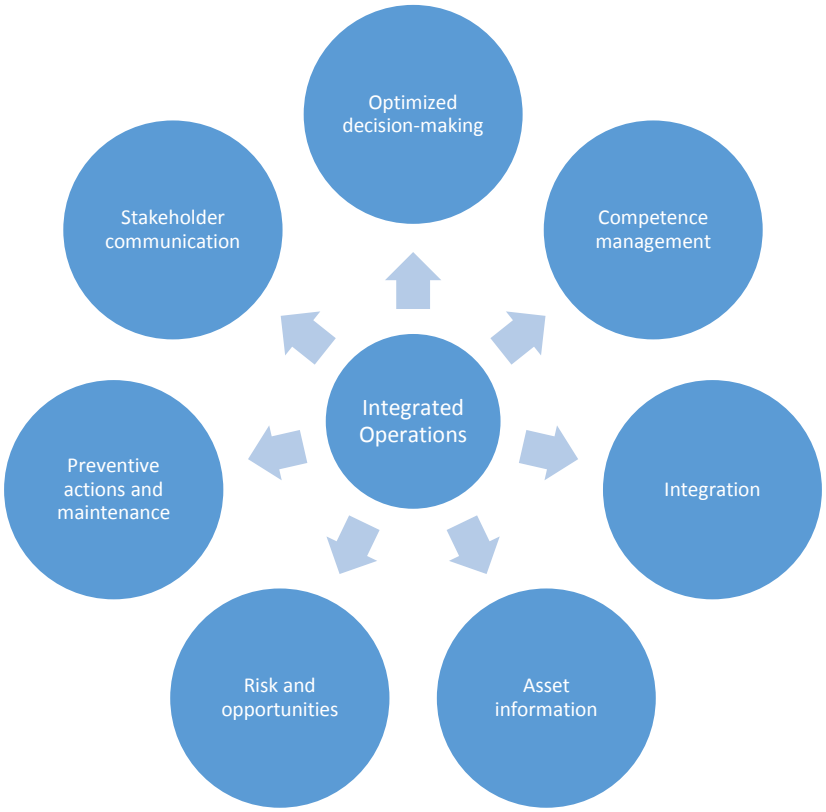

Figure 30 – Asset management aspects optimized through IO implementation

Optimized Decision-making

As described in Chapter 3 - *Asset Management Fundamental Elements*, optimized decision-making is one of the fundamental aspects of good asset management. PAS 55-2 (2008) states that adequate information about the assets and the asset strengths, weaknesses, opportunities and threats characterise good decision-making. In addition, the IAM (2014) explains that asset knowledge is important for AM decision-making, and it is central to the understanding of the criticality and condition of the asset. Integrated Operations is about the use of advanced ICT and real-time data, and this is made possible through the advances in automation and sensor technologies (Resource, 2010). IO enables the organization, with its experts both onshore and offshore, to receive real-time condition data of the asset. This makes it possible to optimize the decision-making. For example, when receiving condition data that shows the declining speed of a compressor, the necessary actions can be taken before it breaks down. Another important aspect is the multidisciplinary collaboration that IO provides, and this enables optimal decisions because every aspect of the decision can be discussed between the operators offshore, experts onshore and vendors/suppliers.

Competence Management

A fundamental task for every organization is to make sure that there are enough competent personnel to perform the different activities (IAM, 2014). Competence management related to asset management is about ensuring that top management understands how the competences of their work force relates to the asset management strategy and objectives. This implies that top management needs to develop clear competence requirements that are used to select, develop and review personnel. People come to asset management roles with different backgrounds (technical, operational and managerial), and asset management is about weaving them together to form effective asset management teams. ISO 55001 (2014) also specifies five asset management system requirements for competence management. Integrated Operations will optimize the competence management since it expands the system boundaries to include people across geographical, organizational and disciplinary boundaries (Filstad and Hepsø, 2009). The system boundaries are expanded to ensure that every competent person is reachable and present in the daily activities. The top management do not only need to rely on their own employees, and IO ensures that competent personnel from vendors/suppliers and expert centres are reachable 24/7.

Integration

As discussed in Chapter 3, asset management is best seen as an integration framework (IAM, 2014). Asset management is based on the integration of a set of AM fundamental elements (see Chapter 3 – *Asset Management Fundamental Elements*). Furthermore, PAS 55-1 (2008) states that a core element of asset management is to acknowledge that interdependence and other combined effects are crucial to success. The asset management principles need to be combined and coordinated, and it is critical that all the elements in an organization are managed as a whole. In addition, another core element is about establishing a holistic management. This requires looking at the whole picture, and not focusing on each department. Every department should have the same overreaching goal that "drags" them in the same direction as the others. Integrated Operations is about the integration of all the different systems, operators and suppliers/vendors into a common platform (Filstad and Hepsø, 2009). IO integrates people across geographical and disciplinary boundaries, and it integrates the advanced technology with business processes. Integrated Operations integrates people and technology to remotely monitor, model and control the asset's processes in such a way as to maximize the life cycle and asset value, and hence IO has the necessary features that should optimize asset management integration.

Asset information

PAS 55-1 (2008) states that high-quality data and information is a critical aspect in relation to the performance of the asset and the opportunity to optimize the asset. Asset management is

dependent on the quality of asset information, and good asset information enables better decisions to be made, e.g. determining the optimal asset care (IAM, 2014). Furthermore, the organization needs to develop an asset management strategy that specifies the asset information requirements and the criticality of the asset information. In addition, one should implement an asset information system that is used to support effective asset management decisions. Integrated Operations provides real-time data and information from assets through high-speed cables. In production plants, huge amounts of data are generated, however, the wealth of data is often not utilized optimally (IS Partner, 2008). Integrated Operations ensures that all data is provided in real-time to the relevant functional teams that analyse and extract the useful information. IO also uses extensive filtering to avoid information overload. The useful information is continuously fed back to the asset's operating team. This clearly shows that IO will provide better use and capture of information as the asset information is continuously quality assured.

Risk and Opportunities

ISO 55001 (2014) requires the organization to develop actions to address the risks and opportunities for the asset management system. An ISO 55001-compliant organization needs to establish processes required to identify and assess the risks and opportunities, and provide actions to prevent undesired effects. Asset Management Council (2014) states that asset management risk management addresses risks at both strategic level and operational level, and this enables the organization to achieve the optimum balance between costs, performance and risks. Integrated Operations provides modern methods that support the overall risk assessments, and support the communication of the process to the stakeholders (Filstad and Hepsø, 2009). IO provides condition monitoring, and the availability of real-time condition data makes it possible to perform risk-based inspection (OLF, 2003). The condition monitoring aspect of IO will certainly optimize the identification and treatment of risk and opportunities in an asset management system. Another feature of IO that should optimize asset management is the different technical disciplines that are located at the onshore expert centres. These disciplines consist of several persons with different backgrounds and at least one risk analyst. Multidisciplinary collaboration can lead to the identification of new risks that were not previously addressed.

Preventive Actions and Maintenance

Asset management is about optimizing the trade-offs between asset maintenance and asset utilization. Hastings (2014) states that it is absolute necessary to take care of the asset and ensure that the asset provides the required performance. Furthermore, ISO 55001 (2014) sets requirements to establish processes that identify potential failures in asset performance (clause 10.2). ISO 55001 (clause 6.2 and 8.1) also requires the organization to implement and control the processes determined in the asset management plan (including maintenance plan). An

important feature of Integrated Operations is the use of multidisciplinary "task forces" that perform preparations for maintenance, modifications and repairs (OLF, 2005). They develop the plans onshore and freeze the plan before they go offshore. The onshore planning process will be supported by offshore operators using video conference and updated 3D models of the platform. Furthermore, new technologies will replace manual gathering techniques needed to monitor equipment health. IO provides condition-based maintenance, which monitors equipment and predicts failures before they occur. This makes it possible to plan for timely intervention before the unwanted stops occur. As mentioned above, the availability of real-time condition data makes it possible to perform Risk Based Inspection (RBI). One advantage of sensor and automation technologies is that they will provide better RBI, which is one of the asset management toolkits within the maintenance area. The new sensor technology together with advanced condition monitoring and multidisciplinary teams will clearly optimize asset maintenance.

Stakeholder Communication

EFQM (2003) states that an excellent organization is flexible and responsive to the changing needs of the stakeholders, and Asset Management Council (2014) states that it is the stakeholders that determine the needs of the business. In addition, ISO 55001 (2014) requires stakeholder communication, and ISO 55002 (2014) states that failure to both consult and communicate with the stakeholders can constitute a risk. As mentioned before, one of the key elements of Integrated Operations is the use of advanced information and communication technology (Resource, 2010). This, together with the collaboration rooms at both offshore and onshore locations will ease up the communication process with the stakeholders. It will be easier to have continuous communication with the stakeholders, and the different stakeholders can have meetings from their own desktop through web cameras. The stakeholder communication can also be moved from offshore to onshore, enabling the offshore operators to focus on safe and effective management of the platform.

PART 4 CASE STUDY: STATOIL

Figure 31 – Statoil (Statoil, 2014d)

Introduction

Part 4 addresses the Statoil case study. Firstly, the company is introduced and their current approach to asset management is presented. Secondly, Chapter 8 investigates if ISO 55000 offers perspectives that are not covered in ISO 9000. Thirdly, Chapter 9 assesses if ISO 55000 offers perspectives that are not covered in, or in conflict with, the current PSA Regulations. The ISO 9000 and the PSA Regulation analyses is conducted to identify how a possible ISO 55000 certificate will affect the conformity with the existing standards and regulations in Statoil. Fourthly, Chapter 10 analyses Statoil's governing documentation in relation to ISO 55000. The outcome of this analysis is a preliminary gap analyse, a SWOT analyse and recommendations for further development of asset management in Statoil.

Appendix B, C and D presents the detailed analysis of ISO 9000, the PSA Regulations and Statoil's governing documentation, and these analyses form the basis for the three *Presentation of Results* sub-chapters and ultimately the *Summary of Results* sub-chapters.

Chapter 7 Statoil and Current Asset Management Practice

7.1 Statoil

Company Overview

Statoil is a technology-driven energy company with its primary activities in oil and gas exploration (Statoil, 2014b). Statoil ASA, as it is known after the merge with Hydro in 2007, was formed in 1972 by the Norwegian parliament as a company wholly owned by the Norwegian State. Statoil's role was to secure Norway's participation in the oil and gas industry on the Norwegian Continental Shelf, and build up the competency within the petroleum sector. Statoil grew substantially in the 1980s through the discovery and development of so-called elephant fields like Statfjord and Gullfaks. In the same period, Statoil became a major player in the European gas market. When Statoil merged with Hydro, they became one of the world's largest offshore oil and gas companies with current operations in over 30 countries and more than 22 5000 employees worldwide. Statoil is the leading operator on the NCS and Statoil is present in several of the most important oil and gas provinces in the world. Through Statoil's application of cutting-edge technologies and innovative solutions, Statoil shows their commitment to support the world's energy needs.

Statoil's **Offshore Assets on the NCS**

Statoil's operations are managed through seven different business areas (Statoil, 2014b). Statoil's offshore assets on the NCS are managed through Development and Production Norway (DPN). DPN aim to maximise value creation on the NCS and through excellent HSE and improved operational performance DPN strive to maintain Statoil's position as a world-leading oil and gas operator. In 2014, DPN had Statoil-operated assets in the Norwegian Sea, the North Sea and the Barents Sea. DPN has organized their production operations into four business clusters, Operations North, Operations Mid-Norway, Operations West and Operations South. The figure to the right shows every Statoil-operated asset on the NCS, it also shows were the main onshore headquarters in DPN are located.

Figure 32 – Statoil's offshore assets (Statoil, 2014b)

The main producing fields in the:

- Operations North area is the Snøhvit field
- Operations Mid-Norway area are Åsgard, Kristin and Tyrihans
- Operations West area are Troll, Oseberg, Gullfaks, Kvitebjørn, Visund and Grane
- Operations South area are Sleipner, Gudrun, Snorre and Statfjord

7.2 Challenges on the NCS and Statoil's response

Challenges faced by Statoil on the NCS

Rugsveen (2015) agrees with Cole et al. (2014) and Kar et al. (2014), and states that the cost per produced energy unit is rising. The industry needs to cope with rising operation costs and lower productivity, and simultaneously meet harsher environmental legislation. In 2014, the oil price declined and the profitability of Statoil's oil and gas operations were challenged (Statoil, 2014b). Statoil also identify other challenges as tighter fiscal conditions and increased competition. Furthermore, Rugsveen (2015) states that a sustainable reduction in the operation costs will provide an improvement in Statoil's competitiveness. Several industry peers have embraced these challenges, and have adopted maintenance and reliabilities approaches. The modern reliability-centred organizations have implemented a holistic maintenance and reliability approach. The holistic approach include among others that business goals are transformed into monitoring targets. A result from this is that maintenance is expected to not only deliver results in the operational phase, but also within the business context.

STEP

The increasing operation costs, the declining productivity and oil price have forced Statoil to implement efficiency programmes (Statoil, 2014b). Statoil's ambition is to reduce costs and improve efficiency, and hence a target is set to 1.3 billion USD from 2016 in annual savings. Improvement programmes are Statoil's response to the NCS challenges, and a part of these programmes are the Statoil Technical Efficiency Programme (STEP) (Statoil, 2014d). The current challenges presents a perfect opportunity to simplify the way Statoil work, and it is critical for Statoil to improve their competitiveness. STEP consists of six high impact projects:

- End-to-end well delivery
- Strengthen early phase
- Standardisation and industrialisation
- Enable Operation, Maintenance and Modification (OMM) excellence
- Suppler management and efficiency
- Simplification and resource prioritisation

A part of the STEP program is to update the existing maintenance and reliability strategy, which will be further commented upon.

7.3 Statoil's approach to Asset Management

Industry General

Developments in the oil and industry shows clear signs of a paradigm shift with respect to asset management. Industries have replaced the traditional mindset of "*maintenance is a necessary evil, tapping on profitability*" to the newer mindset "*asset reliability is paramount to business profitability and sustainability*" (Rugsveen, 2015). At the same time, many of the energy producers and distributors in Europe has acquired certification in available asset management standards like PAS55 and ISO 55000. These organizations experiences cost savings and improved productivity. These new standards (e.g. ISO 55000) broaden the management system perspective as they focus on the asset, instead of the traditional management system where the focus is on the quality of the products (ISO 9000).

The way forward for Asset Management in Statoil

Rugsveen (2015) states that Statoil have recognized the new paradigm shift with respect to the asset management approach, and a new corporate maintenance and reliability strategy is proposed. To increase the competitiveness and robustness, Statoil need a holistic approach that align the business objectives with maintenance and reliability. Rugsveen (2015) expects that Statoil will increase the reliability when improving the way Statoil design, operate and maintain the assets. There exist many strategies in the different business levels in Statoil, whose main purpose is to increase efficiency and effectiveness of the organization. However, Statoil lacks a central maintenance and reliability strategy that provide a clear "line of sight" between the different strategies, and hence the strategies at the different business levels may be conflicting and not effective at all. There is another fault with the strategies in Statoil, as they often focus only on reduce the cost, instead of optimize the Life Cycle Cost. Rugsveen (2015) states that Statoil needs to break out of the group of comparable competitors and work to take the place as a leading energy company. The future road of Statoil is to maximize asset value through maintenance and reliability excellence. This is supported by a newly proposed Maintenance Mission statement (Rugsveen, 2015, p3) "*Right maintenance at the right time, with the right effort, is a driver for improved safety and profitability*". This means that the maintenance process shall mitigate risk, and deliver reliability and availability in an effective way to ensure alignment with the business objectives.

In the competitive market, Statoil need to widen the maintenance approach. This includes not only changes to the maintenance process, and according to Rugsveen (2015) one of Statoil's proposed four strategic focus areas will be asset management. Since the operational context continuously changes, Statoil needs to ensure that operation and maintenance is suited to the new conditions. Statoil needs to use the asset management approach to enable informed asset management decisions. This can be done through enabling a clear "line of sight"/alignment from the top management to the front line operators, and this also includes aligning the business objectives throughout in the whole organization. Furthermore, Statoil need to identify and

create KPIs that are relevant and measure the effectiveness of operation and maintenance, and align the O&M goals with business results. Additionally, Statoil needs to ensure that the right asset solution is set at the beginning, and that this solution continues to remain the right solution into the future.

Statoil's **new Maintenance and Reliability Strategy**

As a part of Statoil's corporate initiative to improve technical and organizational efficiency, the Operation and Maintenance Process Owner in Statoil have developed a new maintenance and reliability strategy (Rugsveen, 2015). This newly developed M&R strategy focus on the course toward optimized asset utilization and the balancing of risk, opportunities and costs throughout the asset life cycle. The M&R strategy provide the basis for improvements in safety, regulatory compliance and uptime, in addition to the required cost savings. As mentioned above, the new M&R mission statement is about maximising asset value through M&R excellence. This M&R strategy aim to provide a holistic approach of reliability management through prioritizing asset optimization, better tools for maintenance engineering, follow-up of maintenance results and improved knowledge at every level (Rugsveen, 2014). It also provide the organization with the direction of choosing the right asset (plant) specific maintenance approach. The critical success factors for this strategy is:

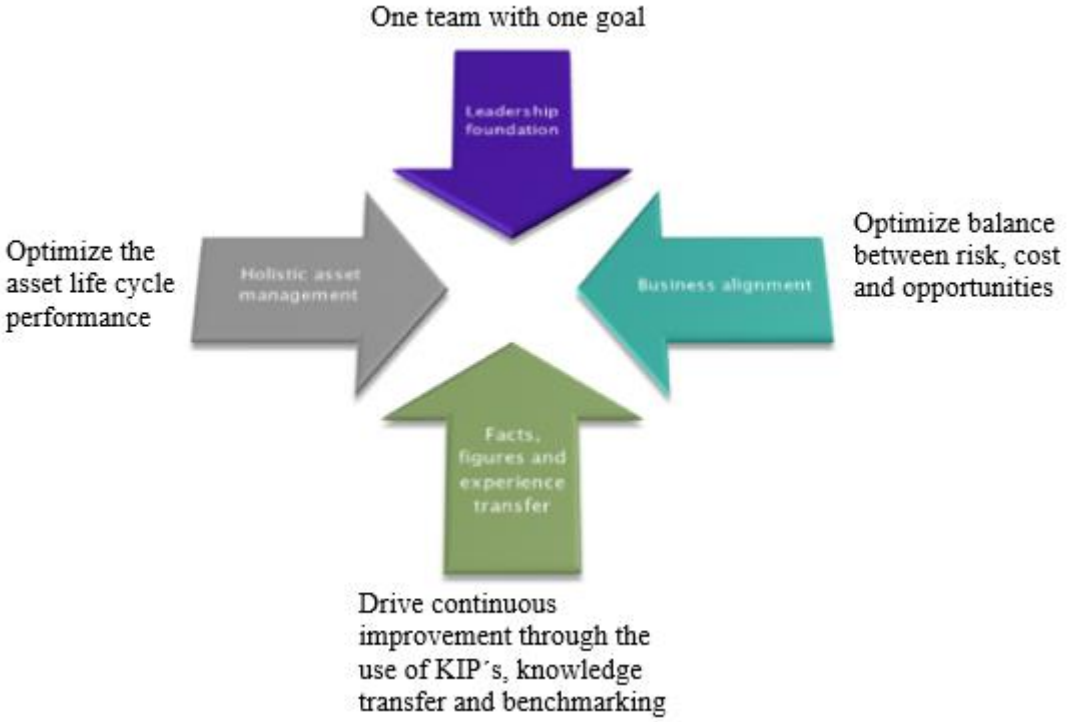

Figure 33 – The critical success factors (Rugsveen, 2014)

One clearly see that Statoil's new M&R strategy have a large emphasis on the fundamentals of asset management. In addition, the strategy have four focus areas where asset management is

one of the areas. Aspects like providing the line of sight and creating a link between the O&M goals and the business results is included in the asset management area of the strategy.

Operations and Maintenance requirements

Furthermore, this M&R strategy have contributed to updating Statoil's Operation and Maintenance governing document (Function Requirement document). The existing O&M requirements have been substantially rewritten (FR06, 2015). Asset Management principles have been built-in and continual improvement is included throughout the document. The document is also rewritten to put more emphasis on value creation and the work processes. Some of the asset management principles included in the O&M Functional Requirement is balancing the cost, opportunities and risk of design and construction, aligning business objectives throughout every level, and apply the skills of personnel in a continual process to improve the performance of the asset together with their own personal competence.

The aim of the next chapter is to identify if Statoil already conforms to some asset management fundamentals and requirements in ISO 55000. Statoil have updated their maintenance and reliability strategy, however, Statoil's operations consists of more than maintenance. The next chapter examines every aspect in Statoil in relation to performing good asset management, as this is needed to overcome the challenges on the NCS.

Chapter 8 ISO 55000 versus ISO 9000

8.1 A brief introduction to the ISO 9000 series

Introduction

It is impossible to achieve the required business results without customers or unsatisfied customers. To keep the customers satisfied, the service or product delivered needs to have high quality. ISO (2009) states that the ISO 9000 family is a well-recognised standard for the establishment of an quality management systems. Furthermore, ISO (2010) explains that this standard is used in 176 countries by small and large organizations, in both the public and private sector. ISO 9001 specifies the minimum requirements for a quality management system that is essential to improve customer satisfaction and deliver the required products and services.

The ISO 9000 family

ISO (2009) explains that organizations will achieve the highest quality when using the entire ISO 9000 family. The ISO 9000 family consist of (ISO 9000, 2005):

- *ISO 9000*: Describes the fundamentals and terminology of quality management systems.
- *ISO 9001*: Specifies the requirements for a quality management system. The organization need to provide products that satisfies the customers and regulatory requirements. The organization also needs to improve customer satisfaction
- *ISO 9004:* This standard includes guidelines to improve the effectiveness and efficiency of the quality management system. Improvement of customer satisfaction and improvement in performance of the organization is the main tasks in this standard.
- *ISO 19011*:… is about auditing quality and environmental management systems

Quality Management Principles

To enable success one need to implement and maintain a system that focus on continual improvement and that ensure that all interested parties/stakeholders are satisfied. ISO 9000 (2005) have identified eight principles needed for improvement in performance:

- *Customer focus:* Every organization is dependent on their customers. It is therefore essential to understand the customers, and meet and exceed their expectations.
- *Leadership*: The leaders establish the vision and direction of the organization. It is the leader's task to create and maintain an internal environment where the employees can be fully involved in achieving the organizational objectives.
- *Involvement of people*: Employees at all levels are the essence of an organization and their full contribution enable their capabilities to be beneficial for the organization.
- *Process approach*: When activities and resources are managed in a process, the preferred results are achieved more efficiently.

- *System approach to management*: Identifying, understanding and managing all the processes in a system enable the organization to achieve its objectives more effectively and efficiently.
- *Continual improvement*: One of the most important objectives in an organization is to continual improve the overall performance.
- *Factual approach to decision making*: Analysis of data and information enable effective decisions.
- *Mutually beneficial supplier relationships*: An organization and its suppliers are interdependent and they need to establish a mutual beneficial relationship to create value to both parties.

The Quality Management System

Creating a quality management system can help an organization to improve customer satisfaction (ISO 9000, 2005). Customers need products that satisfy their expectations, and ISO 9001 require these expectations listed as product specifications. In the end, the customer determine the product acceptability. Since the customer's needs are changing, together with increased competitiveness from other organizations, an organization needs to continually improve their products. The quality management system makes it possible to identify customer requirements, and establish the processes needed to create a product that is customer accepted. The quality management system also provides a framework for continual improvement that will increase the likelihood of achieving customer satisfaction in the future.

The ISO 9000 Process Approach

ISO (2009) states that to achieve continual improvement, the eight quality management principles together with the process approach is needed. When developing, maintaining and implementing a quality management system, one should use a process approach (ISO 9001, 2008). A process can be defined as any activity that transforms inputs into outputs. Using a process approach should increase the effectiveness of the system and the customer satisfaction. An organization needs to manage several activities using resources, and the goal of these activities is to transform inputs to outputs. This is called a process. A successful organization needs to identify and manage several interdependent and interrelated processes to function effectively.

8.2 Correlation Table between ISO 55001 and ISO 9001

ISO 55001	ISO 9001
4. Context of the organization	
4.1 Understanding the organization and its context	6.4 Work environment 7.3.2 Design and development inputs
4.2 Understanding the needs and expectations of the stakeholders	7.2.1 Determination of requirements related to the product 5.2 Customer focus
4.3 Determining the scope of the AM system	4.2.2 Quality manual
4.4 Asset management system	4.1 General requirements
5. Leadership	
5.1 Leadership and commitment	5.1 Management commitment 5.4.2 Quality management system planning
5.2 Policy	5.3 Quality policy
5.3 Organizational roles, responsibilities and authorities	5.5.1 Responsibility and authority 5.5.2 Management representative
6. Planning	
6.1 Actions to address risks and opportunities for the asset management system	Risk management not included in ISO 9001
6.2 Asset management objectives and planning to achieve them	5.4 Planning
6.2.1 Asset management objectives	5.4.1 Quality objectives
6.2.2 Planning to achieve asset management objectives	7.1 Planning of product realization
7. Support	
7.1 Resources	6.1 Provision of resources 4.1 General requirements
7.2 Competence	6.2.1 General (Human resources) 6.2.2 Competence, training and awareness
7.3 Awareness	6.2.2 Competence, training and awareness.
7.4 Communication	5.5.3 Internal communication 7.2.3 Customer communication
7.5 Information requirements	4.1 General requirements 7.4.2 Purchasing information 7.5.1 a) Control of production and service provision
7.6 Documented information	4.2.3 Control of documents 4.2.4 Control of records
8. Operation	
8.1 Operational planning and control	4.1 General requirements
8.2 Management of change	7.3.7 Control of design and development changes
8.3 Outsourcing	4.1 General requirements

9. Performance evaluation	
9.1 Monitoring, measurement, analysis and evaluation	4.1 General requirements 8.1 General 8.2.1 Customer satisfaction 8.2.3 Monitoring and measurement of processes 8.2.4 Monitoring and measurement of product 8.4 Analysis of data 7.1 Planning of product realization
9.2 Internal audit	8.2.2 Internal audit
9.3 Management review	5.6.1 General (Management review) 5.6.2 Review input 5.6.3 Review output
10. Improvement	
10.1 Nonconformity and corrective action	8.3 Control of nonconforming product 8.5.2 Corrective action
10.2 Preventive action	8.5.3 Preventive action
10.3 Continual improvement	8.5.1 Continual improvement

Table 1 – Correlation between ISO 55001 and ISO 9001

8.3 Presentation of Results

Context of the Organization

ISO 55001 (cl. 4.1) require every internal and external contexts to be identified, while ISO 9001 (cl. 6.4) focus on factors that can influence the product. Both ISO 9001 (cl. 5.2, 7.2.1) and ISO 55001 (cl. 4.2) focuses on the identification of stakeholder/customer needs and requirements. The main stakeholder of the ISO 9001 is the customer (and of course regulatory authorities) and that is reflected throughout the whole standard. Moreover, it is worth mention that there will be published a new ISO 9001:2015 version where stakeholder analysis is included. Customer requirements and expectations are important issues in ISO 9001, while ISO 55001 focuses on every stakeholder that are relevant to the organization, including customers.

The author agrees with Asset Management Council (2014) who explains that it is important to assess every stakeholder and not only the customers, since stakeholders like employees, functional groups within the organization, and local communities can affect the business result. The European Foundation for Quality Management (2003) states that an excellent organization is flexible and responsive to the changing needs of the stakeholders and focuses on the customer's needs and expectation. Both EFQM and the Asset Management Council (2014) goes a bit further than ISO 9001 and require the management of every relevant stakeholder and they does not limit themselves to customers.

It is important to identify the organizational boundaries and hence the scope of the management system. Both ISO 55001 (cl. 4.3) and ISO 9001 (cl. 4.2.2) require the establishment of the scope

of their respective management systems. In addition, both ISO 9001 (cl. 4.1) and ISO 55001 (cl. 4.4) require the organization to establish, implement, maintain and continually improve their management systems.

Leadership

Regarding leadership and management commitment, the two ISO standards almost agree on their requirements. The Asset Management Council (2014) states that leadership and culture is essentials for successful management, and it is the leadership and culture that drive the change of behaviour and culture. ISO 9001 (cl. 5.1, 5.4.2) and ISO 55001 (cl. 5.1) require the top management to provide evidence of their commitment to the development and implementation of the management system. In addition, top management needs to ensure that the resources are available and promote continually improvement of the management system. Furthermore, ISO 55001 (cl. 5.1) have a strong emphasis on a clear "line of sight" between top management and the daily operators. Management requirements like supporting persons to contribute to the effectiveness of the asset management system, creating a collaborative culture that focuses on deliver AM objectives, and communicating the importance of effective asset management system into the organization, shows this "line of sight" focus in ISO 55001. ISO 9001 (cl. 5.1) have to some extent included the "line of sight" when stating that top management need to communicate the importance of meeting the customers' requirements.

Both ISO 9001 (cl. 5.3) and ISO 55001 (cl. 5.2) require the development of a policy that is consistent with the direction of the organization. There is a bit different focus when it comes to the organizational responsibilities and authorities. Both ISO 55001 (cl. 5.3) and ISO 9001 (cl. 5.5.1) require the organization to ensure that the relevant authorities and responsibilities are assigned and communicated in the organization. However, ISO 55001 is more detailed about the roles that one need to assigning responsibility to, while ISO 9001 (cl. 5.5.2) require a management representative to ensure that the processes needed for the quality management system are implemented.

The author's opinion is that the two ISO standards provide equal approaches to leadership and commitment, which is one of the fundamental elements of organizational success. ISO 55001 have a more defined approach to the clear "line of sight", which is important to remove the traditional silo management (Woodhouse, 2010b). Elsewhere, they both conforms to Asset Management Council (2014) thought's about leadership.

Planning

ISO 9001 do not include any risk management requirements, while ISO 55001 in several clauses require risk assessment and mitigating the risk to an acceptable level (especially in Clause 6.1 Planning). However, both ISO 9001 and ISO 55000 can be integrated with ISO

31000 (Risk Management), and hence organizations using ISO 9000 or ISO 55000 will have equal risk requirements.

Armstrong and Baron (2005) states that it is essential to derive objectives that enable the measurement of the performance of the organization. Furthermore, Kaplan and Norton (1996) states that the organization should create external objectives for the financial and customer perspective, internal objectives for the processes that are creating high value for the stakeholders, and objectives for learning and growth in the organization. Regarding the objectives, ISO 55001 (cl. 6.2.1) lists 9 "shall" statements, while ISO 9001 (cl. 5.4.1) are less specific in their requirements about the objectives. Both ISO 9001 and ISO 55001 states that the objectives need to be consistent with the policy and the requirements.

The planning process is quite similar. ISO 9001 (cl. 7.1) require a quality plan where the product objectives and requirements are listed, while ISO 55001 (cl. 6.2.2) require an asset management plan to achieve their asset management objectives. These requirements are quite similar, the only difference is that ISO 9001 focus on product objectives and ISO 55001 focus on asset management objectives.

The author's opinion is that the quality objectives (cl. 5.4.1) is limiting for an organization performing operations on the Norwegian Continental Shelf (e.g. Statoil), while it is appropriate for organizations producing products. ISO 9001 focus on the achievement of the product requirements, while ISO 55001 (cl. 6.2.1) require objectives for the processes/assets that actual delivers the required products. If only measuring the achievement of the product requirements, the assets or asset portfolio that deliver the actual product, may perform poor.

Support

Regarding resources, competence and awareness, the two ISO standards have approximately equal requirements. As stated by EFQM (2003), excellent organizations identify people's knowledge and competencies, and develop and maintain these competencies. In addition, excellent organizations manage their external partnerships and internal resources in a way that support the policy and strategy. ISO 9001 (cl. 4.1d, 6.1) and ISO 55001 (cl. 7.1) require the organization to determine and provide the needed resources to develop, maintain and operate the management system. This is in accordance with the EFQM model. Furthermore, both ISO 9001 (cl. 6.2.1, 6.2.2) and ISO 55001 (cl. 7.2) require the identification of necessary capabilities and actions to increase the competence. The only difference between the awareness requirements is that ISO 55001 (cl. 7.3) also require the personnel to be aware of the risks and *opportunities* associated with their activities. Employees that actively seek opportunities with their activities can foster innovation in the organization (Lloyd, 2010b). Innovation can increase the effectiveness of existing processes and deliver higher asset value. It is important to not only focus on the risk and the relevance of the activities, but on the opportunities associated as well. This may create an organization with higher abilities to achieve their objectives.

Communication system are required in ISO 55001 (cl. 7.4) and ISO 9001 (cl. 5.5.3, 7.2.3). ISO 9001 require communication plans with the customers and information requirements (cl. 7.4.2, 7.5.1) about the product. This is included and expanded in ISO 55001, which require communication plans with all the relevant stakeholders and the information requirement (cl. 7.5) covers every information relating to the asset, AM, and AM system. Again ISO 55001 require the organization to identify more stakeholders than customers and the information requirement includes risk management, contingency planning, financial management, service delivery, maintenance management and processes. This is a more holistic way of managing the processes that create the organizational value. Parnell and Driscoll's (2011) thoughts about system thinking supports this, as they explains that organizations should be focused on understanding the whole structure and this makes it possible to create and deliver maximised value to the stakeholders. Lastly, both IOS 9001 (cl. 4.2.1, 4.2.3, 4.2.4) and ISO 55001 (cl. 7.6) include requirements for documented information and document control.

Operation

Both ISO 9001 (cl. 4.1a, 7.5.1) and ISO 55001 (cl. 8.1) require establishment of the control processes needed for their respective management systems. While ISO 9001 focus on the processes regarding production, ISO 55001 require the establishment of operational planning and control processes needed to operate the asset management system.

ISO 9001 (cl. 7.3.7) require changes in the design and development phase to be reviewed, verified and validated. ISO 55001 (cl. 8.2) have a more holistic approach and require that risks associated with any change shall be assessed before implementation. ISO 9001 is here limited to the product, while ISO 55001 is broadened to the asset or the asset management system, and hence require the management of change to include every activity in the management system. Frankel (2008) states that successful management today is about the effective management of change. The management of change include, managing change in markets, service, product, process technology, competitors state, resources, competitors resources, and external political and regulatory developments. It is important according to Frankel (2008) to not only managing the change in product development (ISO 9001), but to include every change in the organization (ISO 55001).

Frankel (2008) states that the increase in technology knowledge has led to outsourcing because skilled staff was needed. To deliver good performance, organizations need expert knowledge on every aspect in the organization. Both ISO 9001 (cl. 4.1) and ISO 55001 (cl. 8.3) require control of the outsourced activities and processes. The only difference between them is that ISO 55001 also require risk assessments of the outsourced activities that can have an impact on the achievement of the asset management objectives. The author's opinion is that ISO 55001 offers a broader perspective on the outsourcing aspect than ISO 9001.

Performance Evaluation

Performance evaluation is emphasized in the two standards. Both ISO 9001 and ISO 55001 require the organization to determine methods for monitoring, measurement, analysis and evaluation. While ISO 55001 (cl. 9.1) require the evaluation of asset performance, ISO 9001 (cl. 8.1, 8.2.4, 7.1) require the organization to demonstrate the conformity to product requirements. The author agrees with Rugsveen (2014b) who explains that it is important to monitor and measure the assets (e.g. production machine or assembly line) that create the required product, and not only measure the product conformity itself. The product may conform to the requirements, however, the assets creating the product may perform ineffective or slow. This is also consistent with systems engineering. A key function of systems engineering is the measurement of how the systems will perform its functions to meet the stakeholder's needs (Parnell and Driscoll, 2011). To do this, one need to measure the assets performance (e.g. asset condition, failures and incidents) and not only the product itself.

Evaluating the effectiveness of the management system is another requirement that is included in both ISO 9001 (cl. 4.1e, 8.1, 8.2.1, 8.2.3, 8.4) and ISO 55001 (cl. 9.1). The only difference is that ISO 55001 require the organization to assess if the asset management requirements and objectives are met, and ISO 9001 require the organization to assess if the customer requirement and product requirements is met. The asset management objectives need to include relevant stakeholder requirements, and hence ISO 55001 can be used to determine if both customer and product requirement have been achieved. EFQM (2003) explains that excellent organizations achieve top results that meet and exceed customer, people, society and key stakeholder expectations. All these aspects are included in ISO 55001, as it require the organization to ensure that the monitoring and measuring process meet the stakeholder expectations. It is therefore the author's opinion that it is more profitable to use ISO 55001 in the context of performance evaluation.

Performance evaluation also consists of internal audits and management reviews. Regarding the internal audit, both ISO 9001 (cl. 8.2.2) and ISO 55001 (cl. 9.2) require the organization to conduct internal audits to ensure that their respective management system conforms to the planned implementation, the organizations own requirements and the requirements of the respective standards. Furthermore, both ISO 9001 (cl. 5.6) and ISO 55001 (cl. 9.3) states that it is the top management's task to perform management reviews to ensure the management systems suitability, adequacy and effectives.

Improvement

The whole improvement clause in ISO 55001 (clause 10) is equal to the requirements in ISO 9001 (cl. 8.5). They both require continual improvement, preventive actions and corrective actions to control and correct a nonconformity. The only difference is that ISO 9001 (cl. 8.3) focus on nonconformities regarding the product developed, while ISO 55001 (cl. 10.1) have a broader focus on nonconformities in the organization. The author favours the asset management

approach, which require the organization to assess every nonconformity. It is important to assess the conformity of the product, however, the management system or management activities itself can fail. If a nonconformity occur in the management system, the product can conform to its requirements but the management system may be ineffective and ultimately the organization can fail to deliver the required business results.

Product Realization

ISO 55001 has a large focus on the asset and the value the asset provide, and not on the quality of specific products created or delivered. This is why parts of the requirements in the Product Realization clause in ISO 9001 is not mentioned in ISO 55001. However, there are some similarities, as the fact that customer and product requirements are listed as stakeholders in ISO 55001.

8.4 Summary of Results

ISO 9000 is a well known management system standard that is used to ensure the quality of the products and services delivered to the customers. ISO 9000 has high focus on the design and development of the products, and the main focus is the customer. It also devotes a large part to ensure the proper control of the deviations of products. However, it does not provide the management of the assets that create the income. ISO 9000 is about the quality of the products, and this may be a costly affair. The organizations need an asset management system that optimizes the balance between performance, costs and risks in order to achieve the optimum value received from the assets. Even though ISO 9000 focuses on high quality product and satisfied customers, the organization can fail on other important areas. ISO 55000 provide the extra perspective on the quality of the products, and the emphasis of this standard is to help the organization to be able to extract the optimum value of the asset at the optimal costs. ISO 55000 provides the “line of sight” from the top management to the front line workers and everyone in the organization is working in the same direction. Furthermore, ISO 55000 focuses on creating processes to ensure proper resource allocation, and the understanding of how and where the money is used and what value they creates to the organization.

Another important issue is that even though the structure is different between ISO 9000 and ISO 55000, they are much alike in many clauses. The largest difference is the focus on products and customers in ISO 9000 and the value the assets provide in ISO 55000. When focusing on the products and the customers, organizations can forget to manage the assets that creates the value for the organization. Measuring product conformity to its requirements is not enough, one should monitor and measure the asset performance to achieve the value needed to achieve the required business results. Many of the specific clauses like documented information, resources, competence, operation, performance evaluation, improvement, and audits and reviews are much alike. This shows that it should not be too difficult to implement an asset management

system when already having ISO 9000 certification. The focus will be to expand some of the clauses to include asset evaluation, operation and improvement instead of only product. These two standards can and should be integrated. They should also be integrated with other standards like ISO 31000 (Risk management), ISO 14000 (Environmental systems) and OHSAS 18000 (Health and Safety systems).

8.5 The new ISO 9001:2015 Standard

As mentioned in *Context of the Organization*, there will be published a new ISO 9001 standard in September 2015. In 2012, it was decided that every ISO standard should use the same framework (DNV, 2014). Joint Technical Coordination Group in "Annex SL" specifies this new framework. This implies that every ISO standard (including ISO 9001:2015) will use an identical high-level structure. The structure will consist of the following elements:

Figure 34 – The high-level structure (Created with reference to DNV, 2014, p.4)

The main purpose of the new structure is the increased focus on effective process management. In addition, this new structure addresses the need for change management in this dynamic and complex market. There have been a growing number of management systems using different structures and definitions. ISO (2014) states that this new structure is particularly interesting for organizations that want to implement several management systems.

Regarding the existing ISO 9001, the main changes will be the structure of the standard together with the increased importance of risk (DNV, 2014). *Actions to address risks and opportunities* has been added to the new ISO 9001 standard. Furthermore, stakeholder analysis in *Understanding the needs and expectations of the interested* parties is also included. Other important changes is more explicit planning and control of changes, stronger emphasis on leadership, quality manual is removed, document control and control of records is replaced by documented information, and there is higher focus on improvement objectives.

ISO 55001 is already using this structure. When ISO 9001 changes to this structure, it would be easier to integrate the standards and avoid conflicts and variation. As listed above, some of the changes will decrease the gap between ISO 9001 and ISO 55001. Risk and opportunities will be included, and both of the standards will include their discipline specific risks. ISO 9001 will also address the risk that the management system itself is not effective (ISO, 2014). Another important aspect that has been identified as a gap between ISO 9001 and ISO 55001 is the stakeholder analysis. ISO 9001 will move from customer as a main stakeholder to include every stakeholder affecting the management system. This conforms to the requirements of ISO 55001 and it would be easier to integrate the two management system standards.

Chapter 9 ISO 55000 versus the PSA Regulations

9.1 A brief Introduction to the PSA Regulations

Introduction

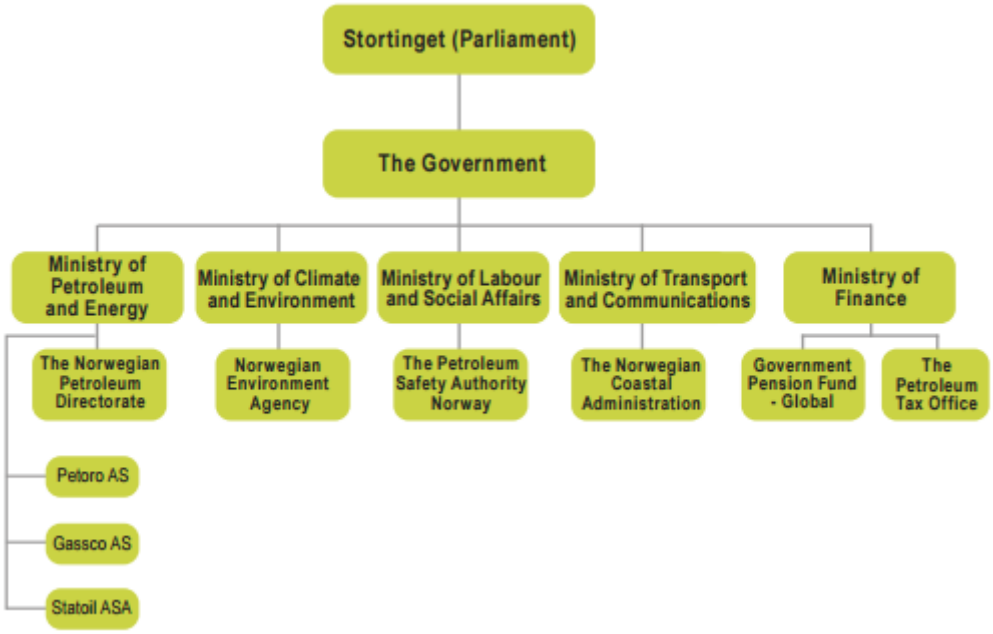

Figure 35 – State organization of the petroleum activities (NPD, 2014, p.31)

The Norwegian Parliament (the Storting) establishes the framework for the petroleum activities in Norway (NPD, 2014). Major developments and other issues concerning fundamental principles need to be discussed in the Storting. The Government holds the executive power over the petroleum policy and they is responsible to the Storting. In applying the petroleum policy, the Government is supported by several ministries. The ministries are again divided into directorates and supervisory authorities.

The Ministry of Labour has the overall responsibility for supervising the work environment, and safety and emergency responses in relation to petroleum activities. The Petroleum Safety Authority Norway is responsible for regulating the work environment, emergency preparedness and the technical and operational safety in the petroleum activities.

The Petroleum Safety Authority Norway

The PSA Norway is an independent government regulator that have the overall responsibility for safety, the working environment and emergency preparedness in connection with petroleum activities (PSA, 2015). The PSA was a part of the Norwegian Petroleum Directorate until the government decided in 2002 that safety supervision should be separated from NPD, and PSA was created. The PSA's main goal is to set terms for safety, health and the environment, together with emergency preparedness in the petroleum sector. Furthermore, the PSA's work

include follow-up to ensure that offshore operators maintain high standards within HSE. PSA's authority covers every petroleum activity on the Norwegian Continental Shelf (NCS) and eight land-based plants. PSA has the HSE responsibility for 25 000 people, 80 fixed installations, 56 rigs and 300 subsea installations. Appendix E shows PSA's area of responsibility. It is also a map of the offshore fields in the North Sea, Norwegian Sea and Barents Sea.

The PSA Regulations

There is five sets of regulations that are concerning HSE on NCS and some land-based plants (PSA, n.d.). These regulations are risk-based, and a large emphasis is on reducing safety, health and environmental risk. The aim is to reduce environmental damages, personal injury and accidents. Furthermore, the regulations are formulated as performance-based requirements, and the requirements is about the quality or characteristics of the product or processes.

The five regulations are presented below (PSA, n.d.):

- The Framework Regulations: "*Regulations relating to health, safety and the environment in the petroleum activities and at certain onshore facilitates*". The Framework Regulations apply on both the NCS and on land. The regulations are issued by royal decree and are enforced by PSA, ministries and health authorities. Furthermore, the regulations provide a framework for prudent activities and require the employees to be involved in every activity that may impact HSE.
- The Management Regulations: "*Regulations relating to management and the duty to provide information in the petroleum activities and at certain onshore facilitates*". The Management Regulations apply on both the NCS and on land. The PSA both issue these regulations and enforce them. The Management Regulations gather all management requirements relating to HSE, and define requirements concerning risk reduction, barriers, resources, analyses and management elements.
- The Activities Regulations: "*Regulations relating to conducting petroleum activities*". These regulations apply only on the NCS and also the Activities Regulations is both enforced and issued by the PSA. The regulations comprises the offshore activities and specify requirements for aspects as health-related factors, the environment, maintenance, maritime operations, working environment factors and monitoring.
- The Facilities Regulations: "*Regulations relating to design and outfitting of facilities, etc., in the petroleum activities*". These apply on the NCS. These regulations is concerning the design and outfitting of offshore facilities and specifies aspects as robust solutions, barriers, materials, drilling and well systems and safety functions and loads.
- The Technical and Operational Regulations: "*Regulations relating to technical and operational matters at onshore facilities in the petroleum activities*". These regulations apply to land-based facilities.

Regarding the correlation table, all the sections in the Framework Regulations is named FR, and all the sections in the Management Regulations is named MR.

9.2 Correlation Table between ISO 55001 and the PSA Regulations

ISO 55001	The Framework and Management Regulations
4. Context of the organization	
4.1 Understanding the organization and its context	FR - 9: Application of the principles in Chapter 2 FR - 10: Prudent activities FR - 11: Risk reduction principles
4.2 Understanding the needs and expectations of the stakeholders	FR - 7: Responsibilities pursuant to these regulations FR - 8: Employer's duties toward employees other than its own FR - 10: Prudent activities FR - 26: Documentation in the early phase. MR - 11: Basis for making decisions and decision criteria MR - 15: Information MR - 28: Information to the general public relating to safety measures for onshore facilities.
4.3 Determining the scope of the AM system	FR - 7: Responsibilities pursuant to these regulations
4.4 Asset management system	FR - 17: Duty to establish, follow up and further develop a management system MR - Chapter 3 (Section 7, 8, 9, 10 and 11)
5. Leadership	
5.1 Leadership and commitment	FR - 7: Responsibilities pursuant to these regulations FR - 15 : Sound health, safety and environment culture FR - 19: Verifications MR - 4: Risk reduction MR - 5: Barriers MR - 7: Objectives and strategies MR - 12: Planning MR - 13: Work processes
5.2 Policy	FR - 10: Prudent activities FR - 15: Sound health, safety and environment culture MR - 6: Management of health, safety and the environment MR - 7: Objectives and strategies MR - 8: Internal requirements MR - 11: Basis for making decisions and decision criteria
5.3 Organizational roles, responsibilities and authorities	FR - 12: Organization and competence MR - 6: Management of health, safety and environment MR - 14: Manning and competence

6. Planning	
6.1 Actions to address risks and opportunities for the asset management system	FR - 11: Risk reduction principles MR - 4: Risk reducing MR - 9: Acceptance criteria for major accident risk and environmental risk MR - 17: Risk analyses and emergency preparedness assessments. MR - 23: Continuous improvement
6.2 Asset management objectives and planning to achieve them	
6.2.1 Asset management objectives	MR - 7: Objectives and strategies MR - 8: Internal requirements
6.2.2 Planning to achieve asset management objectives	MR - 4: Risk reducing MR - 5: Barriers MR - 12: Planning MR - 17: Risk analyses and emergency preparedness assessments
7. Support	
7.1 Resources	MR - 12: Planning
7.2 Competence	FR - 12: Organization and competence MR - 14: Manning and competence
7.3 Awareness	MR - 5: Barriers
7.4 Communication	FR - 26: Documentation in the early phase MR - 15: Information MR - 28: Information to the general public relating to safety measures for onshore facilitates MR - 29: Notification and reporting of hazard and accident situations to the supervisory authorities MR - 30: Information on follow-up of hazard and accident situations
7.5 Information requirements	FR - 23: General requirements for material and information FR- 46: Oceanography, meteorology and earthquake data MR - 15: Information MR - 19: Collection, processing and use of data
7.6 Documented information	FR- 23: General requirements for material and information FR- 24: Use of recognised standards MR - 24: Organization of material and information
8. Operation	
8.1 Operational planning and control	MR - 13: Work processes Activity Regulations - 48: Planning and prioritisation
8.2 Management of change	FR - 17: Duty to establish, follow up and further develop a management system.

	MR - 11: Basis for making decisions and decision criteria. MR - 14: Manning and competence MR - 22: Handling of nonconformities MR - 23: Continuous improvement
8.3 Outsourcing	FR - 8: Employer`s duties toward employees other than its own FR - 18: Qualification and follow-up of other participants
9. Performance evaluation	
9.1 Monitoring, measurement, analysis and evaluation	FR - 48: Duty to monitor and record data from the external environment MR - 8: Internal requirements MR - 10: Measurement parameters and indicators MR - 16: General requirements for analyses MR - 18: Working environment analysis
9.2 Internal audit	MR - 21: Follow-up
9.3 Management review	FR - 19: Verifications MR - 21: Follow-up
10. Improvement	
10.1 Nonconformity and corrective action	FR - 11: Risk reduction principles FR - 20: Coordination of offshore emergency preparedness MR - 20: Registration, review and investigation of hazard and accident situations MR - 22: Handling of nonconformities
10.2 Preventive action	FR - 16: Health-related matters MR - 5: Barriers MR - 17: Risk analyses and emergency preparedness assessments MR - 19: Collection, processing and use of data
10.3 Continual improvement	FR - 15: Sound health, safety and environment culture FR - 17: Duty to establish, follow up and further develop a management system MR - 7: Management of health, safety and environment MR - 23: Continual improvement

Table 2 – Correlation between ISO 55001 and the PSA Regulations

9.3 Presentation of Results

Context of the Organization

The PSA Regulations require sound health, safety and environmental management, while the new ISO 5501 offers a new approach regarding asset management and asset value optimization. Both PSA Regulations (FR-9-10-11) and ISO 55001 (cl. 4.1) require the organization to determine the external and internal issues that can affect the ability to achieve its outcome. The PSA Regulations require the organization to assess the activities, local conditions, operational assumptions, factors that can cause harm, and other requirements. ISO 55001 require the organization to cover every issue, and ISO 55002 provide a more comprehensive list of issues to include in the internal/external context.

Additionally, both ISO 55001 (cl. 4.2) and the PSA Regulations (FR-7-8-10, MR-11-28) require stakeholder analyses. The PSA Regulations require the identification of different stakeholders to be able to communicate information to the relevant users and informing the general public of safety measures. The PSA Regulations also require prudent activities, which include the identification of relevant stakeholders. ISO 55001 require the organization to identify all the different stakeholders that range from internal employees to taxpayers and local communities.

According to the EFQM (2003), an excellent organization is flexible and responsive to the changing needs of the stakeholders, and information is collected from both current and future stakeholders. Furthermore, an excellent organization identifies all their stakeholders and works with them on joint improvement activity. ISO 55001 is compliant with these statements. The PSA Regulations cover HSE legislation and it is natural that the stakeholder analysis required in the regulations concern stakeholders that can affect the HSE. However, reviewing the PSA Regulations from a business perspective, there may be other stakeholders affecting the business result. It is the author's opinion that the requirements in ISO 55001 can stimulate to identify more relevant stakeholders than in the PSA Regulations, and hence there should be no surprise when an organization carry out their work (e.g. a local community contacts the media regarding pollution of their drinking water). In addition, if an organization operating on the NCS implement ISO 55001, the organization needs to take into consideration the PSA Regulations as ISO 55001 require this.

Regarding the scope of the management system, the author's opinion is that ISO 55001 (cl. 4.3) require a more broad view of the boundaries since is include more than the PSA Regulations (FR-7) and HSE legislation. Lastly, both ISO 55001 (cl. 4.4) and the PSA Regulations (FR-17) require a management system. Even though a HSE management system and an asset management system have different requirements, both PSA and ISO 55001 require a management system to be implemented and maintained.

Leadership

ISO 55001 have created a separate clause (5 *Leadership*) that specifies top management requirements. The PSA does not mention "top management" in their regulations, however, they refer to the responsible party or operator. Many sections (MR-4-5-7-12-13) in the PSA Regulations concern the responsible party needs to be performed by the top management, thus a certain link does exist. Furthermore, the PSA Regulations (FR-15) require the organization to achieve/enable a sound HSE culture, to be responsible to the regulations (FR-7), and perform verifications (FR-19). Even though it does not state that it is the top management's task, it is certainly their task.

Asset management Council (2014) and EFQM (2003) stresses that leaders of excellent organizations unite and motivate the employees, and establishes collaborative work cultures needed to achieve the organizational objectives. ISO 55001 (cl. 5.1) complies with these statements, while PSA require a sound HSE culture to be established. The PSA Regulations mention little of the motivation effort by the top management. The "line of sight" aspect have also a strong emphasis in ISO 55001. Management requirements like communicating the importance of effective asset management and supporting persons to contribute to the effectiveness of the asset management system shows this. The clear "line of sight" between top management and the daily operators is important to remove the traditional silo management (Woodhouse, 2010b).

The Framework Regulations (sect. 10, 15) require a high level of HSE and a sound HSE culture. Furthermore, the Management Regulations (sect. 6) require the organization to ensure that the management of HSE is included in every activity, resources and processes. Since PSA is a health, safety and environmental regulator, their policy will have a strong focus on HSE. ISO 55001 (cl. 5.2) require the organization to establish a policy that is appropriate to the direction of the organization and that provide a framework for setting the AM objectives. Organizations performing operations on the NCS needs to comply with the PSA Regulations, and hence if implementing ISO 55001 there needs to be a focus on HSE legislation in the policy. ISO 55001 can supplement the PSA Regulations to focus on optimizing the value created by the assets with a strong focus on HSE.

Both ISO 55001 (cl. 5.3) and the PSA Regulations (MR-6) require that top management ensure that all responsibilities and authorities are assigned for the relevant roles. ISO 55001 is more specific in their description of the responsibilities, however, the PSA Regulations and ISO 55001 is consistent with each other in this point, and neither of them is in conflict.

Planning

The *Planning* clause in the ISO 55001 (cl. 6.1) focus on addressing risks and opportunities, and hence this complies with the PSA Regulations (FR-11, MR-4-9-17). The Continuous Improvement section in the PSA Regulations (MR-23) require the organization to continual

identify improvements in the activities and processes, and this is consistent with the opportunity requirements in ISO 55001. The PSA Regulations have several sections concerning risk reduction, barriers, acceptance criteria and analysis, and it might require a more strict approach to address the risk issue. However, ISO 55001 (cl. 6.1) states that risks should be addressed to prevent and reduce undesired effects, and this would include barriers and analysis of risk. The author's opinion is that risk assessment have a large focus in the PSA Regulations, and ISO 55001 might not improve the risk assessments. Moreover, if implementing ISO 55001, one should also consider ISO 31000 (Risk management) and this will provide the additional risk management.

Regarding the objectives, ISO 55001 (cl. 6.2.1) offers a more specific approach to the objectives than the PSA Regulations (MR-7-8). The PSA Regulations require the objectives to focus on improving the HSE legislation, which is expected since PSA is a government regulator that have the overall responsibility for HSE. However, an organization cannot achieve excellent business results only focusing on HSE, and ISO 55001 can provide a more holistic approach to the objectives. Kaplan and Norton (1996) states that to create value to the stakeholders and customers, it is essential to create long-term objectives within the financial, customer, internal processes, and learning and growth perspective. The PSA Regulations cover the internal perspective (health, safety and environment) while ISO 55001 also cover the financial, customer, and learning and growth perspective. It is the author's opinion that ISO 55001 should provide further value to all the different stakeholders than only being complaint to the PSA Regulations.

ISO 55001 (cl. 6.2.2) require documentation of the whole "planning to achieve the objective" process, and it lists among others the methods, criteria's, processes and actions to address the risks. The PSA Regulations (MR-4-5-12-17) has several sections about addressing the risk and it require the activities to be aligned with the objectives. Nevertheless, it is the author's opinion that ISO 55001 require a more comprehensive approach to the planning of achieving the objectives process, and this should benefit organizations seeking ISO 55001 compliance.

Support

Both ISO 55001 (cl. 7.1) and the PSA Regulations (MR-12) require the organization to provide the necessary resources needed to perform activities and develop and implement the management system. However, ISO 55002 (cl. 7.1) offers a more comprehensive guideline to resource management than the guidelines linked to the PSA Regulations. Mapping the available resources and performing resource gap analyses is something suggested in ISO 55002. ISO 55002 is clear about the "line of sight" principle in this sub-clause as it is suggested that parts of the organization may need to provide additional resources to supplement the primary asset management activity. This approach needs a holistic view of the resource management, and it ensures that the resources are used where it creates the highest value (Woodhouse, 2010b).

Therefore, it is the author's opinion that the use of ISO 55001 and certainly ISO 55002 will supplement the PSA Regulations to ensure effective resource management.

ISO 55001 (cl. 7.2) states that persons working under the organization's control shall have the necessary competence, and this is consistent with the competence requirements of PSA Regulations (FR-12, MR-14). However, ISO 55001 require a broader competence management than which is required by the PSA Regulations. For instance, it is not mentioned in the PSA Regulations that an organization needs to review the current capability of persons to increase the competence in the organization.

The PSA Regulations (MR-5) require personnel to be aware of the barriers that have been established and their performance requirements. These barriers exists to identify and prevent failures, accident situations, and hazards. The barrier awareness is consistent with the awareness of risks associated with the work activities required by ISO 55001 (cl. 7.3). Additionally, ISO 55001 require the personnel to be aware of the AM policy and their own contribution to the effectiveness of the (asset) management system. Risks is in ISO 55000 (cl. 3.1.12) defined as both risks and opportunities, and hence the personnel needs to be aware of the opportunities of their work activities. ISO 55001 is compliant with the PSA Regulations, however, ISO 55001 offers something more. When the personnel is aware of their own contribution to the effectiveness of the management system, it can lead to more effective management system performance and innovation can be fostered (Woodhouse, 2010b).

Both ISO 55001 (cl. 7.4) and the PSA Regulations (MR-15) require communication systems both for internal and external communication. The section 28, 29 and 30 in the Management Regulation require the organization to communicate with PSA Norway in the case of hazardous situations. ISO 55002 (cl. 7.4.2) states that an organization should develop communication plans to promote engagement with the stakeholders, and to inform and influence the stakeholders that can affect the intended outcome. Since organizations performing operations on the NCS needs to comply with the PSA Regulations, communication plans with PSA needs to be established if seeking ISO 55001 compliance. The requirements in ISO 55001 and the PSA Regulations is quite general when it comes to communication, and they is consistent with each other. Communication is further regulated by the Activity Regulations (ref. section 80).

The PSA Regulations (MR-15) require a compliant organization to identify the information necessary to plan and carry out activities. ISO 55001 (cl. 7.5) require the determination of information requirements to support the asset, AM and AM system. Furthermore, the PSA Regulations (FR-23) require documentation that can demonstrate that the activities are planned and carried out in a prudent manner, and include documentation that demonstrate compliance with the PSA Regulations. ISO 55001 (cl. 7.6) require documented information required by ISO 55001 and legal and regulatory requirements. The author's opinion is that ISO 55001 and the PSA Regulations are consistent with each other in these sections (*Information requirements* and *Documented information*). ISO 55001 and the PSA Regulations is not in conflict with each other, and the PSA Regulations should not act as a barrier for an effective implementation of ISO 55001.

Operation

The PSA Regulations specify some requirements regarding underwater operations (MR-35), drilling and well activities (MR-37), and other onshore/offshore plant operations that are not mentioned in the ISO 55001. Furthermore, the PSA Regulations (MR-13) require the creation of work processes that fulfil the requirements related to HSE, and ISO 55001 (cl. 8.1) require processes needed to support the asset management plan, corrective actions and actions that addresses risks and opportunities. The asset management plan does not only include activities related to HSE, but every activity that is needed to achieve the asset management objectives. ISO 55002 (cl. 8.1.2, 8.1.3) suggests that the operational planning and control should include procedures, resource allocation, competency development and control mechanisms. To achieve excellent business results within the operation phase, ISO 55001 would be a good supplement to the PSA Regulations. It is also worth mention that a large part of the Activity Regulations is concerning operations.

Regarding the important aspect management of change, both ISO 55001 (cl. 8.2) and the PSA Regulations (FR-17, MR-11-14-22-23) addresses this. The PSA Regulations require the organization to identify improvement measures for the management system, nonconformities and processes/activities. When implementing these measures the organization needs, according to PSA Regulations, to adequately understand and assess HSE related issues. ISO 55001 states that risks with every planned change should be assessed. The PSA Regulations require the management of change within its scope (HSE), while ISO 55001 is more consistent with Frankel's (2008) thoughts about management of change. Frankel (2008) states that to achieve successful management one should manage changes in markets, process technology, service, resources, competitors resources and political and regulatory developments. Both ISO 55001 and the PSA Regulations require management of change, but ISO 55001 require a broader view.

The control of the outsourced activities is something that is of great focus in both ISO 55001 (cl. 8.3) and the PSA Regulations (FR-8-18). Issues like ensuring competence and knowledge sharing in the outsourced activity is included in both.

Performance Evaluation

PSA is a safety authority and their main performance evaluation requirements consist of HSE related issues. The PSA Regulations (FR-48, MR-8-10-16) does not focus on performance measures concerning effectivity of the production or the quality of the product. Organizations that operates on the NCS needs to comply with the PSA Regulations, and hence a part of their performance measures needs to concern HSE related issues. ISO 55001 (cl. 9.1) provide a broader approach to the performance evaluation.

Campi (1993) states that organizations that conduct world-class performance include measures like customer satisfaction, shareholder, financial and employee satisfaction. Additionally, Kaplan and Norton (1996) states that the performance measures should be divided into four

balanced perspectives: financial, customer, internal processes, and learning and growth. ISO 55001 (cl. 9.1) require that the organization shall evaluate the asset management performance, including financial and non-financial performance. Furthermore, ISO 55002 (cl. 9.1.1.2) explains that the evaluation of performance should include proactive and reactive indicators, quality and reliability of asset information, evaluation of compliance to regulatory requirements, and evaluation of persons competence and awareness.

The author's opinion is that ISO 55001 require an extra dimension within the performance evaluation in relation to the PSA Regulations, since it focus on more than HSE related measures. ISO 55001 should help the organization to both focus on HSE related measures and asset performance measures. In addition, it is worth mention that the PSA Regulations does not act as a barrier for the *Performance Evaluation* clause in ISO 55001. ISO 55001 states that the monitoring and measuring should enable that the organization to meet the requirement of the stakeholders. PSA is a stakeholder, and some of the measures in ISO 55001 needs to consider HSE related issues.

The Follow-up section (21) in the Management Regulations covers both the internal review and the management review. The PSA Regulations link the internal audit and management review to ISO 9000 (cl. 2.8, 3.8, 3.9) to achieve a more specific process. The process in ISO 9000 is, as aforementioned, consistent with ISO 55001 (cl. 9.2, 9.3).

Improvement

The *Improvement* (10) clause in ISO 55001 complies with the PSA Regulations. They both require action to nonconformities (FR-20, MR-20-22), identification of root cause and prevent recurrence. Preventive actions (MR-5) and continual improvement (FR-15-17, MR-6-23) is also included in both. Emergency preparedness assessments (MR-17) is more specified in the PSA Regulations, but is to some extent covered in the Preventive action clause in ISO 55001.

9.4 Summary of Results

The PSA Regulations is about managing health, safety and the environment in a management system. The PSA Regulations does not focus on improving and measuring production effectivity or the quality of products. Therefore, from the author's point of view, it would be beneficial to implement an additional management system. It would be beneficial to implement ISO 55001 in addition to the required PSA Regulations. While PSA Regulations focus on HSE related matters, the main emphasis of ISO 55001 is to help the organization to be able to extract the optimum value of the asset at the optimal costs. ISO 55000 provides the "line of sight" from the top management to the front line workers and everyone in the organization is working in the same direction (Statoil, 2014a). This "line of sight" will increase the innovation and creativity within the organization, which again can lead to more effective work procedures (Woodhouse, 2010b). Furthermore, ISO 55001 focuses on the how money and the different

assets will contribute to value creation. ISO 55001 sets a framework for supporting decisions and ensure a steady course of the organization.

As commented in each clause in appendix C and the *Presentation of Results* sub-chapter, the PSA Regulations should not act as a barrier for the implementation of ISO 55001 when already being compliant to the PSA Regulations. However, it is not possible to only implement ISO 55001 and then comply with the PSA Regulations. The PSA Regulations is much more specific than ISO 55001. The Activity Regulations include specific requirements, e.g. sections about radiation, noise, pollution, emissions and working hours, and the Management and Framework Regulations include specific requirements for pollution, underwater operations, load-bearing structures, drilling and well activities and information regarding oceanography. It is not possible only implement ISO 55001 for organizations performing operations on the NCS.

ISO 55001 put a lot of emphasis on stakeholder requirements, and PSA's requirements and demands should be well covered when implementing ISO 55001. ISO 55001 (cl. 4.2) require the organization to identify and determine the needs and expectations of the stakeholders relevant to the asset management system. ISO 55002 (cl. 4.2.3) states that these stakeholders can include government organizations and regulatory authorities. The PSA Norway is an independent government regulator with the responsibility for safety, preparedness and emergency in the Norwegian petroleum sector (PSA, 2015). In addition, ISO 55001 (cl. 4.1) require the organization to identify the internal and external context that affect its ability to achieve the outcome of the AM system. Communication plans should be developed to promote engagement with the stakeholders, and the performance evaluation needs to meet the requirements of the stakeholders. Stakeholders is of great importance in ISO 55001, and PSA is one of the major stakeholders for organizations operating on the NCS. Offshore operating organizations needs to comply with the PSA Regulations, and if implementing ISO 55001 they need to expand the HSE management system required by PSA Regulations.

The scope of this analysis concern the Management Regulations and the Framework Regulations (the Activity Regulations is excluded). The author has identified some main clauses in ISO 55001 that should provide extra value to an organization that is already compliant with the PSA Regulations. Within the support clause in ISO 55001, the author has identified that implementing ISO 55001 should provide better Resource and Competence management. Awareness has more focus in ISO 55001 and it should increase the innovation in the organization. The Operation clause in ISO 55001 should be a good supplement to the HSE related PSA Regulations. Regarding the sub-clause Management of Change in ISO 55001, it focus on every change and not changes related to HSE. The Leadership clause in ISO 55001 constitute the imperative "line of sight" aspect. Furthermore, the Performance Evaluation clause should provide an extra dimension in monitoring and measurement since it focus on Kaplan and Norton's (1996) four perspectives: financial, customer, internal processes, and learning and growth. The performance measures is also linked with the Objective sub-clause in ISO 55001, which should provide further value to all the different stakeholders, and not only stakeholders that focus on HSE.

Chapter 10 Asset Management and ISO 55001 versus Statoil

10.1 Correlation Table between ISO 55001 and Statoil's Governing Documentation

ISO 55001	Statoil and Gerhardsen
4. Context of the organization	
4.1 Understanding the organization and its context	FR11: 2 Sustainability in Statoil FR11: 3 Sustainability function requirements SB: Introduction – p8 SB: Sustainability: How we work – p61 PAS: 4 HSE PAS: 5 Quality Management PDO: 2.9 Organization and execution PDO: 10 HSE PDO: 10.1 Acceptance criteria and requirements PDO: 10.4 Environmental assessment of the chosen solution
4.2 Understanding the needs and expectations of the stakeholders	FR04: 2.5.8 Stakeholder management and communication plan FR05: 2.5.1 Integration management: Stakeholder management FR09: 2.3.4.3 Customer relationship management FR09: 2.3.4.4 Supplier relationship management FR20: 3.5 Stakeholder involvement OMC01-000: 2.9 External partnerships and reporting PAS: 3.5 Authority coordination PDO: 9 Operation and maintenance PDO: 10.1 Acceptance criteria and requirements
4.3 Determining the scope of the AM system	FR06: 3.2 Accountability
4.4 Asset management system	FR20: 2 The management system function OMC01-000: 3 Management model PAS: 2.2.2 Management system PDO: 11.1.1 Main goal PDO: 1.1.2 Basis for the management system
5. Leadership	
5.1 Leadership and commitment	FR10: 3.1 Leadership FR10: 3.2 Compliance and leadership FR16: 2.1 The line management FR16: 2.2 The PO function OMC01-000: 2.3.5 Staff functions OMC01-000: 4.1 Roles and responsibilities for the management system SB: Introduction – p8 SB: Our responsibilities – p9 SB: People partnerships – p16 SB: External orientation – p17

	SB: The role and responsibility of the process owner – p41: SB: Authorities and internal control in Statoil – p50 PAS: 3.1 Asset owner and asset owner representative PAS: 3.10 Staffing resources PAS: 5 Quality Management
5.2 Policy	FR06: 3.4 Operation OMC01-000: 2.3.1 Strategy and Portfolio SB: Organizational principles – p24 OMC01-036: 2 Overall strategy
5.3 Organizational roles, responsibilities and authorities	FR06: 3.2 Accountability FR15: 2.2 Roles and responsibilities OMC01-000: 2.1 Role and responsibilities OMC01-000: 2.3.3 Operating Areas OMC01-000: 3.4 Process and function relationships SB: The role and responsibility of the process owner – p41: PAS: 3.2 Assignment structure PAS: 3.4 Business Case Leadership Team (BCLT) OMC63: 4.1 General
6. Planning	
6.1 Actions to address risks and opportunities for the asset management system	FR04: 2.5.4 Risk management FR06: 3.3 Integrity and risk management FR08: Risk Management FR09: 2.3.4.5 Risk management FR10: 3.3 Risk management FR20: 3.3 Manage risk OMC01-000: Risk management SB: Safety: How we work – p57 SB: Risk: How we work – p67 PAS: 3.4 Business Case Leadership Team (BCLT) PDO: 10.1 Acceptance criteria's and requirements PDO: 10.2 Safety PDO: 11.1.3 Risk management
6.2 Asset management objectives and planning to achieve them	
6.2.1 Asset management objectives	FR06: 3.4 Operation FR06: 3.5 Maintenance OMC01-000: 3.1 Ambition to action SB: Ambition to Action – p27 SB: Strategy translation and target-setting – p29 PAS: 3.8 Ambition to Action for the Gerhardsen project PDO: 11.1.1 Main goals
6.2.2 Planning to achieve asset	FR06: 3.3 Integrity and risk management FR06: 3.5 Maintenance FR10: 3.4 Barrier management

management objectives	FR10: 3.10 Technical and operational safety FR14: 3.2 Investment decisions SB: Planning – p30 OMC01-036: 3.2 Strategy for operations and maintenance topside OMC63: 4.3 Maintenance
7. Support	
7.1 Resources	FR06: 3.5 Maintenance OMC01-000: 2.3.5.3 PO OMC01-004: 3.6.5 Collaboration SB: Execution – dynamic resource allocation – p31 SB: Safety: How we work – p57
7.2 Competence	FR06: 3.8 Competence and learning FR09: 2.3.4.2 Expertise development FR16: 4.2 Performance and development FR20: 3.6 Implementation and use OMC01-000: 2.3.5.3 PO OMC01-004: 3.6.6 Competence management SB: People@Statoil – p19 SB: Our common career model – p20 PDO: 11.2.3 Competence requirements and training OMC63: 3.5 Competence and training
7.3 Awareness	SB: People@Statoil – p19: SB: Compliance and Leadership – p34
7.4 Communication	FR04: 2.5.8 Stakeholder management and communication plan FR05: 2.2 Ownership and organizational structure FR05: 2.5.1 Integration management: Stakeholder management FR13: Communication
7.5 Information requirements	FR05: 2.5.9 Communication, information and document management FR06: 3.1.5 Life cycle information FR06: 3.3 Integrity and risk management FR14: 2 The finance and control function (2.1) FR14: General document. Especially 3.4 Tax FR15: 4.6 Information management SB: Governing documentation – p39
7.6 Documented information	FR05: 2.5.9 Communication, information and document management FR15: 4.5 Information security FR20: 3.1 Architecture and content FR18: 3.1 Correct information, accounting and reporting FR20: 3.1 Architecture and content. FR20: 3.2 Ownership and validity FR20: 4 Governing documentation management SB: Governing documentation – p39

8. Operation	
8.1 Operational planning and control	FR06: 3.3 Integrity and risk management FR06: 3.4 Operation FR06: 3.5 Maintenance FR10: 3.4 Barrier management FR10: 3.10 Technical and operational safety PDO: 9.2 Maintenance OMC63: 2 Operating model for Gudrun OMC63: 4.1 General
8.2 Management of change	FR05: 2.5.1 Integration management: Change management FR16: 4.5 Change management and continuous improvement FR20: 3.7 Management of change (MOC) PAS: 2.2.2 Management system PAS: 6.4 Changes to the project basis
8.3 Outsourcing	FR09: 2 The Supply Chain Management Function FR09: 2.3.4.4 Supplier Relationship Management FR09: 2.3.4.5 Risk Management FR20: 3.4 External requirements and standards FR20: 4.3 Service providers and contractors OMC01-004: 2.4.3.4 Company representative for M&M contracts OMC01-004: 2.4.5 Partner-operated Licences SB: Procurement: We are committed to – p70 OMC63: 5 Integrated Operations (IO) for Gerhardsen
9. Performance evaluation	
9.1 Monitoring, measurement, analysis and evaluation	FR06: 3.4 Operation FR06: 3.5 Maintenance FR09: 2.3.4.1 Master data and best practice performance FR10: 3.6 Performance management and monitoring FR20: 3.11 Monitoring OMC01-000: 4.3 Monitoring SB: Monitoring – p43 SB: Follow-up – p44 SB: Safety: How we work – p57
9.2 Internal audit	SB: Monitoring – p43 SB: Follow-up – p44 SB: Verification – p45 SB: Internal audit – p45 SB: Control bodies – p 51:
9.3 Management review	FR20: 3.10 Learning and improvement SB: Follow-up, forward-looking and action-oriented – p32 SB: Monitoring – p43 SB: Follow-up – p44 SB: Follow-up – p45

	PAS: 3.3 Project steering committee PSC
10. Improvement	
10.1 Nonconformity and corrective action	FR06: 3.4 Operation FR10: 3.7 Nonconformities FR10: 3.8 Incident investigation FR20: 3.9 Manage nonconformities SB: Security: How we work – p59:
10.2 Preventive action	FR06: 3.5 Maintenance
10.3 Continual improvement	FR06: 3.4 Operation FR09: 2.3.4 Continuous improvement FR10: 3.9 Improvement and learning OMC01-000: 4.4 Further development and continual improvement of the management system SB: Safety: How we work – p57

Table 3 – Correlation between ISO 55001 and Statoil's governing documentation

10.2 Presentation of Results

Context of the Organization

Liyanage (2012) states that stakeholders in the traditional industrial climate included shareholders and governments, however, organizations operating in the modern industrial climate need to take into account a wider stakeholder approach. Modern management of assets needs to balance a large range of complex factors with a much wider perspective than before. ISO 55001 (cl. 4.1, 4.2) is compliant with these thoughts as it sets requirements to identify external and internal issues relevant to the outcome of the AM system, and determine every stakeholder that is relevant to the AM system. Statoil have adopted this modern stakeholder approach as it focuses on identifying the environmental and social issues that are relevant to the organization (FR11: Ch. 2 and 3). One of Statoil's fundamental objectives is to operate the management system in a way that complies with every internal and external requirements (Statoil Book: p.8). Statoil clearly focuses on both identifying external/internal issues and all the relevant stakeholders, and this clearly shows that Statoil is compliant with the two first requirements of ISO 55001. A complete stakeholder analysis is needed according to the Asset Management Council (2014) since it is ultimately the stakeholders that determine the degree of failure and success.

ISO 55001 (cl. 4.3, 4.4) require the organization to determine the scope of the AM system and eventually develop, implement, maintain and improve the AM system. Asset management can be seen as an integration framework (IAM, 2014) and ISO 55002 (cl. 4.4) states that a critical success factor is to integrate the AM system with its associated processes and activities, with other functions like quality, accounting, safety and risk management. Statoil have not adopted the asset management approach or implemented any asset management system, and hence Statoil's governing documentation is far from compliant with ISO 55001 requirements sub-clause 4.3 and 4.4. To be compliant, Statoil needs to develop the AM system and integrate it with other management systems like quality management and risk management.

Leadership

Leadership and culture are two essential elements of asset management that are needed to realize the asset value and make asset management blossom in the organization (ISO 55000, 2014; Asset Management Council, 2014). This is also supported by EFQM (2003) as they express that leaders in excellent organizations needs to unite the employees and establish a collaborative work culture that is necessary to achieve the organizational (and AM) objectives. ISO 55001 (cl. 5.1) specifies ten leadership requirements that need to be fulfilled in order to achieve compliance with this standard. Both ISO 55001 and ISO 55002 (cl. 5.1) focus on the "line of sight" as they require the AM system to be aligned with other organizational functions, practices and management systems. Statoil have clearly recognized the importance of leadership, and specific requirements in Statoil's governing documentation require the leaders to establish the management system, create a strong collaborative culture and to align the business needs with personal employee goals (Statoil Book, p.16, p.17 and p.41). It should not be difficult to be compliant with ISO 55001 sub-clause 5.1 if implementing an AM system, however, Statoil should also consider AM leadership fundamentals that lie outside the scope of ISO 55001 to perform good asset management.

Statoil have not created an asset management policy, however, their organizational principles and strategy (Statoil Book: p.24) is in accordance with some of the requirements in ISO 55001 (cl. 5.2). To fulfil the requirements in sub-clause 5.2, Statoil needs to create an AM policy that should be communicable to the whole organization (ISO 55002: cl. 5.2). Good asset management practice also require the policy to include a commitment to integrate asset management with corporate planning, and budgetary and reporting processes.

To satisfy the requirements in ISO 55001 sub-clause 5.3, the organization needs to assign responsibility and authority for relevant roles. Statoil's OMC (e.g. OMC01-000) documents clearly specify the responsibilities and authorities for every relevant role in Statoil. Since there SAMP, AM plan, or AM system exists in Statoil, it is obvious that Statoil does not fulfil the requirements of sub-clause 5.3. Nevertheless, if Statoil decide to implement and integrate an AM system and update the OMC documents with relevant AM roles and responsibilities, they will be very close to satisfying the requirements.

Planning

Sub-clause 6.1 in ISO 55001 is about the identification of every risk and opportunity in the asset management system. Asset management is about integration, and ISO 55002 (cl. 6.1) explains that the approach of managing risks in the AM system should be aligned with the organization's risk management approach. Statoil have created their own functional requirement document for risk management where identification and treatment of risk is the main core. Statoil require managers at all levels to identify, analyse, evaluate, follow up and communicate the main risks in their activities. The management of Gerhardsen needs to satisfy Statoil's risk management requirements (FR08) and a specific requirement for Gerhardsen is to

use the ALARP principle (PDO: Ch. 10.1). It is not difficult to conclude that Statoil's risk management approach will certainly fit the requirements in ISO 55001. To perform good asset management, Statoil should remember to integrate the AM risk approach with the requirements in their Risk Management requirements.

Kaplan and Norton's (1996) work with balanced scorecard have identified that successful management create their objectives within the financial, internal process, customer, and learning and growth perspective. ISO 55001 is consistent with these thoughts, as it requires the organization to consider the requirements of stakeholders and financial, technical and regulatory requirements when developing the AM objectives. Statoil's approach to setting the organizational objectives is through the Ambition to Action process (Statoil Book: p.27-29). Ambition to Action is about translating strategies into actions and strategic measureable objectives. If Statoil decided to create specific AM objectives, they could certainly be created with reference to the Ambition to Action process, and hence Statoil is close to satisfy all of the requirements in sub-clause 6.2.1 in ISO 55001. It is also important that Statoil focus on developing objectives that cover the whole life cycle of the asset, and the objectives should address among others the total cost of ownership and life cycle costs.

The main purpose of the sub-clause 6.2.2 in ISO 55001 is to establish, implement and maintain an asset management plan that describes every activity needed to achieve the AM objectives. The Statoil Book, which is the superior document in Statoil, require actions that address risks and actions needed to achieve the objectives and KPI targets. This also include action planning (what, who, how, when). ISO 55002 (cl. 6.2.2.1) states that the AM plan often include maintenance and financial plans, and Statoil is compliant with this through FR06 (Ch. 3.5) and FR14 (Ch. 3.2). Even though Statoil has not yet created an AM plan, their planning processes is consistent with most of the requirements in sub-clause 6.2.2 in ISO 55001. It is also important for Statoil to remember that risks changes with time, and this is needs to be addressed in the AM plan (ISO 55002: cl. 6.2.2.4).

Support

ISO 55001 require an organization to determine and provide the necessary resources in the AM system (cl. 7.1), and sub-clause 7.2 requires that the organization to determine the necessary competence of persons that can affect the asset performance. Statoil's dynamic resource allocation framework (Statoil Book, p.31) ensures that the resources are available for operations and Statoil uses a join competence management process that ensures that all O&M personnel have the necessary competences (OMC01-004: Ch. 3.6.6). Statoil's governing documentation is quite consistent with ISO 55001 concerning both resource allocation and the competence management. Statoil should however not be satisfied with only fulfilling the requirements in ISO 55001, and they should use the ISO 55002 guideline as much as possible because it provide some good asset management approaches. ISO 55002 (cl. 7.1) states that the organization should consider both internal and external resources and one should assess if the AM activities

needs resources from other parts of the organization. Those responsible for the AM activity needs to coordinate effectively. In addition, ISO 55002 (cl. 7.2.1) states that an ISO 55001 compliant organization should ensure alignment between roles and levels, and hence persons with competence in specific asset management-related tasks should also have a clear understanding of the AM tasks that others perform.

ISO 55001 (cl. 7.3) states that every person that is doing work under the organization's control needs to be aware of their contribution to the effectiveness of the AM system and the risks and opportunities associated with the work they do. Both Statoil's People@Statoil process and the Compliance and Leadership model, contribute to increase awareness in the organization. However, it is difficult to find documentation specifying that people needs to be aware of the (asset) policy, their contribution to the effectiveness of the (asset) management system, or how well the organization is performing in achieving the organizational objectives. It is similarly not stated that the employees need to be aware of opportunities associated with their work. Some asset management fundamentals exists in Statoil regarding the awareness clause, however, there is a small gap between the requirements of ISO 55001 and Statoil's current practice.

ISO 55001 (cl. 7.4) requires the organization to determine the needs of internal and external communication relevant to the asset management system. Statoil have created a separate communication document that specifies communication plans regarding media relations, internal communication, political and public affairs and brand communication. If Statoil decides to develop an AM system in the future, the requirements in FR13 should satisfy the requirements in ISO 55001.

ISO 55001 (cl. 7.5) requires the organization to determine the information requirements to support the assets, AM and AM system and the achievement of the organizational objectives. Statoil's information requirements are spread around in different documents, and include among other requirements for life cycle information (FR06: Ch. 3.1.5) and financial information (FR05: Ch. 2.5.9). Information security and information management (IM) requirements are specified in FR15 (Ch. 4.5, 4.6). Asset specific information requirements is listed in the more technical documents like WR and TR. In summary, many of Statoil information principles comply with ISO 55001 requirements. Statoil should also try to align the information requirements for different levels and functions in the organization, which include vertical alignment of information from top management to operational areas and horizontal alignment between functions (ISO 55002: cl. 7.5.3). This will contribute to overcoming the traditional silo management and enhance the asset management approach.

ISO 55001 (cl. 7.6) states that the AM system needs to include documented information for regulatory requirements and documented information determined as being necessary for the effectiveness of the AM system. Statoil's management system is documented in Statoil's governing documentation and the governing documentation is aligned across the whole organization. The requirements in ISO 55001 (7.6.2 Creating and Updating, and 7.6.3 Control) can be linked to the five-step cycle in Statoil's governing documentation management. Statoil

satisfies most of the requirements in the Documented information sub-clause in ISO 55001 and only small changes will be needed if Statoil decides to implement an asset management system.

Operation

The first sub-clause (8.1) in the Operation clause require the organization to implement and control the processes required to fulfil the requirements for risks and opportunities, the AM plan, AM objectives, and corrective and preventive actions. Statoil have developed a common operating model for DPN and every platform, including Gerhardsen, needs to operate following the same requirements (OMC63: Ch. 2). FR06 (Ch. 3.5) states that every offshore asset needs a maintenance program, point 3.4 (FR06) require the implementation of operational measures, and FR10 (Ch. 3.10) require barrier management. As mentioned earlier, Statoil is quite consistent with the AM plan, and Statoil's governing documentation is also consistent with the requirements regarding the processes needed to achieve the requirements in the AM plan.

Frankel (2008) stresses that successful management in today's competitive markets is managing changes in technology, products and markets. The markets are constantly changing and if the organizations do not embrace these changes they lose competitiveness. The management of change clause (cl. 8.2) in ISO 55001 is about the managing the risks these changes impose. Statoil states that management of change (MOC) will be applied to every planned change in Statoil to ensure acceptable risk (FR20: Ch. 3.7). Statoil's focus on MOC implies that they should be very close to compliance with the requirements of sub-clause 8.2 in ISO 55001.

ISO 55001 sub-clause 8.3 is about managing the risks of every outsourced activity that can have an impact on the achievement of the AM objectives. The Supply Chain Management function manages Statoil's suppliers with a comprehensive approach, and they evaluate its external and internal exposure to risk (FR09: Ch. 2.3.4.5). Furthermore, one of Gerhardsens main targets is to approach IO Generation 2 (OMC63: Ch. 5), and hence the information exchange requirement in ISO 55001 is taken care of. Statoil's governing documentation is more or less compliant with the requirements in sub-clause 8.3 in ISO 55001. The ISO 55001 requirements for competence, awareness and documented information in the outsourced activities are not present in Statoil's governing documentation, and this needs to be addressed by a future asset management approach in Statoil.

Performance Evaluation

Sub-clause 9.1 in ISO 55001 covers monitoring, measurement, analysis and evaluation in the asset management system. Statoil's governing documentation addresses issues like the establishment of operational targets, the monitoring of the O&M processes, the evaluation of the effectiveness of maintenance processes, the monitoring of the asset performance and compliance with requirements (FR06: Ch. 3.4, 3.5). However, most of the abovementioned issues are stated in only one of Statoil's functional requirements (FR06), and to perform good

asset management Statoil need to address these issues in every governing document. In addition, the Statoil Book (p. 43) mention that the monitoring process in Statoil assures compliance with the management system, however, it is also important to evaluate the effectiveness of the management system. Nevertheless, Statoil have a comprehensive approach regarding the monitoring and measurement process, and hence the requirements of a future asset management system are satisfied by Statoil's current practices. Moreover, to enhance the asset management approach, it is important to not only measure the asset performance, therefore Statoil's measurement and evaluation process should include proactive and reactive indicators, the quality and reliability of information, evaluation of compliance to regulatory requirements, evaluation of competences of personnel, and assessment of the performance of the AM processes (ISO 55002, cl. 9.1.1.2).

Statoil's internal monitoring consists of three main categories: follow-up, verification and internal audit. These three categories cover the requirements in ISO 55001 (cl. 9.2 and 9.3) and Statoil does not need to put much effort in changing the internal monitoring categories to be compliant with the requirements of Internal audit and Management review in ISO 55001.

Improvement

Statoil's governing documentation requires that nonconformities in the organization is identified and handled, and their consequences and root causes shall be known (FR20: Ch. 3.9). Moreover, failure management strategies shall be selected for the most serious failure modes (FR06: Ch. 3.5). These Statoil requirements are consistent with the requirements in sub-clause 10.1 in ISO 55001 as it require an ISO 55001 compliant organization to react to nonconformities and incidents, take control of the nonconformity and deal with the consequences. Statoil's aforementioned requirements are also consistent with ISO 55001 (cl 10.2) which require the organization to identify potential failure in asset performance.

FR20 (Ch. 2) states that the leaders in Statoil shall continuously evaluate improvements proposed to the management system. This is consistent with the continual improvement requirements in ISO 55001 (cl. 10.3). Statoil specifies requirements for continual improvement in many of their Functional Requirements, and if implementing an asset management system, Statoil is not far from fulfilling the requirements in this clause. However, even though continual improvement is included in Statoil's high-level documents, it is not always included in the work processes that describe how to actual perform activities in Statoil. It is also worth mentioning that Statoil should actively seek new knowledge about AM technology and practices (ISO 55002: cl. 10.3.3), and this can be achieved through active participation in professional AM bodies like the IAM and the Asset Management Council.

10.3 Gap Analysis

This gap analysis is performed with reference to the ISO 55001 comparison. Each sub-clause is given a grade that shows how close Statoil is to satisfying the requirements in ISO 55001. Further comments about the gap analysis can be found in the table below.

Grade	% Compliant	
5	80-100	Professional
4	60-80	Foundation
3	40-60	Developing
2	20-40	Initial
1	0-20	None

Table 4 – Compliant grade description

ISO 55001	Actual	GAP
4. Context of the organization		
4.1 Understanding the organization and its context	5	0
4.2 Understanding the needs and expectations of the stakeholders	5	0
4.3 Determining the scope of the AM system	2	3
4.4 Asset management system	1	4
5. Leadership		
5.1 Leadership and commitment	4	1
5.2 Policy	3	2
5.3 Organizational roles, responsibilities and authorities	4	1
6. Planning		
6.1 Actions to address risks and opportunities for the asset management system	5	0
6.2 Asset management objectives and planning to achieve them		
6.2.1 Asset management objectives	4	1
6.2.2 Planning to achieve asset management objectives	5	0
7. Support		
7.1 Resources	5	0
7.2 Competence	5	0
7.3 Awareness	4	1
7.4 Communication	5	0
7.5 Information requirements	4	1
7.6 Documented information	5	0
8. Operation		
8.1 Operational planning and control	5	0
8.2 Management of change	5	0
8.3 Outsourcing	5	0
9. Performance evaluation		
9.1 Monitoring, measurement, analysis and evaluation	5	0
9.2 Internal audit	5	0
9.3 Management review	5	0
10. Improvement		
10.1 Nonconformity and corrective action	5	0
10.2 Preventive action	5	0
10.3 Continual improvement	5	0

Table 5 – Gap analysis

Gap Analysis Discussion

It is important to understand that even though most of the clauses have been given the grade 5, the requirements in the respective clauses may not be 100% satisfied by Statoil's governing documentation. The grade 5 is set to 80-100% compliance with the requirements because it is impossible with the present scope and time limit to fully assess if every requirement in ISO 55001 is satisfied. The table above shows where Statoil needs to put in most effort in order to ensure 100% ISO 55001-compliance. The clauses given the grade 4 can quickly be changed to the grade 5 by implementing the asset management policy and the SAMP. Clauses 5.1, 5.3 and 6.2.1 are given the grade 4 because some of the requirements in these clauses are related to the asset management policy and the SAMP. Furthermore, it is natural that clauses 4.3, 4.4 and 5.2 are given the grades of 2, 1 and 3 respectively, since Statoil has not attempted to create either an asset management system or an asset management policy. Further comments about Statoil's compliance with each clause are given in each point in Appendix D.

10.4 SWOT Analysis

The SWOT analysis is a method used to identify and understand an organization's strengths and weaknesses, and the business market's opportunities and threats (SNL, 2013). The method consists of an external analysis at the macro and participant level, and an internal analysis where one seeks to identify factors that that can both enhance and weaken the competitiveness of the organization. This SWOT analysis seeks to identify Statoil's strengths, weaknesses, opportunities and threats regarding asset management and ISO 55000. The factors are drawn from the ISO 55001 comparison, some Statoil internal documents like M&R strategy and meetings regarding asset management at Statoil. This SWOT does not only focus on the requirements in ISO 55001 as ISO 55000 compliance is only the starting point of performing good asset management. Statoil's relation to good asset management approaches is also included.

Strengths

- Already large degree of ISO 55001 compliance
- ISO 9001 compliant (ISO 55001 have many similar requirements)
- Many principles in Statoil are in accordance with AM fundamental elements
- Good stakeholder management and communication
- Large focus on risk management in every function and DG's in projects
- Gerhardsen's approach to IO Gen. 2 has the possibility to optimize AM
- Focus on Management of Change
- O&M requirements are updated with reference to AM elements

Opportunities

- Maximise asset profitability
- Better whole-life management
- Optimize the balance between costs, risks and performance
- ISO 55001 provides the first formal AM standard and methods to address risks, reliability and unplanned events
- Clear understanding of how Statoil's assets contribute to the business goals
- Provide the "line of sight" between organizational objectives and the daily operations and activities
- The alignment of O&M priorities, asset business objectives and corporate goals
- Lower the costs and increase production efficiency, i.e. optimize the profit
- Employees speak of value instead of cost

SWOT

Weaknesses

- Awareness not fully addressed in the organization
- It may be difficult to integrate AM with other functions like e.g. finance, quality, risk management, because the size and complexity of the organization
- Large degree of ISO 55001 compliance, however, Statoil lacks some AM fundamental elements (e.g. "line of sight"/alignment)
- Not alignment of strategic objectives and KPIs through the organization
- Many KPIs in Statoil are reflecting cost and not value
- Statoil's management system does not specify how to perform continuous improvement

Threats

- Lost opportunities in new licences resulting from the lack of ISO 55001 compliance
- Compromised reputation
- Lose competitiveness if not addressing AM and ISO 55001
- Not able to properly address the decreasing production efficiency and the increasing costs

10.5 Summary of Results

The former Statoil CEO Helge Lund stated in 2014 that Statoil should have a more clear emphasis on value, reduce unplanned losses and reduce the cost base (Statoil, 2014c). Asset management is an approach that addresses these issues, because asset management does not focus on the asset itself, but on the value the asset can provide to the organization. In addition, as aforementioned in this thesis, the asset management approach can help in overcoming the cost challenges in the NCS. The lack of a formal asset management standard has left the Statoil and other O&G companies to determine their own best practices, and hence the organizations assessments regarding risks, reliability and unplanned events have been more arbitrary (Shea and Hollywood, 2013). The new ISO 5500 series provide the first international formal asset management standard, and Statoil should assess the opportunity to achieve ISO 55001 certification.

Strengths – Areas where Statoil already performs good Asset Management

Asset Management Approaches

Statoil have already adopted some good asset management approaches as they have a comprehensive approach to their stakeholder management and their risk management. From the gap analysis, it is easy to identify that Statoil's approach to Operation, Performance evaluation and Improvement is quite consistent with the asset management requirements stated in ISO 55001. Management of Change, Resource Management (Execution – dynamic resource allocation) and Competence Management are also quite consistent with the requirements in ISO 55001, even though some AM fundamentals lack in these clauses (e.g. lack of alignment between role and levels). An example of good resource management is Statoil's "Offshore Competence Centre", which consists of employees within every discipline. These employees are deployed to offshore installations that needs extra personnel, and this way Statoil effectively allocates the resources where they are needed the most. Internal processes in Statoil as Ambition to Action and People@Statoil help departments and functions to align the organizational objectives with strategic asset objectives and KPIs, and this should assist in ensuring the necessary "line of sight" in the organization. It is explained in the Statoil Book (2013, p.29) that the objectives and targets are set with reference to shareholders, customers and stakeholders; this can also be seen as performing good asset management. Even though the intention of Ambition to Actions is good, the *Weakness* sub-chapter will explain that the translation process is not completely in line with the asset management approach. The Compliance and Leadership model is a framework for managing risks and thus it ensures prudent risk management.

The new Operation and Maintenance requirements

Another strength is that Statoil has updated its O&M requirements with reference to some AM fundamental elements. FR06 in Statoil consists of requirements like translating business objectives into asset-specific goals, balancing costs, risks and performance, striving toward an optimal asset solution, and applying skills and innovation of personnel in a continual process to improve the performance of the asset. Continuous improvement is also present in the O&M requirements as the Maintenance Management Cycle support the PDCA improvement cycle. Another important aspect with the new FR06 is the inclusion of Root Cause analysis as this is a requirement in ISO 55001 (cl. 10.1). The new FR06 in Statoil covers many AM fundamentals, and this is certainly a step in right direction for Statoil.

Compliance with ISO 9000 and the PSA Norway Regulations

Statoil's offshore assets already conform to the quality management standard ISO 9000. Even though ISO 55000 is about managing the asset value and ISO 9000 is about managing the quality of the products, they are much alike in many clauses. Clauses like documented information, resource, competence, operation, performance evaluation and improvement contain approximately equal requirements, and this shows that Statoil does not need to start from scratch if seeking compliance with the new asset management standard. It is also worth mentioning that the PSA Norway Regulatory does not act as a barrier for approaching the asset management standard. PSA Norway is one of Statoil's main stakeholders and the asset management system provides an ideal framework for integrating relevant standards, regulatory requirements, codes, guidelines and best practices (Rugsveen, 2013).

Opportunities – Asset Management Potential Improvement Areas

Adopting the asset management approach should among others maximise asset profitability, provide better whole-life management of assets, and provide Statoil with a clear understanding of how their assets contribute to the business goals (Rugsveen, 2014a). It is not enough anymore to only be certified against ISO 9000, as it does not consider the management of the assets that actually produce the required quality of the products. ISO 55000 provides the extra perspective of the quality of the products. With the use of this standard, Statoil still ensures the quality of their products (mainly the oil and gas produced), but with a better chance of enhancing sustainability of their competitive position in the business environment. Implementing ISO 55000 should ensure that Statoil procures the correct asset solution in the first place and that it remains the correct solution in the future. An asset management system should help Statoil to get a more extensive understanding of the assets, their performance, the risks associated with the assets, investment needs, and the asset value. Asset management also support communication and interaction across functions, and it ensures that the assets are managed in an integrated manner. Asset management is an approach that should assist Statoil in overcoming

the current challenges in the NCS, see Chapter 5.4. For more benefits of asset management, see Chapter 2.6 - *Benefits of good asset management*.

Weaknesses – Statoil's Gaps in Relation to Performing Good Asset Management

Awareness in the Organization

Statoil's People@Statoil process contributes to increasing awareness in the organization by the setting of personal delivery and behaviour goals. These goals are defined from the offshore asset's strategic objectives that again are derived from the organizational objectives. However, none of Statoil's high-level governing documents specify that the employees need to be aware of their contribution to the effectiveness of the management system, or that they need to be aware of the opportunities associated with their work activities. Management requirements like communicating the importance of effective (asset) management and supporting people to contribute to the effectiveness of the (asset) management system are not present in Statoil governing documentation either. This indicates that Statoil lacks the clear connection between the organizational business plan and the daily activities (e.g. activities performed by the operation and maintenance function). It is imperative to have this clear connection, also known as "line of sight", since the front line workers need to know the reason for their activities. "Line of sight" can foster an innovative culture and ultimately this can lead to the development of new and more cost-effective ways of performing work (Woodhouse, 2010b). Additionally, a clear "line of sight" should lead to everyone working in the organization having a clear understanding of how he or she contributes to the business results, and hence avoiding decisions that will sub-optimize their function (Hawkins, 2013).

Statoil's Organizational Complexity and Size

Hendrick (2002) states that three common types of differentiation in a work system structure exist and that the increase in one of them will increase the complexity of the structure. Vertical differentiation is about how many layers exist from the CEO to the floor operators and horizontal differentiation refers to the degree of specialization within a work structure. With more specialized departments, the complexity increases because more control is needed. With reference to Hendrick's (2002) statements, it is correct to say that Statoil's organizational structure is both complex and large. Beneath the CEO in Statoil there are thirteen functions consisting among others of Development and Production Norway (DPN), People and Organization, Exploration, Legal, Corporate Audit, Projects, and Marketing. Moreover, Statoil's top management need to manage over 22,000 employees in 30 different countries (Statoil, 2014b). If Statoil seeks compliance with ISO 55000, they need to integrate the asset management system within all these different functions. This can be challenging and it would require a change in the management culture and large efforts by both managers and employees in the organization. The hierarchical size and complexity in Statoil may prevent an effective

establishment and implementation of asset management approaches and compliance with ISO 55000. However, it may not be necessary to reorganize the whole Statoil organization, and as explained by Woodhouse (2010b), many oil and gas companies have already benefited from the creation of discrete, multi-disciplinary teams and single-point accountable asset managers. Woodhouse comments that many organizations spend months and great energy debating organizational structure, whereas a great deal of progress can be made within the existing structure if only a little common sense is used.

Strategic Objectives and KPIs

It is stated in the Statoil Book (2013, p.29) that Statoil managers need to translate relevant Ambitions to Actions to reflect their own business realities, and this enables strong ownership and alignment with overall corporate ambition. However, this process is not completely aligned throughout the organization.

Statoil have an extensive list of KPIs and strategic objectives at several levels ranging from the corporate level to the offshore asset level (Statoil, 2015c). Strategic objectives have been developed for each functional level in Statoil, and ultimately strategic objectives have been developed for each offshore asset on the NCS. The corporate objectives focus on high performing leaders; however, this is not reflected in many of the offshore assets' strategic objectives. It is difficult to achieve Statoil's corporate objective of high-performing leaders and continual improvement of leadership if the offshore assets do not focus on high-performing leaders. This is also the case with the KPIs as Statoil's organizational objectives include unit production costs, cash flow improvement, improving personnel development, continuous improvement and leadership renewal, and the different offshore asset objectives include production effectiveness, sick leave, backlog, overtime, maintenance costs and field costs. Sick leave can be a good indicator of the well-being of the employees (and hence the motivation of employees), however, none of the assessed offshore installations had a goal of ensuring continual improvement or leadership renewal. ISO 55001 states that the asset management objectives should be consistent and aligned with the organizational objectives, and good asset management practice requires specific offshore asset objectives to be aligned with organizational objectives. This alignment is partly lacking in Statoil.

Moreover, there is a lack of strategic objectives that is related to regulatory requirements and KPIs targeting the effectiveness of the management system itself. It is a requirement in ISO 55001 to assess the effectiveness of the (asset) management system and to evaluate if the management system conforms to relevant legal and regulatory requirements (cl. 9.1). A good example in Statoil is the lack of an assessment framework for maintenance management. Statoil have adopted PSA's maintenance management model, shown in Chapter 3.5, however, Statoil lacks a methodology to assess the maintenance management performance. It is listed as a requirement in Statoil new FR06, however, a methodology has not yet been developed. In addition, the objectives and KPIs often reflect cost and not value. It is only the O&M

requirements that require the low-level specific objectives to be aligned with the organizational objectives, and other Functional Requirements concerning objectives reflecting finance, market and people organization do not include this alignment.

Continual Improvement

As previously mentioned in this thesis, ISO 55000 builds upon the PDCA cycle for continuous improvement. The concept of continuous improvement is in widespread use in Statoil, however, the management system does explicitly describe how the approach is implemented. For example, Statoil's Maintenance Management Cycle (FR06, cl. 3.5, also see Chapter 3.5 in this thesis for a similar cycle) supports continuous improvement, however the related work process OM02 "Maintain a plant" only describes the Plan and Do part of continuous improvement. OM02 "Maintain a plant" describes the establishment of maintenance orders and how to execute them, however, OM02 does not describe how to evaluate the executed maintenance orders (Check part) or how to Act on possible identified deviations. This also applies to OM01.05 "Plant and system operation" as it only describes how to manage operational interruptions and not how to assess the effectiveness of any corrective action taken as ISO 55001, sub-clause 10.1 requires.

Threats - Implications of not Adopting Asset Management

As previously mentioned, Statoil's governing documentation has a high degree of compliance with the requirements in ISO 55001. However, Statoil should not stop at only ensuring compliance with this standard. Statoil needs to establish and implement an asset management system because the implications of not adopting the AM approach, or of not being ISO 55001-compliant, can be severe (Woodhouse, 2010b). ISO 9001 is one of the world's most used standards, and every organization that is certified against ISO 9001 clearly demonstrated to the market that they can deliver high quality products. ISO 55001 has the opportunity to reach equal status, and if not being ISO 55001 compliant, Statoil could lose opportunities in new licences, lose partnerships, and lose competitiveness against competitive organizations (Rugsveen, 2014a). In addition, the AM approach includes some well-proven methods that have the potential to increase the asset value (e.g. RCM, RBI and RAMS), and these methods will help Statoil in tackling the cost and production effectiveness challenges in the NCS.

10.6 Closing the Gaps - Recommendations for Further Development of Asset Management in Statoil

The Asset Management System

As mentioned in the gap analysis and the SWOT analysis, Statoil's current practice is not far away from satisfying the requirements in ISO 55001. To reach a higher compliance percentage, Statoil needs to establish and integrate a structured asset management system and develop an AM policy, SAMP, AM objectives and an AM plan. Statoil should at least cluster nearby offshore installations like e.g. Sleipner, Draupner and Gudrun to create an asset portfolio. The asset management system will then govern the asset portfolio, see figure 5 in Chapter 2.5.

It is imperative to create the SAMP and AM objectives from Statoil's main strategic objectives and Statoil's corporate business plan. In order to identify a sustainable level of investment of business opportunities, it is necessary to understand the costs, work volumes, risks and expected outcomes over the life cycle of the assets (Edwards, 2010b). Statoil should therefore produce and maintain a fully budgeted SAMP. Statoil should also include reputational, environmental and social risks in the SAMP. In creating a prudent SAMP, Statoil can use it to engage with the different stakeholders and create a common understanding of requirements and future funding. It is imperative that the SAMP includes a number of scenarios that should include the lowest whole-life costs of assets, minimum expenditure to achieve safety limits, the impact of climate change, and scenarios concerning new technology. The level of stakeholder confidence will be determined through Statoil's capability to demonstrate an understanding of whole-life cost models, asset information, justification of asset policies, and how assets deteriorate with age and the risks associated with deterioration.

The SAMP is at the heart of an effective asset management system, and Woodhouse (2010a) requires the SAMP to include SWOT analyses and key information such as asset strategy, how the asset management principles will be implemented, and references to information sources such as production forecasts and the main assumptions and uncertainties. Statoil has already created the corporate strategy, and a possible next step will be to document the asset management principles that Statoil needs to use to achieve the organizational objectives. This is to some extent fulfilled in the maintenance and operations function, as FR06 requires the employees in Statoil to use AM principles to achieve the O&M objectives that again should be linked to the organizational objectives.

Lastly, it is important for Statoil to understand that the new asset management standard should complement existing standards like ISO 9000 (Quality Management System), ISO 14000 (Environmental Management), and ISO 31000 (Risk Management). By integrating these standards, Statoil can demonstrate capabilities that provide assurance to customers, regulators, owners and other stakeholders. The asset management system should not be a stand-alone management system, and it is imperative to integrate it with Statoil's requirements for Quality Management (several FRs), Risk Management (FR08), HSE management (FR10), and Environmental Management (FR11). In addition, Statoil of course needs to make small

adjustments in their requirements to satisfy every requirement for an asset management system as required by ISO 55001 (2014).

Leadership and Culture in Statoil

It is the responsibility of Statoil's top management to adopt the asset management approach and spread the asset management knowledge and practice downwards through the organization. A combination of assessments, requirements and development processes are required to ensure that the employees are competent and motivated to make the necessary contribution to achieve the asset management objectives (Woodhouse, 2010b). The imperative "line of sight" in the organization is also dependent on Statoil's top management (Lafraia and Hardwick, 2013). Furthermore, it is also the daily operator's responsibility to understand and use the asset management principles to ensure that AM plans are continuously improved and updated. This can be done through identifying improvement areas associated with their work activities, and it is critical that these improvement areas are documented in a careful manner.

In addition, it is crucial for Statoil to define an asset management culture that focuses on asset management's primary goal, namely optimizing the delivery, performance reliability and safety of assets (Johnson, 2010). Statoil cannot leave the development of an asset management culture to chance, as this will result in conflicting subcultures and inconsistent practices. Statoil's top management needs to have a clear idea of how their asset management culture is going to be and how they are going to establish it. It is also important to understand, according to Johnson (2010), that there is no such thing as one correct asset management culture. They key for Statoil is to develop the sort of asset management culture that is most beneficial for Statoil.

Asset Management is more than ISO 55000 Compliance

It is critical for Statoil to understand that compliance with the requirements in ISO 55001 should only be considered a minimum goal in achieving good asset management (ISO 55002, 2014). It is possible to adopt the asset management approach without being compliant with the new asset management standard, however, it is the documented policies, strategies and procedures that create value, and hence ISO 55000 will provide a good asset management framework. Like other standards, Statoil needs to avoid ISO 55001-certification based on just paperwork and good intentions (Woodhouse, 2010b). Seeking compliance with ISO 55001 can lead to a compliance culture where organizations believe they have achieved an appropriate level of asset management. ISO 55001 only provides a good asset management framework, and the development of asset management capabilities goes much further than ISO 55001-compliance (Edwards, 2010b). Statoil needs to understand the whole asset management approach and benchmark their results against others to continuously adopt the best AM practices around the world (IAM, 2014). To achieve substantial performance Statoil needs to embrace the asset management fundamental elements that are outlined in Chapter 3.

Many of the asset management principles in Chapter 3 are derived from the IAM's (2014) 39 subjects, which are the same as the aspects covered by the Global Forum's Asset Management Landscape. The Asset Management Landscape is an internationally-accepted document that specifies asset management in terms of 39 subjects (Botha, n.d.). ISO 55000 does not address the best practices during an asset's life cycle, and hence Statoil should also address the AML document. The AML document is the most comprehensive and standardized definition of asset management and it provides a valuable framework for asset management. Statoil should use the AML document to specify the asset management best practices and the ISO 55000 series to create and implement an asset management system. The link between ISO 55000 and the AML document is shown in the figure below.

Figure 36 – Positioning ISO 55000 vs the GFMAM's 39 subjects (Botha, n.d., p.7)

Strategic Objectives and KPIs

Asset management is about balancing asset utilization versus asset care, and Statoil's KPIs should reflect this balancing act. Instead of measuring the quantity of barrels produced or production cost, the KPIs should reflect the value of the barrels produced or the value of production. The KPIs should among others reflect $/boe or (CAPEX + OPEX) / production.

It is necessary to monitor the health and performance of the asset (IAM, 2014). A robust measurement framework includes measures that relate to the health and performance of the asset and asset systems. It is important that the performance measures and targets are derived from the business objectives and goals, and stakeholder requirements as defined in the SAMP. Appropriate performance measures form a basis for asset management decision-making. Good asset management requires a level of monitoring both at the asset level and asset system level. If an asset portfolio consists of the aforementioned Gudrun, Sleipner and Draupner, Statoil needs to monitor the performance of e.g. Gudrun and the asset portfolio itself. The IAM (2014) suggests that Statoil should use both leading and lagging performance indicators. ISO 55001 (2014) specifies a range of performance evaluation requirements and ISO 55002 (2014) suggests that reactive measures (capacity or condition) and reactive measures (near misses and false alarms) should be used in the performance evaluation.

As previously mentioned in the Weakness section, Statoil lack performance metrics regarding legal and regulatory requirements. To perform good asset management one needs to evaluate the compliance with legal and regulatory requirements, as well as other requirements to which the organization subscribes (ISO 55002, 2014, cl. 9.1.1.2). Furthermore, Statoil needs to develop strategic objectives and KPIs that can be used to evaluate the effectiveness of the asset management system. It is additionally important to ensure that the monitoring process meets the requirements of Statoil's stakeholders.

To perform sound asset management, Statoil should enable KPIs that can be used to verify that (ISO 55002, cl. 9.1.2.2):

- the procedures are up-to-date,
- processes have been clearly defined,
- the organization's assets fulfil their purpose,
- change control processes are in place,
- the management plan(s) have been effectively communicated to the stakeholders,
- the management system is appropriate to the level of risk

Systems Engineering

Edwards (2010b) states that many organizations have achieved certification against PAS 55. However, organizations in Australia have adopted an alternative asset management framework, namely ISO 15288 "Systems Engineering – System Lifecycle Processes". The Asset Management Council (2014, p.36) states that systems engineering is "*the translation of a set of stakeholder requirements into a balanced and verified solution*". Systems engineering includes the consideration of Reliability, Availability, Maintainability and Safety (RAMS). Systems engineering considers the lowest life cycle costs as a balance of CAPEX and OPEX, and hence it is possible to achieve the optimum life cycle costs. Systems engineering presents a good verification process that should enhance the asset management approach, and hence Statoil should consider this process to optimize the balance between CAPEX and OPEX in the design phase of new projects. Using the systems engineering verification process will help Statoil to balance the trade-offs between equipment quality, redundancy, condition monitoring etc., and it should enhance Statoil's approach to asset management. ISO 55001 does not require the adoption of Systems Engineering, however, it would be a good starting point to perform good asset management. ISO 15288 provides a good-practice approach to Systems Engineering.

The Norwegian transport group NSB adopted RAMS Engineering in 1998 (Rehman, 2013). The roots of RAMS Engineering and Systems Engineering are equal. While Statoil should address ISO 15288, NSB is compliant to the European standard for railway applications EN-50126. NSB has significantly improved their performance by approaching RAMS Engineering (see Chapter 5.4). This "Verification and Validation" process is more detailed than the processes Statoil uses today, as it includes the development of functional and technical

specification, safety approval and installation processes that are in line with RAMS requirements.

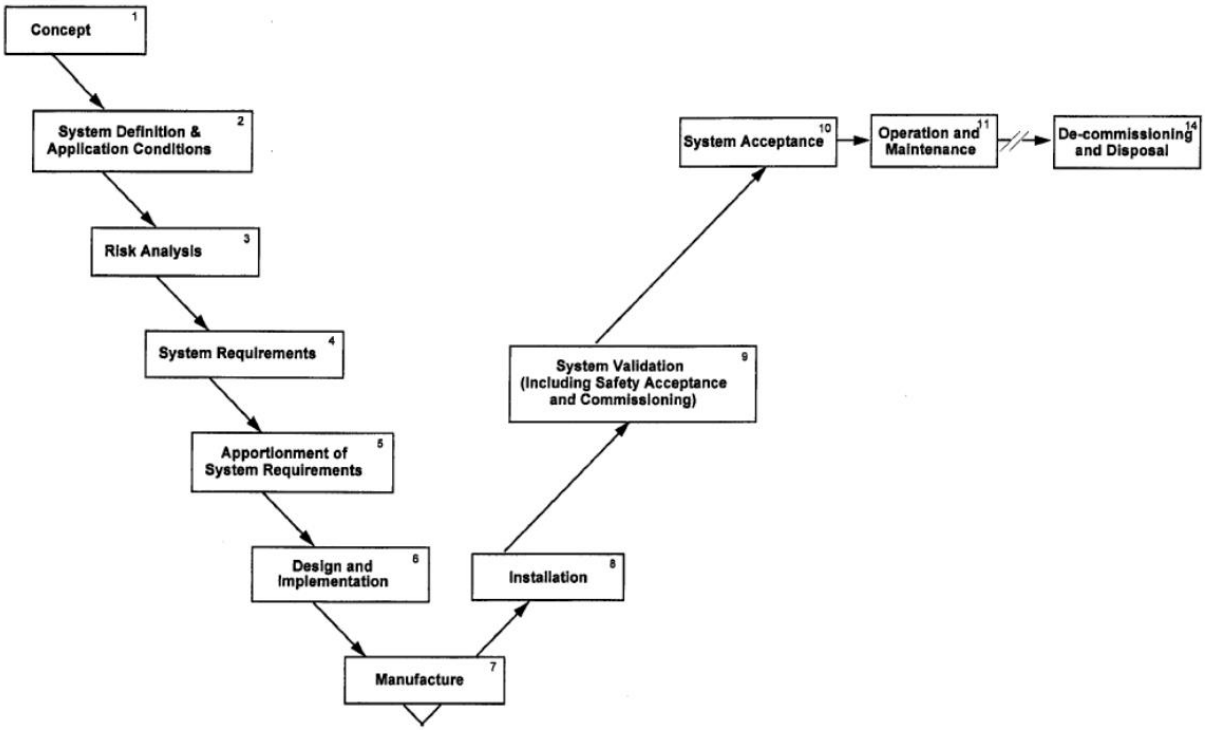

Figure 37 – EN-50126 RAMS Engineering process (Rehman, 2013, p.7)

PDCA and Continual Improvement of Maintenance

Statoil has already included continual improvement in many of its best practices, e.g. the People@Statoil process (Statoil Book, 2013). The process consists of these four steps: Preparation, People@Statoil dialogue, Capability and deployment review, and Follow-up dialogue. This process clearly follows the continual improvement cycle.

The scope of this thesis is to focus on the high-level governing documentation (Functional Requirements, the Statoil Book and OMC), however, a lack of continual improvement within the operation and maintenance function was identified. This gap is described in "Weaknesses" in the previous sub-chapter. The following process flow is a suggestion of how OM01.05.04 "Manage operational deviation" should be structured according to clause 10.1 in ISO 55001. The suggestion considers continual improvement via the Plan-Do-Check-Act cycle.

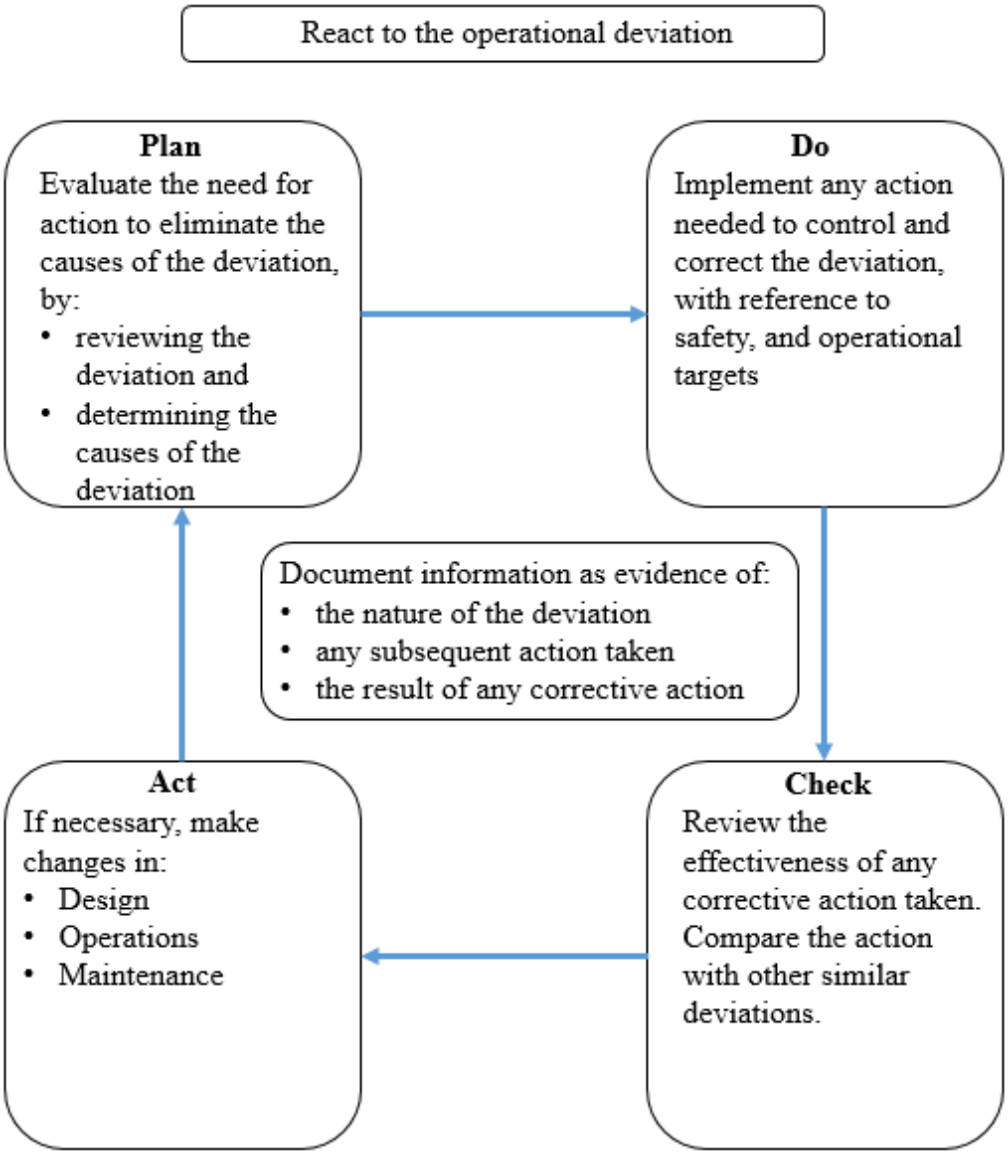

Figure 38 – Continual improvement of "Manage Operational Deviation"

PART 5 DISCUSSION, FINDINGS AND CONCLUSION

Figure 39 – Time for discussion (authorstream,com)

Introduction

The last part of this thesis sums up and pulls together the main findings of the work. Learning opportunities and challenges encountered during the work are discussed and areas for further study are presented. Finally, the conclusion sums up the entire scope of the work and presents it in one page.

Chapter 11 Discussion and observation

11.1 Objectives and Scope of Work

The scope of this thesis was to look at the possibilities related to asset management as a management philosophy for offshore assets. It was therefore vital to get an overview of asset management and the new asset management standard ISO 55000. The scope also included several other significant topics such as Integrated Operations, the quality management standard (ISO 9000) and the Petroleum Safety Authority Norway Regulations.

Asset management development, description, benefits and the overbearing fundamental elements are covered in Part 2: State of the Art. A comprehensive literature review was conducted and nine asset management fundamental elements were identified. Part 3 further enriches the understanding of asset management as it puts asset management in an oil and gas context. Furthermore, Part 3 addresses the Integrated Operations objective by linking IO to asset management fundamental elements (see Figure 30).

Prior to the Statoil analysis, analyses were conducted on ISO 9000 and the PSA Regulatory. This was to enhance the Statoil case study. Lastly, a case study was undertaken to identify how close Statoil's governing documentation is to fulfilling the requirements in ISO 55001. The results from this case study are presented in a correlation table, presentation of results, a preliminary gap and SWOT analysis, and recommendations for further development of asset management.

The thesis covers an evaluation of asset management and ISO 55000, a discussion of ISO 55000 in a Statoil context and a preliminary gap and SWOT analysis. It is therefore the author's opinion that the objectives of this thesis are achieved. It is, however, worth mentioning that this thesis focuses on Statoil's high-level governing documentation and it only presents a preliminary gap analysis. If Statoil seeks to achieve ISO 55000 compliance, a more detailed requirement analysis is required.

11.2 Main Findings

Based on relevant asset management literature, and collaboration with Statoil's asset management academic environment, PSA Norway, and the supervisor at Industrial Asset Management, the following findings were discovered. These findings should be used not only by Statoil, but also by students and other organizations seeking to achieve higher knowledge about asset management and realize ISO 55000 certification.

Part 2: State of the Art

The journey began with an academic review of asset management and the related ISO standard. In the second part of the thesis, the *State of the Art* part, the asset management fundamentals

are presented. This thesis has identified IAM's description as most suitable for asset management;

Asset management can be seen as a management philosophy that converts the fundamental aims of an organization into practical allegations for choosing, creating, operating and maintaining assets, and it does so while seeking to achieve the optimal combination of costs, performance and risk.

The asset management fundamental elements identified through the work with the thesis cover imperative aspects such as "line of sight", optimized decision-making, leadership and life cycle management. Asset management is an integration framework, and if some of the abovementioned elements are lacking in the management of assets, the asset value will be reduced. Several authors highlight "line of sight" as the backbone of good asset management, and the clear connection between the organizational business plan and the daily activities is critical in today's asset-intensive business environment.

The long-awaited ISO 55000 series was published in 2014. The new ISO standard is structured around Deming's PDCA cycle of continual improvement, and it provides the requirements for developing and managing an asset management system. It is especially important to understand that the standard only specifies requirements for an asset management system, and does not include any asset management best practices. Asset management best practices should lay as a foundation in every asset-intensive organization, and hence it is critical to study e.g. IAM's Conceptual Model or the Asset Management Landscape.

Part 3: Asset Management, Integrated Operations and the Norwegian Oil and Gas industry

Organizations on the Norwegian Continental Shelf are experiencing increasing operational costs, decreasing production efficiency, and stricter regulatory requirements. To cope with the current challenges, a McKinsey report (Handscomb, 2014) suggests that organizations need to shift from managing volume to managing value instead. The report further proposes that the management needs to be committed to change, to establish a "one-team" culture and to create clear performance goals and targets. This is what asset management is all about, and the imperative "line of sight" will enable every function in an organization to understand how they contribute to the business results, and hence avoid decisions that sub-optimize their function at the expense of others. Additionally, several asset management methods are identified such as RCM, RBI, LCC, Root cause analysis, and Systems Engineering. Appropriately targeting these methods to critical assets has proven to both reduce maintenance costs and improve reliability.

Integrated Operations is a leading enabler for any organization to make quick and mindful decisions leading to business value. Several Statoil assets have approached IO Generation 2, and it is acknowledged in this thesis that the IO concept certainly has the potential to optimize asset management in any organization. IO can lead to optimized decision-making, provide

better competence management, enhance stakeholder communication and act as a link between different systems and departments.

Part 4 Case Study: Statoil

Both ISO 9000 and the PSA Regulations affect the way Statoil manages its assets. From the case study, it can be said that neither ISO 9000 nor the PSA Regulations act as barriers for the effective implementation of ISO 55000. ISO 55000 should be integrated with other standards, and integrating ISO 55000 with ISO 9000 will provide an extra perspective on the quality of the products. ISO 9000 focuses on the quality of the products; however, it does not consider the management of the assets that produce the actual value. ISO 55000 should help organizations to extract the optimum value of the asset at the optimal cost. Furthermore, several aspects of ISO 55000 are identified that should provide extra value to an organization that already is compliant with the PSA Regulations. PSA Norway is one of Statoil's main stakeholders, and ISO 55000 provides an ideal framework for integrating relevant standards, regulatory requirements and best practices.

From the preliminary gap analysis, it is easy to identify that Statoil already conforms to several of the requirements in ISO 55000. Statoil's approach to Operation, Performance evaluation and Improvement is quite consistent with the requirements in ISO 55000. In addition, internal processes and models like Ambition to Action, People@Statoil and the Leadership and Compliance model support different functions in Statoil to achieve line of sight between the organizational plan and the daily work activities. Among the asset management-related weaknesses is the lack of awareness, lack of asset management fundamental elements, lack of alignment of strategic objectives throughout the organization and inconsistent continual improvement. The red and yellow clauses in the gap analysis can be closed if Statoil develops and implements a formal SAMP, asset management policy, asset management plan, and asset management objectives. Additionally, to fulfil every requirement in ISO 55000, Statoil needs to update their management system with reference to asset management. In any case, to achieve ISO 55000 certification, Statoil needs to perform a more thorough gap analysis. The gap analysis consists of Statoil's high-level governing documentation (the Statoil Book, Functional Requirements and OMC documents), and regarding all the requirements in ISO 55001, only the main content in every sub-clause is taken into consideration.

It is critical for Statoil to understand that compliance with the requirements in ISO 55001 should be considered as a minimum goal of performing good asset management. Closing the asset management gaps means that Statoil should develop and implement an asset management system, define an asset management culture, ensure the right leadership, assess asset management best practices, and redefine some of their strategic objectives and KPIs. Moreover, Statoil should consider Systems Engineering as a viable asset management contributor.

11.3 Knowledge and understanding obtained

Over the past few months, an extensive understanding of the asset management approach has been gained. The academic journey began with a review of ISO 55000 to firstly understand its content and applicability. The former asset management specification PAS55, Chris Lloyd's book "Whole-life management of physical assets" and the IAM's document "Asset Management – an anatomy" further extended the authors knowledge about asset management, and they formed the basis for the asset management fundamental elements.

By combining relevant asset management theory with the challenges faced by the oil and gas industry, it was possible to elaborate on how asset management can overcome these challenges. The author has learned that asset management is applicable for the oil and gas industry, and hence it is imperative for oil and gas organizations to assess how they can approach the asset management approach. Additionally, many organizations approach Integrated Operations with great effort. Chapter 6 discusses how Integrated Operations can further optimize the asset management approach, and the author has learnt that if e.g. Gerhardsen implements asset management, they would certainly benefit from the IO implementation.

It was a very time-consuming process to create the three correlation tables. Nevertheless, when finished, the main knowledge obtained from the analyses was that ISO 55000 provides an extra perspective on the quality of the products, and ISO 55000 covers a large range of critical management aspects that are not covered in the PSA Regulations (which should not come as a surprise, since the PSA Regulations refers to managing HSE).

Creating the preliminary gap analysis, together with the SWOT analysis, provided the author with insightful information about how close Statoil is to fulfilling the requirements in ISO 55000. However, throughout this thesis, the author has become aware of that it is not enough to only seek ISO 55001 compliance. Seeking ISO 55001 compliance should be considered a minimum goal of achieving good asset management, and it is the author's opinion that Statoil should also assess e.g. IAM's Conceptual Model or the Asset Management Landscape to get a full overview of asset management best practices.

To summarize the knowledge gained, the author has obtained new knowledge about asset management, Integrated Operations, the ISO 9000 series, the ISO 55000 series, the PSA Regulations and Statoil's governing documentation.

11.4 Challenges Encountered during the Study

Due to the limited time scale in this thesis, several boundaries were defined in order to arrive at more reasonable conclusions. There have been some challenges over the course of carrying out the scope of work and while some have been resolved adequately, others required taking a slightly different approach to still be able to answer the main objectives.

At the beginning, the asset management topic, ISO 55000, ISO 9000 and the PSA Regulations was not familiar to the author, and although some familiarity with asset management had been acquired through the "*Decision Engineering and Performance Management*" class taken at the University of Stavanger, most of the knowledge had to be acquired before and after the start of the thesis. This posed several challenges, as it was difficult at the start to select the proper asset management literature. When googling the term "asset management", one gets many different hits. Financial services dominate the search results, and it required an effort to identify the literature that supported the newly developed ISO 55000. However, as the thesis progressed, it became more evident which literature was proper to use.

The main aim of the thesis was to look at the possibilities related to asset management as a management philosophy for a selected offshore asset. The aim of the thesis was later changed to include a more general view of Statoil's offshore assets. This was due the lack of specific offshore asset documentation. The required asset information was not retrievable and the few specific asset documents were not able to form a complete view of information needed in the thesis. However, Statoil's governing documentation was available, and it was decided that the specific offshore asset information already retrieved would be used as examples to enrich the case study.

It was discovered early on that assessing each "shall" statement (the requirements) in ISO 55001 would be extremely time consuming. It was therefore decided to assess the main content in the sub-clauses. Even though not every "shall" statement is taken into consideration in this thesis, the preliminary gap analysis shows where Statoil needs to put their effort in order to achieve 100% ISO 55000 compliance.

The last challenge relates to the content in this thesis. The thesis include work performed on:

- Asset management
- Integrated Operations
- The ISO 9000 series – ISO 9000 and ISO 9001
- The ISO 55000 series – ISO 55000, ISO 55001 and ISO 55002
- The PSA Regulations – Framework Regulations and Management Regulations
- Statoil's governing documents – The Statoil Book, Functional Requirements, Organization, Management and Control documents, and asset specific documentation

The vast amount of theory assessed and covered in this thesis may compromise the quality on each subject. However, it is the author's opinion that the presented master thesis adequately addresses the different subjects and that the results could be used to enhance the asset management knowledge in Statoil.

11.5 Area for Further Study

The asset management approach is a very large subject with many interesting areas of research. However, this thesis has only been able to investigate a small section of the complete subject. The case study has only investigated Statoil's high-level governing documentation in relation to ISO 55000. It has not taken into consideration Statoil's Work Requirements, Work Processes, Key Controls, or Technical Requirements. A future study proposal is to identify if the requirements in Statoil's high-level governing documentation are reflected in the Work Processes and Work Requirements. Even though continual improvement is a requirement in FR06, it is not always reflected in the Work Processes. To achieve ISO 55000 certification, every aspect of the management system needs to be reviewed, and a future study should address this issue.

Another subject of interest could be to perform structured interviews with both managers and operators on a selected offshore asset. An offshore asset on the NCS needs to comply with Statoil's governing documentation, however, it would be interesting to investigate if the actual offshore asset's best practices are aligned with asset management approaches. Critical asset management questions should be asked, and could include, among others:

- Does the employee know where to find all relevant management information, and do they actually know what Statoil's KPIs are?
- How well are nonconformities documented?
- Does every member of the offshore staff know the opportunities associated with their work?
- Are the daily operators aware of the management policy, and what is their contribution to the effectiveness of the management system?
- How do managers of an offshore asset promote continual improvement and ensure cross-functional collaboration within the organization/asset?

This thesis only presents a few recommendations for closing the gaps between Statoil's governing documentation and ISO 55000. A further study should address these gaps and identify methods, techniques and activities that enable Statoil to close the asset management gaps. As a suggestion, a complete table should be created where asset management methods are linked with each sub-clause in ISO 55001. ISO 55000 does not describe how to implement the requirements, and a table can enable an organization to easily identify what needs to be done in order to satisfy the requirements. The author recommends, among others, the Asset Management Landscape document and Hastings (2014) updated version of "Physical Asset Management" as relevant literature for this study. It is also recommended that the study elaborates and evaluates how RCM, RBI, LCC, RAMS analysis, TPM and Root Cause analysis can enhance the asset management approach, as these methods are only briefly mentioned in this thesis.

One of the most interesting subjects to research would be to look at a future dynamic management system. Statoil's management system and the asset management system (ISO

55000) tend to be very static. In addition, PSA Regulatory, the NORSOK standards, ISO 9000, ISO 31000 and current practice sets a framework for the management system in Statoil. It is not possible to manage Statoil in the future with rigid boundaries. The STEP project, efficiency programmes, and asset management put forward a suggestion for a reorganization of the management system in Statoil. A future study should address a future dynamic management system and include the relevant standards that need to be addressed.

Chapter 12 Conclusion

The aim of this thesis was to get an overview of asset management, identify if asset management suits the oil and gas business, identify gaps between Statoil's governing documentation and ISO 55000, and propose solutions to close these gaps.

From Part 2 and 3 it is learnt that organizations are under constant pressure from demanding customers, stakeholders and regulators to deliver higher value without increasing costs and risks. Organizations operating on the NCS truly need to consider adopting the discipline of integrated, risk-based, optimized, whole-life management of assets. ISO 55000 (2014, p.14) define asset management as:

"*The coordinated activity of an organization to realize value from assets*".

Approaching asset management and managing the coordinated activities is not a straightforward process, and achieving ISO 55000 certification is not enough. Organizations need to embrace asset management activities (see the outlined fundamental elements in Chapter 3) and integrate them with other functional processes like human resources, information systems, finance and logistics. ISO 55000 provides the asset management system to direct, coordinate and control the assets. However, not all asset management activities can be formalized through the asset management system, and aspects such as leadership, culture, motivation and behaviour needs to be managed outside the asset management system. ISO 55000 provides a good checklist and framework of the asset management approach, however, organizations approaching asset management should both seek ISO 55000 compliance as well as implementing asset management best practices.

In terms of asset management and the Norwegian oil and gas sector, it is evident that asset management can be used as an approach to overcome the challenges faced by the oil and gas industry on the NCS. Additionally, it is beneficial for organizations to implement Integrated Operations, as IO has the possibility to further optimize the asset management approach.

To see if Statoil's current practice reflects asset management practices, a case study was conducted in Part 4. By comparing the clauses in ISO 55000 with the requirements in Statoil's governing documentation, it was possible to discuss Statoil's gaps related to the performance of good asset management. From the preliminary gap analysis, it is easy to identify that Statoil already conforms to quite a few of the requirements in ISO 55000. However, several gaps were identified and recommendations for further development of asset management in Statoil are presented, ranging from changing the culture to implementing Systems Engineering. However, more work is required to assess Statoil's compliance to ISO 55000 and further studies are proposed in the *Discussion* chapter.

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Note[1]

[1] If the web-links above does not work, one need to copy the link and check for spaces, as this tends to occur

APPENDICES

Appendix A – Correlation table between PAS 55-1 and ISO 55001

ISO 55001	PAS 55-1
4. Context of the organization	
4.1 Understanding the organization and its context	
4.2 Understanding the needs and expectations of the stakeholders	4.3.1 c) identify and consider the requirements of relevant stakeholders. It is mentioned several times in PAS 55-1, however, it is not created a specific clause concerning stakeholders
4.3 Determining the scope of the AM system	
4.4 Asset management system	4.1 General requirements
5. Leadership	
5.1 Leadership and commitment	4.3.1 Asset management strategy
5.2 Policy	4.2 Asset management policy
5.3 Organizational roles, responsibilities and authorities	4.4.1 Structure, authority and responsibilities
6. Planning	
6.1 Actions to address risks and opportunities for the asset management system	4.4.7 Risk management
6.2 Asset management objectives and planning to achieve them	
6.2.1 Asset management objectives	4.3.2 Asset management objectives
6.2.2 Planning to achieve asset management objectives	4.5.1 Life cycle activities More specific in PAS 55-2: 4.5.1.1 Implementing the asset management plan(s)
7. Support	
7.1 Resources	4.5.2 Tools, facilities and equipment
7.2 Competence	4.4.3 Training, awareness and competence
7.3 Awareness	4.4.3 Training, awareness and competence
7.4 Communication	4.4.4 Communication, participation and consultation
7.5 Information requirements	4.4.6 Information requirements 4.6.6 Records
7.6 Documented information	4.4.5 Asset management system documentation
8. Operation	
8.1 Operational planning and control	4.5.1 Life cycle activities
8.2 Management of change	4.4.9 Management of change
8.3 Outsourcing	4.4.2 Outsourcing of asset management activities

9. Performance evaluation	
9.1 Monitoring, measurement, analysis and evaluation	4.6.1 Performance and condition monitoring 4.6.3 Evaluation of compliance
9.2 Internal audit	4.6.4 Audit
9.3 Management review	4.7 Management review
10. Improvement	
10.1 Nonconformity and corrective action	4.6.2 Investigation of asset-related failures, incidents and nonconformities 4.6.5.1 Corrective and preventive action
10.2 Preventive action	4.6.5.1 Corrective and preventive action
10.3 Continual improvement	4.6.5.2 Continual improvement

Table 6 – Correlation between ISO 55001 and PAS 55-1

Appendix B – Detailed Analysis between ISO 55001 and ISO 9001

4.1 Understanding the organization and its context

ISO 9001:

- 6.4 Work environment.
- 7.3.2 Design and development inputs.

Comment: The internal and external issues required in ISO 55001 does not only relate to physical factors, as it does in ISO 9001. ISO 9001 is more about the context of the product, while ISO 55000 is about every internal and external context that can affect the organization.

4.2 Understanding the needs and expectations of stakeholders

ISO 9001:

- 7.2.1 Determination of requirements related to the product.
- 5.2 Customer focus.

Comment: ISO 9001 focuses on the identification of customer requirements and ISO 55001 require all relevant stakeholder and their requirements to be identified. Since customer/users are stakeholders, a part of ISO 55001 is covered in the ISO 9001. Both ISO 9001 and ISO 55001 require the identification of the regulatory requirements.

4.3 Determining the scope of the asset management system

ISO 9001:

- 4.2.2 Quality manual.

Comment: Both ISO 9001 and ISO 55001 require the scope to be defined, including interactions with processes and other management systems.

4.4 Asset management system

ISO 9001:

- 4.1 General requirements.

Comment: Nearly 100% equal text in the two clauses. Only difference is the ISO 9001 require a quality management system and ISO 55001 require an asset management system.

5.1 Leadership and commitment

ISO 9001:

- 5.1 Management commitment.
- 5.4.2 Quality management system planning.

Comment: ISO 9001 and ISO 55001 have more or less equal requirements regarding management commitment and leadership.

5.2 Policy

ISO 9001:

- 5.3 Quality policy.

Comment: The only gap between ISO 9001 and ISO 55001 in relation to this clause is the actual term quality policy and asset management policy, elsewhere the clauses are equal.

5.3 Organizational roles, responsibilities and authorities

ISO 9001:

- 5.5.1 Responsibility and authority.
- 5.5.2 Management representative.

Comment: Both ISO 9001 and ISO 55001 require the organization to ensure that the relevant authorities and responsibilities are assigned and communicated in the organization. However, ISO 9001 specifies the need for a management representative, while ISO 55001 focus on what parts the responsibilities and authorities needs to be defined for.

6.1 Actions to address risks and opportunities for the asset management system

ISO 9001:

- 0.4 Compability with other management system: This International Standard does not include requirements specific to other management systems, such as risk management.

Comment: ISO 9001 does not include any risk management requirements, while ISO 55001 has a major focus on risk and opportunity identification, and reduction of their unintended effects.

6.2.1 Asset management objectives

ISO 9001:

- 5.4.1 Quality objectives.

Comment: ISO 55001 contains a more comprehensive list of requirement regarding the objectives that ISO 9001, however, the overall determination of the asset management/quality objectives is equal.

6.2.2 Planning to achieve the asset management objectives

ISO 9001:

- 7.1 Planning of product realization.

Comment: ISO 9001 require a quality plan where the product objectives and requirements are listed, while ISO 55001 require an asset management plan to achieve the asset management objectives. These requirements are quite similar, the only difference is that ISO 9001 focus on product objectives and ISO 55001 focus on asset management objectives.

7.1 Resources

ISO 9001:

- 6.1 Provision of resources.
- 4.1 General requirements.

Comment: Both ISO 9001 and ISO 55001 require the availability of resources needed to establish, maintain and operate their respective management systems.

7.2 Competence

ISO 9001:

- 6.2.1 General (Human resources).
- 6.2.2 Competence, training and awareness.

Comment: The main content in these clauses are including equal requirements, as they both require the determination of necessary competence, and where appropriate, take action to acquire the necessary competence. Bottom line, the clauses in ISO 90001 and ISO 55001 are approximately equal.

7.3 Awareness

ISO 9001:

- 6.2.2 Competence, training and awareness.

Comment: ISO 55001 require the personnel to be aware of the risks and opportunities associated with their work, and this is not included in ISO 9001. Besides that, both clauses are requiring organizations to ensure that their personnel are aware of the importance of their activities, and how they contribute to the effectiveness of the management system.

7.4 Communication

ISO 9001:

- 5.5.3 Internal communication.
- 7.2.3 Customer communication.

Comment: Establishing communication processes are required in both ISO 9001 and ISO 55001. Furthermore, ISO 55002 require communication plans, which consider stakeholders who can affect the asset management objectives. Customers is a stakeholder that can affect the objectives, and hence this clause is at least covered in ISO 55001.

7.5 Information requirements

ISO 9001:

- 4.1 General requirements.
- 7.4.2: Purchasing information.
- 7.5.1: Control of production and service provision.

Comment: ISO 9001 focus on product and purchase information requirements, while ISO 55001 require an organization to identify all information requirements to support the AM, AM system and its assets.

7.6 Documented information

ISO 9001:

- 4.2.1 General.
- 4.2.3 Control of documents.
- 4.2.4 Control of records.

Comment: Both ISO 9001 and ISO 55001 states that their management systems needs to include documents and procedures that are in accordance with the respective standards. Additionally,

both standards require the establishment of document control processes. The content in sub-clauses 4.2.1, 4.2.3 and 4.2.4 in ISO 9001 equals the content in sub-clause 7.6 in ISO 55001.

8.1 Operational planning and control

ISO 9001:

- 4.1 General requirements.
- 7.5.1 Control of production and service provision.

Comment: ISO 55001 require an organization to establish, implement and control the processes needed to address risk and opportunities, achieve the AM objectives and control corrective and preventive actions. ISO 9001 require an organization to determine the processes needed for the quality management system, and to determine the processes to control production and service provision. Bottom line, both ISO 9001 and ISO 55001 require the establishment of the control processes needed for their respective management systems. While ISO 9001 focus on the processes regarding production, ISO 55001 focus on the processes regarding risk, opportunities, AM objectives and corrective/preventive actions.

8.2 Management of change

ISO 9001:

- 7.3.7 Control of design and development changes.

Comment: ISO 9001 focus on managing the changes in the design and development phase of the product, while ISO 55001 focus on manage the risk associated with every change in the organization.

8.3 Outsourcing

ISO 9001:

- 4.1 General requirements.

Comment: Both ISO 9001 and ISO 55001 require control over the outsourced processes and activities that may affect conformity to the product (ISO 9001) or the AM objectives (ISO 55001). However, ISO 55001 also require an organization to assess the associated risks of an outsourced activity. Additionally, ISO 55001 require that the responsibilities and authorities of the outsourced activities are determined. There exists a small gap between the requirements of ISO 9001 and ISO 55001 in this sub-clause.

9.1 Monitoring, measurement, analysis and evaluation

ISO 9001:

- 4.1 General requirements.
- 8.1 General (Measurement, analysis and improvement).
- 8.2.1 Customer satisfaction.
- 8.2.3 Monitoring and measurement of processes.
- 8.2.4 Monitoring and measurement of product.
- 8.4 Analysis of data.
- 7.1 Planning of product realization.

Comment: Both ISO 9001 and ISO 55001 require the organization to determine methods for monitoring, measurement, analysis and evaluation. ISO 55001 states that the organization shall assess if the AM requirements and objectives are met, and ISO 9001 require an assessment of product conformity and conformity of the quality management system. An important note is that ISO 55001 can be used to determine if both customer and product requirements have been achieved. In addition, both standards require an organization to measure the effectiveness of their respective management systems.

9.2 Internal audit

ISO 9001:

- 8.2.2 Internal audit.

Comment: Internal audits is covered in both ISO 9001 and ISO 55001.

9.3 Management review

ISO 9001:

- 5.6.1 General (Management review).
- 5.6.2 Review input.
- 5.6.3 Review output.

Comment: ISO 55001 (p.9) include this statement: "*Top management shall review the organization's asset management system, at planned intervals, to ensure its continuing suitability, adequacy and effectiveness*", and ISO 9001 (p.5) include; "*Top management shall review the organization's quality management system, at planned intervals, to ensure its continuing sustainability, adequacy and effectiveness*". It is fair to express that the management review requirements in the two standards are equal. Additionally, the rest of the "shall" requirements have approximately equal overall content.

10.1 Nonconformity and corrective action

ISO 9001:

- 8.3 Control of nonconforming product.
- 8.5.2 Corrective action.

Comment: ISO 9001 relates the nonconformity to the product, while ISO 55001 has a broader focus an include nonconformities within the asset, AM and AM system. Elsewhere, the requirements is equal in this section, as they both require corrective action and actions that prevent recurrence.

10.2 Preventive action

ISO 9001:

- 8.5.3 Preventive action.

Comment: Both ISO 9001 and ISO 55001 require the establishment of actions/processes that proactively identify potential failures.

10.3 Continual improvement

ISO 9001:

- 8.5.1 Continual improvement.

Comment: Continual improvement is of equal importance in the two standards, and they both is built around Deming's PDCA Cycle.

Appendix C – Detailed Analysis between ISO 55001 and the PSA Regulations

4.1 Understanding the organization and its context

The Framework Regulations:

- Section 9: Application of the principles in Chapter 2.
- Section 10: Prudent activities.
- Section 11: Risk reduction principles.

Comment: ISO 55001 require the organization to determine the external and internal issues that can affect the outcome, and especially in section 10 the Framework Regulations states that the organization should give consideration to the specific nature of the activities, local conditions and operational assumptions. Furthermore, the PSA Regulations require that the factors that can cause harm to be replaced, and this also complies with the ISO 55001 requirements. Section 9 in the Framework Regulation also require compliance with the principles in the Framework Regulations and other supplementary regulations.

It is the author's opinion that ISO 55001 complies with the PSA Regulations in this clause. The only difference is that ISO 55002 provide some more issues to include in the internal context than the PSA Regulations. The PSA Regulations does not act as a barrier in this clause for the implementation of ISO 55001.

4.2 Understanding the needs and expectations of stakeholders

The Framework Regulations:

- Section 7: Responsibilities pursuant to these regulations.
- Section 8: Employer's duties toward employees other than its own.
- Section 10: Prudent activities.
- Section 26: Documentation in the early phase.

The Management Regulations:

- Section 11: Basis for making decisions and decision criteria.
- Section 15: Information.
- Section 28: Information to the general public relating to safety measures for onshore facilities.

Comment: PSA require that everyone who carries out work on behalf of an organization to comply with the requirements in the HSE legislation. Further, the organization needs according to PSA Regulations to communicate information to the relevant users and inform the general public relating to safety measures. To fulfil the above requirements, the organization needs to identify all the relevant stakeholders, and the PSA Regulations is consistent with the

requirements in clause 4.2 in ISO 55001. However, ISO 55001 require all relevant stakeholders to be identified.

It is the author's opinion that the text in ISO 55001 can stimulate to the identification of more stakeholders than in the PSA Regulations, and hence there should be no surprise when the organization carry out their work (e.g. a local community contacts the media regarding pollution of their drinking water). Lastly, both ISO 55001 and the Management Regulations include the establishment of decision criteria. Regarding the documentation requirements in Section 26 in the Framework Regulations, the ISO 55001 fulfils these requirements since PSA is a stakeholder and ISO 55001 require communication with stakeholders.

4.3 Determining the scope of the asset management system

The Framework Regulations:

- Section 7: Responsibilities pursuant to these regulations.

Comment: The PSA Regulations require the organization itself and everyone who carries out work on its behalf to conform to the PSA Regulations and the HSE legislation. ISO 55001 require the organization to define its boundaries, and hence the scope, based on the outcome of stakeholder analysis and the internal/external context. Since the PSA is a stakeholder, the PSA requirements should be included when an organization operating on the NCS establishes the scope of the AM system. Both the PSA Regulations and ISO 55001 require the determination of the scope, however, the author identifies that ISO 55001 provide a more holistic view as it does not only include the PSA Regulations and HSE legislation.

4.4 Asset management system

The Framework Regulations:

- Section 17: Duty to establish, follow up and further develop a management system.

The Management Regulations:

- Section 7: Objectivities and strategies
- Section 8: Internal requirements
- Section 9: Acceptance criteria for major accident risk and environmental risk
- Section 10: Measurement parameters and indicators
- Section 11: Basis for making decisions and decision criteria

Comment: The PSA Regulation require a HSE management system and the ISO 55001 require and asset management system. Even though a HSE management system and an asset management system have different requirements, both PSA Regulations and ISO 55001 require a management system to be implemented and maintained.

5.1 Leadership and commitment

The Framework Regulations:

- Section 7: Responsibilities pursuant to these regulations.
- Section 15: Sound health, safety and environment culture.
- Section 19: Verifications.

The Management Regulations:

- Section 4: Risk reduction
- Section 5: Barriers
- Section 7: Objectives and strategies
- Section 12: Planning
- Section 13: Work processes
- Section 18: Working environment analysis

Note: In many of PSA's sections, it is stated that the requirements should be performed by the party responsible. It is often the top management of the party responsible that has the responsibility to fulfil the requirements, and hence the Management Regulation sections above can be linked to the ISO 55001. E.g. Section 7: Objectives and strategies: The responsible party shall stipulate and further develop objectives and strategies to improve the HSE. It is the top management in the organization that develop these objectives and strategies.

Comment: The PSA regulation does not define any specific task/requirements for the top management or the managers of the organization. However, as aforementioned, the top management performs many of the tasks performed by the party responsible. E.g. Section 7 in the management regulation is consistent with one of the requirements of ISO 55001 (cl. 5.1). Furthermore, the three sections under the Framework Regulations require the organization to have a sound HSE culture, to be responsible to the regulations and perform verifications. The top management also does this, and it is the author's opinion that the ISO 55001 Leadership requirements is complementary with the PSA Regulations.

In addition, ISO 55001 have a strong emphasis on the clear "line of sight" between top management and the daily operators. Sub-clause 5.1 *Leadership* include requirements like supporting persons to contribute to the effectiveness of the AM system, creating a collaborative culture that focuses on deliver the AM objectives, and communicating the importance of the effective AM system. This clearly shows the presence of "line of sight" in the ISO 55001 standard. Focusing on "line of sight" between top management and the daily operators will create innovation and creativity that again will improve the way people work (Woodhouse, 2010b).

5.2 Policy

The Framework Regulations:

- Section 10: Prudent activities.
- Section 15: Sound health, safety and environment culture.

The Management Regulations:

- Section 6: Management of health, safety and the environment.
- Section 7: Objectives and strategies.
- Section 8: Internal requirements.
- Section 11: Basis for making decisions and decision criteria.

Comment: The Framework Regulations (sect. 10) require a high level for HSE and Section 15 require a sound HSE culture. Furthermore, the Management Regulations require the organization to ensure the management of HSE and establishing objectives and strategies according to HSE. Since the PSA Regulations relates to HSE, the policy created will of course have a strong focus on HSE.

ISO 55001 states that the policy should be appropriate to the purpose of the organization and it should provide a framework for the setting of the objectives. ISO 55001 does not mention specific HSE in their standard, however, if performing operations on the NCS, the responsible party need to comply with the PSA Regulations, and hence if implementing ISO 55001 the policy needs to include HSE. Bottom line, ISO 55001 offers a broader policy than the PSA Regulations. The Policy requirements in the ISO 55001 standard are not in conflict with the PSA Regulations and it offers a perspective that is not covered in the PSA Regulations.

5.3 Organizational roles, responsibilities and authorities

The Framework Regulations:

- Section 12: Organization and competence.

The Management Regulations:

- Section 6: Management of health, safety and the environment.
- Section 14: Manning and competence.

Comment: Both the PSA Regulations and ISO 55001 require that the responsibilities and authorities are defined and assigned for the different roles in the organization. However, the ISO 55001 goes a bit further and lists specific tasks the responsibilities and authorities need to be assigned to. Since both the PSA Regulations and ISO 55001 require necessary competence, they are consistent with each other in this sub-clause, and neither of them are in conflict.

6.1 Actions to address risks and opportunities for the asset management system

The Framework Regulations:

- Section 11: Risk reduction principles.

The Management Regulations:

- Section 4: Risk reduction.
- Section 9: Acceptance criteria for major accident risk and environmental risk.
- Section 17: Risk analyses and emergency preparedness assessments.
- Section 23: Continuous improvement.

Comment: PSA Regulations presents several sections about risk reduction. ISO 55001 complies with the risk sections in the PSA Regulations. Sub-clause in 6.1 is about identifying the risks in the planning phase and it require an organization to determine the risks and opportunities that needs to be addressed to prevent undesired effects and give assurance that the AM system achieve its intended outcome. The PSA Regulations covers a broad range of risk requirements, and it is the author's opinion that ISO 55001 does not offers something new regarding risk management. It is also worth mention that ISO 31000 (Risk Management) should be integrated with ISO 55001.

ISO 55002 (cl. 6.1) states that the term risk also includes opportunities. One can relate the Continuous Improvement section in the PSA Regulations to this sub clause. The Continuous Improvement (MR-23) clause require the organization to identify the processes and activities that needs improvement, and this is consistent with the opportunity requirement in ISO 55001.

6.2.1 Asset management objectives

The Management Regulations:

- Section 7: Objectives and strategies.
- Section 8: Internal requirements.

Comment: The ISO 55001 offers a more specific approach to the objectives than the PSA Regulations. The PSA Regulations state that the objectives need to be developed to improve the HSE, while ISO 55001 in addition lists how the objectives needs to be. Management Regulations section 8 include that the relevant stakeholders should be considered when setting the objectives, but none of the financial and technical requirements is mentioned.

6.2.2 Planning to achieve the asset management objectives

The Management Regulations:

- Section 4: Risk reducing.
- Section 5: Barriers.
- Section 12: Planning.
- Section 17: Risk analyses and emergency preparedness assessments.

Comment: Section 12 in the Management Regulations states that the planned activities should be in accordance with the objectives and strategies. This is in accordance with the ISO 55001 requirements, however, the PSA Regulations do not include anything more. ISO 55001 require documentation on the whole objective planning process and the different elements in the process. Section 4, 5 and 17 in the Management Regulations focuses on risk and that is one of the requirements in the planning process in ISO 55001. Bottom line, ISO 55001 require a more comprehensive approach to the "planning to achieve (asset management) objectives" process.

7.1 Resources

The Management Regulations:

- Section 12: Planning.

Comment: ISO 55001 and the Management Regulations have equal requirements regarding the resources. However, ISO 55002 (cl. 7.1) offers a more broad perspective to the resources than the Management Regulation guidelines in section 12. ISO 55002 include issues like mapping the available resources and performing a resource gap analysis to ensure that there is sufficient recourses. ISO 55002 is clear about the "line of sight" principle in this sub-clause, and states that parts of the organization may need to provide additional resources to supplement the primary asset management activity. This approach has a holistic view of the resource management, and it ensures that the resources are used where it creates the highest value. Therefore, the author has identified that the use of ISO 55001, and certainly ISO 55002, will supplement the PSA Regulations to ensure effective resource management.

7.2 Competence

The Framework Regulations:

- Section 12: Organization and competence.

The Management Regulations:

- Section 14: Manning and competence.

Comment: Both ISO and PSA require that the persons working under an organization's control, shall have the necessary competence. In addition, ISO 55001 require reviews of the current competence and actions that will increase the competence. The author's opinion is that ISO 55001 should provide additional competence management to the PSA Regulations. It is important to ensure that everyone have the necessary competence, however, it is equal important to continually increase the competence.

7.3 Awareness

The Management Regulations:

- Section 5: Barriers.

Comment: The Management Regulations require personnel to be aware of the barriers that have been established and their performance requirements. These barriers exists to identify and prevent failures, accident situations, and hazards. ISO 55001 goes a bit further and require the personnel to be aware of the AM policy and their own contribution to the effectiveness of the AM system. Another issue in ISO 55001 is that the employees need to be aware of the risks and opportunities associated with the work performed. ISO 55001 is compliant with the PSA Regulations, however, ISO 55001 offers something more. When the personnel are aware of their own contribution regarding AM objectives, and aware of the opportunities they can create, it should lead to more effective management performance and innovation can be fostered.

7.4 Communication

The Framework Regulations:

- Section 26: Documentation in the early phase.

The Management Regulations:

- Section 15: Information.
- Section 28: Information to the general public relating to safety measures for onshore facilities.
- Section 29: Notification and reporting of hazard and accident situations to the supervisory authorities.
- Section 30: Information on follow-up of hazard and accident situations.

Comment: Both ISO 55001 and the PSA Regulations require the development of communication systems. According to ISO 55002 (cl. 7.4.2) an organization needs to develop communication plans for managing and informing stakeholders (e.g. PSA) who can impact the AM objectives. Section 28, 29 and 30 in the Management Regulation require that an organization communicate with the PSA in the case of hazardous situations and this is covered in ISO 55001 (since PSA is a critical stakeholder for organizations operating on the NCS).

7.5 Information requirements

The Framework Regulations:

- Section 23: General requirement for material and information.
- Section 46: Oceanography, meteorology and earthquake data.

The Management Regulations:

- Section 15: Information.
- Section 19: Collection, processing and use of data.

Comment: Section 15 in the Management Regulations require the identification of information necessary to plan and carry out activities and ISO 55001 require the determination of information requirements to support the asset, AM and AM system. ISO 55001 and PSA Regulations is therefore consistent to each other in this section. The only difference is that ISO 55001 is more specific in specifying what information it needs and not only require the "information necessary". In addition, both ISO 55001 and the PSA regulation include requirements for collection and processing the information.

7.6 Documented information

The Framework Regulations:

- Section 23: General requirement for material and information.
- Section 24: Use of recognised standards.

The Management Regulations:

- Section 24: Organization of material and information.

Comment: ISO 55001 and the PSA Regulations specifies approximately equal requirements regarding documented information.

8.1 Operational planning and control

The Management Regulations:

- Section 13: Work processes.

The Activity Regulations:

- Section 48: Planning and prioritisation.

Comment: The PSA Regulations require work processes that fulfil the requirements to HSE, and ISO 55001 require the establishment of processes needed to support actions addressing risk and opportunities, the AM plan and corrective actions. The activities contained in the asset

management plan does not only consists of HSE related activities, it includes every activity needed to achieve the asset objectives. The PSA Regulations does not act as a barrier to ISO 55001 and ISO 55001 will provide additional considerations in the operation phase.

8.2 Management of change

The Framework Regulations:

- Section 17: Duty to establish, follow up and further develop a management system.

The Management Regulations:

- Section 11: Basis for making decisions and decision criteria.
- Section 14: Manning and competence.
- Section 22: Handling of nonconformities.
- Section 23: Continuous improvement.

Comment: The PSA Regulations require that changes with manning needs to be reviewed and ISO 55001 require that every change needs to be risk assessed. Furthermore, the PSA Regulations require the organization to follow up the management system, nonconformities and processes/activities to implement improvement measures. When implementing these measures, the Management Regulation link to Section 11. This section require that before an improvement measure is implemented, HSE related issues needs to be adequately understood and assessed. Both PSA Regulations and ISO 55001 require an assessment of the planned change, and hence they are consistent with each other. It is however the author's opinion that it is not enough to only consider HSE related issues when assessing changes, and all the risks needs to be addressed.

8.3 Outsourcing

The Framework Regulations:

- Section 8: Employer's duties toward employees other than its own.
- Section 18: Qualification and follow-up of other participants.

Comment: The PSA Regulations explain and clearly state what type of control and management is expected of the outsourced activities. ISO 55001 is consistent with these requirements, as it also require control of the outsourced activities.

9.1 Monitoring, measurement, analysis and evaluation

The Framework Regulations:

- Section 48: Duty to monitor and record data from the external environment.

The Management Regulations:

- Section 8: Internal requirements.
- Section 10: Measurement parameters and indicators.
- Section 16: General requirements for analyses.
- Section 18: Working environment analysis.

Comment: Since PSA is a safety authority, their main monitoring will consist of HSE related measures. The PSA Regulations does not focus on performance measures concerning effectivity of the production or the quality of the products. Since organizations that operates on the NCS needs to comply with the PSA Regulations, it is naturally that a part of their performance measures is about HSE. Furthermore, if implementing ISO 55001 it will provide a more comprehensive approach to the monitoring process. ISO 55001 does not only focus on HSE related measures, and it require measures that enable the evaluation of the asset and asset management performance.

The PSA Regulations does not act as a barrier for the *Performance Evaluation* clause in ISO 55001. ISO 55001 require an organization to ensure that monitoring and measurement processes is consistent with the needs and expectations of stakeholders. PSA is a stakeholder, and some of the measures in ISO 55001 needs to consider HSE related issues.

9.2 Internal audit

The Management Regulations:

- Section 21: Follow-up.

Comment: ISO 55001 clause 9.2 and Management Regulations section 21 contain equal overall information. ISO 55001 provide detailed requirements to the audit, and section 21 link to ISO 9000, chapter 2.8 where the same level of detail exists.

9.3 Management review

The Framework Regulations:

- Section 19: Verifications.

The Management Regulations:

- Section 21: Follow-up.

Comment: ISO 55001 clause 9.3 and Management Regulations section 21 contain the same overall information. ISO 55001 provide detailed requirements to the management review, and section 21 link to ISO 9000, chapter 2.8 where the same level of detail exists.

10.1 Nonconformity and corrective action

The Framework Regulations:

- Section 20: Coordination of offshore emergency preparedness.
- Section 11: Risk reduction principles

The Management Regulations:

- Section 20: Registration, review and investigation of hazard and accident situations.
- Section 22: Handling of nonconformities.

Comment: Both the PSA requirements and ISO 55001 require immediate action to incidents and nonconformities. They both agree that the root cause needs to be found in order to prevent recurrence, and that this process should be documented.

10.2 Preventive action

The Framework Regulations:

- Section 16: Health-related matters.

The Management Regulations:

- Section 5: Barriers.
- Section 17: Risk analyses and emergency preparedness assessments.
- Section 19: Collection, processing and use of data.

Comment: The requirements of ISO 55001 is included in the PSA Regulations. PSA Regulations require both barriers and risk analyses to prevent potential failures, and this is consistent with the processes stated in ISO 55001. Again, the PSA focuses of course on HSE related matters, and ISO 55001 is not bound to only HSE.

10.3 Continual improvement

The Framework Regulations:

- Section 15: Sound health, safety and environment culture.
- Section 17: Duty to establish, follow up and further develop a management system.

The Management Regulations:

- Section 6: Management of health, safety and environment.
- Section 23: Continual improvement.

Comment: Both ISO 55001 and PSA regulations focuses on continual improvement.

Appendix D – Detailed Analysis between ISO 55001 and Statoil's Governing Documentation

4.1 Understanding the organization and its context

Statoil governing documentation

- FR11: 2 Sustainability in Statoil.
- FR11: 3 Sustainability function requirements.
- SB: Introduction – p8.
- SB: Sustainability: How we work – p61.

Gerhardsen specific documentation

- PAS: 4 HSE.
- PAS: 5 Quality Management.
- PDO: 2.9 Organization and execution:
- PDO: 10 HSE.
- PDO: 10.1 Acceptance criteria and requirements.
- PDO: 10.4 Environmental assessment of the chosen solution.

Comment: The first clause in ISO 55001 require the organization to identify every external and internal issues that can affect the intended outcome of the asset management system. Even though this it is not stated specific in any Statoil requirement, they have certainly focused on identifying every context. FR11 (Ch. 2 and 3) lists requirements for environmental and social performance, and more specifically it lists requirements for the balance of energy supply and climate impact, preventing harm to local environment, and respect for human rights. It is stated in the Statoil Book (p.8) that one of the main objective of the management system is to contribute to safe, reliable and efficient operations that enable Statoil to comply with internal and external requirements. Other requirements for external and internal issues stated in Statoil's governing documents relates to the limitation of greenhouse gas emissions, the respect for labour standards and the rights of indigenous people, the management of social and environmental risks, and the use of clean technology to reduce environmental impacts (Statoil Book, p. 61).

Gerhardsen needs to comply with all the aforementioned requirements, and in addition, it have some platform specific requirements. Gerhardsen's procurement needs to comply with EEA (PDO: Ch. 2.9) and there is created specific requirements for the HSE programme (PDO: Ch. 10). PDO (Ch. 10.4) require environmental assessment of natural resources and environmental conditions, emissions to the air and sea, corals, cultural heritage and community financial profitability. The author's opinion is that even though it is not specified in Statoil's governing documentation to identify every internal and external context, they certainly have.

4.2 Understanding the needs and expectations of stakeholders

Statoil governing documentation

- FR04: 2.5.8 Stakeholder management and communication plan.
- FR05: 2.5.1 Integration management.
- FR09: 2.3.4.3 Customer relationship management.
- FR09: 2.3.4.4 Supplier relationship management.
- FR20: 3.5 Stakeholder involvement.
- OMC01-000: 2.9 External partnerships and reporting.

Gerhardsen specific documentation

- PAS: 3.5 Authority coordination.
- PDO: 9 Operations and maintenance.
- PDO: 10.1 Acceptance criteria's and requirements.

Comment: ISO 55001 require the organization to identify all relevant stakeholders, and the requirements and expectations of these. In relation to project management, Statoil require that every stakeholder is identified and followed-up (FR05: Ch. 2.5.1) and that the project is in accordance with relevant laws and regulations. When developing and improving internal governing documentation, Statoil require stakeholders to be involved and their requirements needs to be handled in an effective way. Furthermore, OMC01-000 (Ch. 2.9) lists the external partnerships (e.g. PSA, OD, Norwegian Radiation Protection Authority, Ministry of Petroleum and Energy, and suppliers) and the associated reporting. FR04 (Ch. 2.5.8) require a stakeholder communication plan, while FR09 (Ch. 2.3.4.3 and 2.3.4.4) require both customer and supplier relationship management.

Gerhardsen's specific requirements concern authority coordination (PAS: Ch. 3.5) and that Statoil will be accountable to the government and partners for all the activities performed (PDO: Ch. 9). ISO 55002 (cl. 4.2.2 and 4.2.3) lists possible internal and external stakeholders, and it is the author's opinion that Statoil have processes that enable Statoil to identify every relevant stakeholder. Statoil's governing documentation are consistent with ISO 55000 sub-clause 4.2.

4.3 Determining the scope of the asset management system

Statoil governing documentation

- FR06: 3.2 Accountability

Comment: An ISO 55000 compliant organization needs to determine the boundaries and scope of the asset management system. The scope shall consider the interaction with other management systems, e.g. Risk Management or Quality Management. Statoil has not focused on developing an asset management system, and hence the scope of the system is not stated anywhere. However, ISO 55002 (cl. 4.3) states that the scope should contain the boundaries of

the asset and asset portfolio, and FR06 (Ch. 3.2) require the asset's physical boundaries to be clearly defined. Statoil are partly consistent with the requirements in this sub clause.

4.4 Asset management system

Statoil governing documentation

- FR20: 2 The management function.
- OMC01-000: 3 The Management Model.

Gerhardsen specific documentation

- PAS: 2.2.2 Management system.
- PDO: 11.1.1 Main goals.
- PDO: 11.1.2 Basis for management system.

Comment: FR20 (Ch. 2) states that Statoil's management system shall be developed and improved based on business needs and it require that governing documentation is understood. Statoil's management system shall contain principles, Ambition to Action, process areas, process owners, monitoring and other related management documentation (OMC01-000: Ch. 3). It is further stated that Gerhardsen's management system shall be implemented with reference to Statoil's management system. ISO 55001 require the organization to develop, implement and improve an asset management system. Statoil's management system is not about asset management, and therefore Statoil is not compliant with this sub clause. To be compliant with this sub clause, Statoil needs to develop an asset management system that needs to be integrated with other management systems in Statoil like Risk Management, Financial Management and Quality Management.

5.1 Leadership and commitment

Statoil governing documentation

- FR10: 3.1 Leadership.
- FR10: 3.2 Compliance and leadership.
- FR16: 2.1 The line management.
- FR16: 2.2 The PO Function.
- OMC01-000: 2.3.5 Staff functions.
- OMC01-000: 4.1 Roles and responsibilities for the management system.
- SB: Introduction – p8.
- SB: Our responsibilities – p9.
- SB: People partnerships – p16.
- SB: External orientation – p17.
- SB: The role and responsibility of the process owner – p41.

- SB: Authorities and internal control in Statoil – p50.

Gerhardsen specific documentation

- PAS: 3.1 Asset owner and asset owner representative.
- PAS: 3.10 Staffing resources.
- PAS: 5 Quality Management.

Comment: Being an ISO 55001 compliant organization include that the top management needs to demonstrate leadership and commitment through ensuring that the AM policy, the SAMP and the AM objectives is established. Furthermore, top management needs to ensure that the AM system is integrated, the required resources is available and they need to promote continual improvement. In addition, clause 5.1 has a strong emphasis on the "line of sight" between top management and the daily operators. The standard require the top management to support persons to contribute to the achievement of the AM objectives, communicate the importance of an effective AM system, create cross-functional collaboration, and create an collaborative culture that focuses on delivering the AM objectives. "Line of sight" is one of the asset management fundamentals (Woodhouse, 2010b).

OMC01-000 (Ch. 2.3.5) require the staff functions in Statoil to contribute to risk management and ensure that Statoil comply with the requirements. The management staff needs to advise, support and challenge the line managers within every specific discipline. Moreover, the management staff needs to share experiences, and support training and improvement initiatives. Additionally, it is stated in the Statoil Book (p. 9) that every leader is responsible for ensuring that their employees know where to find relevant documentation and understand how to use the management system. About the collaborative work culture that ISO 55001 mention, the Statoil Book (p.16-17) require the leaders to promote a stimulating work environment guided by Statoil's values, ensure commitment to employee development, and develop a strong safety and security culture (FR10: Ch. 3.1). It is also top management's responsibility to ensure that the management system is developed, implemented and improved (OMC01-000: Ch. 4.1). Another issue is that Statoil's governing documentation require the process managers to work with the line managers to ensure alignment of the business needs (Statoil Book, p.41). In addition, Gerhardsen have some specific "Leadership and Commitment" requirements, e.g. the project management team needs to base its decisions of the overall economic life of the asset.

I have identified fifteen requirement chapters in Statoil's governing documentation that can be fully or partly linked to sub-clause 5.1 in ISO 55001. The establishment of the management system, the development of a collaborative work culture and ensuring alignment of the business needs is consistent with the requirement of ISO 55001 sub-clause 5.1. Even though Statoil have not created an asset management system, their governing documentation is compliant with the requirement of this clause. The only gaps is the requirements relating to the AM policy, SAMP, AM objectives and the AM system, since there exists no such management system in Statoil.

5.2 Policy

Statoil governing documentation

- FR06: 3.4 Operation
- OMC01-000: 2.3.1 Strategy and Portfolio.
- SB: Organizational principles – p24: The Principles.

Gerhardsen specific documentation

- OMC01-036: 2 Overall strategy.

Comment: ISO 55001 require top management to establish an asset management policy that define the purpose and direction of an organization. The AM policy needs to provide a framework for the AM objectives and it should also include a commitment to relevant requirements. The Statoil Book (p.24) lists the organizational principles that e.g. states that value and performance in Statoil is created from a combined asset-based and function-based organization. FR06 (Ch. 3.4) states that each business area shall ensure that its O&M strategy is updated, and that asset specific O&M strategies shall be considered as a supplement to Statoil overall Strategy. Gerhardsen's specific strategy focuses on the delivery of quality in every activity, the right use of resources and continual improvement.

Even though Statoil's principles and strategies are not related to asset management, their policy is in accordance with some of the requirements in ISO 55001 sub-clause 5.2. To be fully compliant, Statoil needs to develop an asset management policy.

5.3 Organizational roles, responsibilities and authorities

Statoil governing documentation

- FR06: 3.2 Accountability.
- FR15: Roles and responsibilities.
- OMC01-000: 2.1 Role and responsibilities.
- OMC01-000: 2.3.3 Operating Areas.
- OMC01-000: 3.4 Process and function relationships.
- SB: The role and responsibility of the process owner – p41:

Gerhardsen specific documentation

- PAS: 3.2 Assignment structure.
- PAS: 3.4 Business Case Leadership Team (BCLT).
- OMC63: 4.1 General.

Comment: ISO 55001 states that the responsibilities and authorities for every role shall be assigned and communicated. Further, it also specifies some specific responsibilities relating to the asset management system. The Statoil Book (p.41) and OMC01-000 (Ch. 2.1, 2.3.3 and 3.4)

specifies the roles and responsibilities in Statoil and specifically in DPN. FR06 (Ch. 3.2) states that the performance of barrier functions in Statoil shall be designated, while FR15 (Ch. 2.2) specifies the roles and responsibilities within the use if IT in Statoil.

PAS (Ch. 3.2) require the Gerhardsen project to follow Statoil's project model, and each project manager is responsible for the formal reporting to the relevant function manager. The Business Case Leadership Team will manage the Gerhardsen project (PAS: Ch. 3.4). The author's opinion is that Statoil have set requirement for all the relevant roles in the organization. However, there exists no requirements for e.g. updating the SAMP or ensuring that the asset management system supports the delivery of the SAMP. To be fully compliant to ISO 55001, Statoil needs to assign responsibilities for asset management specific roles.

6.1 Actions to address risks and opportunities for the asset management system

Statoil governing documentation

- FR04: 2.5.4 Risk management.
- FR06: 3.3 Integrity and risk management.
- FR08: Risk Management
- FR09: 2.3.4.5 Risk management.
- FR10: 3.3 Risk management.
- FR20: 3.3 Manage risk.
- OMC01-000: Risk management.
- SB: Safety: How we work – p57.
- SB: Risk: How we work – p67.

Gerhardsen specific documentation

- PAS: 3.4 Business Case Leadership Team (BCLT).
- PDO: 10.1 Acceptance criteria's and requirements.
- PDO: 10.2 Safety.
- PDO: 11.1.3 Risk management.

Comment: When planning for the asset management system, the organization needs to consider the internal/external context and the stakeholders, and determine the risks and opportunities. ISO 55001 require the organization to implement actions to address these risks and opportunities and how to prevent or reduce undesired effects. Statoil have created its own Risk Management requirement document (FR08), where the identification and treatment of risks is at the core. Statoil's Management System requirement document (FR20: Ch. 3.3) states that one should use risk assessment, taking into account both upside and downside risks, when developing new governing documentation. The Statoil Book (p.57) states that Statoil work systematically to manage risks, and at page 67 it is stated that Statoil identifies risks relating to strategies and plans, Statoil uses Value at Risk measures, and Statoil manage risk on a short- and long-term basis. Furthermore, risk assessment is included in FR04 (Ch. 2.5.4), FR06 (Ch.

3.3), FR09 (Ch. 2.3.4.5) and FR10 (Ch. 3.3), which shows that risk management is containing a large part Statoil's management system.

Gerhardsen's Plan for Development, Installation and Operation (PDO: Ch. 10.1) require the project team to use the ALARP principle. Furthermore, the project have performed several risk analyses consisting of several elements like hazard identification, and qualitative and quantitative risk assessment (PDO: Ch. 10.2). It is also stated in PDO (Ch. 11.1.3) that through risk management the Gerhardsen project shall identify both risks and opportunities and perform measures that exploit the opportunities and limits the downsides.

ISO 55002 (cl. 6.1) states that the risk assessment in the asset management system should be aligned with the organization's risk management approach. The risk assessment in Statoil covers both upside and downside risks, and Statoil's organizational risk approach can be used on a possible future asset management system. Statoil's governing documentation should therefore be compliant with the requirement of this sub-clause.

6.2.1 Asset management objectives

Statoil governing documentation

- FR06: 3.4 Operation.
- FR06: 3.5 Maintenance.
- OMC01-000: 3.1 Ambition to action.
- SB: Ambition to Action – p27.
- SB: Strategy translation and target-setting – p29.

Gerhardsen specific documentation

- PAS: 3.8 Ambition to Action for the Gerhardsen project.
- PDO: 11.1.1 Main goals.

Comment: The main purpose of Statoil's Ambition to Action process is to translate strategies into strategic objectives, KPIs and actions with a medium-term time horizon (OMC01-000: Ch. 3.1; Statoil Book: p.27-29). Ambition to Action covers these five perspectives: HSE, Operation, People and Organization, Market and Finance. The KPIs are created to measure the delivery against the strategic objectives. The functional requirements of the Operations and Maintenance process in Statoil states that the operational targets should be established to support the business objectives. Furthermore, business objectives and safety targets shall be translated into specific asset goals. This is consistent with ISO 55001's approach to asset management objectives. ISO 55001 require the asset management objectives to be consistent with the asset management policy and to be aligned with the organizational objectives. It is also required that the organization shall consider requirements of stakeholders and financial, technical and regulatory requirements when establishing the objectives. The PDO (Ch. 11.1.1) lists some specific goals for the platform Gerhardsen.

Ambition to Action is about translating strategies into actions and objectives, and this is consistent with the text in ISO 55001. Moreover, within the Operations and Maintenance function it is specified that the operational objectives should be derived from the organizational objectives. Even though Statoil does not have an asset management system, it is clear for the author that Ambition to Action and FR06 comply with many of the requirements in ISO 55001 clause 6.2.1. If Statoil implement an AM system, the process of creating AM objectives should not be challenging.

6.2.2 Planning to achieve the asset management objectives

Statoil governing documentation

- FR06: 3.3 Integrity and risk management.
- FR06: 3.5 Maintenance.
- FR10: 3.4 Barrier management.
- FR10: 3.10 Technical and operational safety.
- FR14: 3.2 Investment decisions.
- SB: Planning – p30.

Gerhardsen specific documentation

- OMC01-036: 3.2 Strategy for operations and maintenance topside.
- OMC63: 4.3 Maintenance.

Comment: The main aspect of this sub-clause is to establish, maintain and document an asset management plan needed to achieve the asset management objectives (ISO 55001). When planning to achieve the AM objectives, the organization also needs to integrate this process with other planning activities like financial and human resources. Decision making criteria and processes needed to manage the assets over their life cycle needs to be determined. One also needs to establish processes to identify and assess risks and opportunities. ISO 55002 states that an AM plan often include O&M plans, capital plans, and financial and resource plans.

The Statoil Book (p.30), which describes Statoil's values, leading principles and the way Statoil operate, states the planning process in Statoil shall start with understanding risks and actions needed to manage risks. Furthermore, the Statoil Book require the actions needed to achieve the objectives and the KPI targets, this also include action planning (what, who, how, when). FR06 (Ch. 3.5) require maintenance plans and FR14 (Ch. 3.2) states that e.g. investment decisions are part of Statoil's Capital Investment Process (CVP). In addition, FR06 (Ch. 3.3), FR08 (the whole), FR10 (Ch. 3.4) and FR10 (Ch. 3.10) is about risk and barrier management. It is also worth mention that it is stated in OMC63 (Ch. 4.3) that Gerhardsen shall follow the overall activities for DPN.

The Statoil Book require actions to address risks, objectives and KPIs, and it require action planning (e.g. who, what). This is consistent with ISO 55001 (cl. 6.2.2). ISO 55002 states that

the AM plan often consists of O&M plans and financial plans, and Statoil is also consistent with the ISO 55001 standard in this point. Statoil have not developed an asset management system, however, if they decide to do so, they should have all the planning processes in place.

7.1 Resources

Statoil governing documentation

- FR06: 3.5 Maintenance.
- OMC01-000: 2.3.5.3 PO.
- OMC01-004: 3.6.5 Collaboration.
- SB: Execution – dynamic resource allocation – p31.
- SB: Safety: How we work – p57.

Comment: The Statoil Book (p.31) states that Statoil's dynamic resource allocation framework makes sure that resources are available for operations through various mechanisms or are allocated at project decision point. Within the safety perspective, the Statoil Book (p.57) explains that Statoil's people are provided with the necessary resources to deliver in accordance with their responsibilities. The Personnel Organization in Statoil have the responsibility to ensure strategic resource optimization in line with the long-term development of the fields (OMC01-000: Ch. 2.3.5.3). The maintenance process in FR06 (Ch. 3.5) also require the identification of the resources needed to achieve the maintenance objectives.

ISO 55001 require the organization to determine and provide the resources needed to establish and maintain an asset management system. Statoil's governing documentation is clear about the resource allocation and this is consistent with the requirements in this ISO 55001 sub-clause. However, ISO 55002 explains that the organization needs to coordinate the resources and this may imply that other parts of the organization needs to provide additional resources in order to support the asset management activity. This is a holistic view of resource management, and it ensures that the resources are used where it creates the optimal value. Statoil's resource allocation framework partly cover this holistic management of resources, however, the "line of sight" should have been better in Statoil's resource management.

7.2 Competence

Statoil governing documentation

- FR06: 3.8 Competence and learning.
- FR09: 2.3.4.2 Expertise development.
- FR16: 4.2 Performance and development.
- FR20: 3.6 Implementation and use.
- OMC01-000: 2.3.5.3 PO.
- OMC01-004: 3.6.6 Competence management.

- SB: People@Statoil – p19:
- SB: Our common career model – p20.

Gerhardsen specific documentation

- PDO: 11.2.3 Competence requirements and training.
- OMC63: 3.5 Competence and training.

Comment: ISO 55001 require the organization to determine the necessary competence of persons that can affect the assets performance, AM performance and AM system performance. In addition, the organization needs to ensure that these persons are competent and where there exists gaps, the organization needs to take action to acquire the necessary competence.

FR20 (Ch. 3.6) states that the leaders in Statoil shall ensure that their personnel have the necessary competence to use the management system. FR06 (Ch. 3.8) require competence management of every person executing O&M tasks, and OMC01-004 (Ch. 3.6.6) states that the use of Statoil's joint competence management process will ensure that the O&M personnel have relevant expertise that is maintained and continually developed. Top management and HSE competence requirements are listed in Work Requirements. Statoil's People@Statoil (SB: p.19; FR16: Ch. 4.2) is a common process for people development and performance management that ensures alignment between business needs and individual goals. Statoil's common career model (SB: p.20) guide Statoil in developing the expertise needed to meet the business needs. The Gerhardsen platform follow Statoil's common competence management (OMC63: Ch. 3.5).

ISO 55001 (cl. 7.2) require competence management and Statoil is clearly consistent with the requirements in ISO 55001. Statoil's governing documentation contains competence requirements for leaders, HSE, O&M personnel, etc. However, it is hard to identify clearly defined competence requirements for asset managers who needs to have extensive asset knowledge, communication skills, risk management skills and leadership skills (Woodhouse, 2010a). This is not a requirement in ISO 55001 and Statoil's competence management is consistent with the requirements in this sub-clause.

7.3 Awareness

Statoil governing documentation

- SB: People@Statoil – p19:
- SB: Compliance and Leadership – p34.

Comment: ISO 55001 require that personnel working in the organization needs to be aware of the AM policy, their contribution to the effectiveness of the AM system and the risks and opportunities associated with their work activities.

Statoil's People@Statoil (SB: p.19) process ensures alignment between business targets and individual targets. Development actions are agreed upon with the basis in personal development and business needs. Furthermore, Statoil's Compliance and Leadership model (SB: p.34) describes how Statoil plan, execute and continually improve the work. The model is about understanding the task, associated risks and relevant requirements. Especially this point is compliant with ISO 55001, as every employee needs to understand the risks associated with their work. Nevertheless, this model does not take into account the opportunities associated with the work, and this may prevent innovative solutions to occur. The People@Statoil process also ensure that persons are aware of their contribution to achieve the asset objectives and KPIs, and the implications of nonconformities. However, it is not specified in Statoil's governing documentation that staff, contractors or suppliers need to understand why (asset) management is important or how well the organization is performing in achieving the organizational objectives.

7.4 Communication

Statoil governing documentation

- FR04: 2.5.8 Stakeholder management and communication plan.
- FR05: 2.2 Ownership and organizational structure.
- FR05: 2.5.1 Integration management.
- FR13: Communication

Comment: ISO 55001 require the organization to identify internal and external communication plans, and decide what, when, with whom and how to communicate. In addition, ISO 55002 (cl. 7.4.2) states that the organization should develop stakeholder communication plans. A part of Statoil's governing documents is a separate communication requirement document (FR13). This document specifies communication plans regarding media relations, internal communication, political and public affairs, and brand communication. In addition, FR05 (Ch. 2.2) require projects to have start-up meetings between key stakeholders and FR04 (Ch. 2.5.8) require stakeholder management and the development of a communication plan.

Communication is of great importance in Statoil's governing documentation, and if Statoil in the future decide to develop an asset management system, the requirements of ISO 55001 (cl. 7.4) should be satisfied.

7.5 Information requirements

Statoil governing documentation

- FR05: 2.5.9 Communication, information and document management.
- FR06: 3.3 Integrity and risk management.
- FR06: 3.1.5 Life cycle information.
- FR14: 2 The finance and control function.
- FR15: 4.5 Information security.
- FR15: 4.6 Information requirement.
- SB: Governing documentation – p39.

Comment: ISO 55001 require the organization to determine the information requirements to support the assets, AM and AM system and the achievement of the organizational objectives. This includes determine the quality of the required information, the exchange of information with the stakeholders, and implementing processes for managing the information.

The Statoil Book (p.39) states that Statoil's governing documentation ensures best practice across the organization. The Functional Requirements describe what Statoil wants to achieve and, and the process models, work flow diagrams and requirements describe how Statoil will execute the plans. FR06 (Ch. 3.1.5) require life cycle information for plants in operation and FR14 (Ch. 4.6) states that the main purpose of the finance and control function is to deliver reliable and sufficient financial information. The project Functional Requirements (FR05: Ch. 2.5.9) states that appropriate generation, collection, storage and disposition of project information shall be ensured at every level of the project. Information security and information management (IM) requirements are specified in FR15 (Ch. 4.5, 4.6). FR15 states that information management in Statoil shall be an integrated part of the business and processes across the organization.

Statoil's governing documents sets out requirements for information relating to O&M and finance. There is developed specific process models and workflow diagrams that specifies information requirements in relation to the specific disciplines in Statoil. This complies with the requirements written in ISO 55001 (clause 7.5). However, there is hard to identify requirements in Statoil that specifies the consistency and traceability between financial and non-financial data. It is also difficult to find the alignment of information requirements for different levels and functions in the organization, which include vertical alignment of information from top management to operational areas and horizontal alignment between functions. Statoil is close to fulfil the requirements in the Information Requirement clause in ISO 55001, however, Statoil has a larger gap in relation to performing good asset management within this sub-clause because a certain "line of sight" lacks.

7.6 Documented information

Statoil governing documentation

- FR05: 2.5.9 Communication, information and documentation management.
- FR15: 4.5 Information security.
- FR18: Correct information, accounting and reporting.
- FR20: 3.1 Architecture and content.
- FR20: 3.2 Ownership and validity.
- FR20: 4 Governing documentation management.
- SB: Governing documentation – p39.

Comment: ISO 55001 require the asset management system to include documented information for regulatory requirements and the documented information required by ISO 55001. ISO 55001 also specifies requirements for creating, updating and controlling the documented information.

FR20 (Ch. 3.1) states that the management system is documented in Statoil's governing documentation and Statoil's governing documentation shall be consistent and aligned across the whole organization. Furthermore, an approver and owner (FR20: Ch. 3.2) shall be appointed. When working in a project in Statoil, the employees need to ensure full traceability for all documentation (FR05: Ch. 2.5.9). FR20 (Ch. 4) further explains Statoil's governing documentation management, and this management process consists of a systematic five step cycle: Assess and Plan → Develop → Implement → Use → Monitor and Control.

Statoil's requirements to documented information is consistent with the requirements in ISO 55001. The requirements in ISO 55001 (cl. 7.6.2 *Creating and Updating*, and cl. 7.6.3 *Control of documented information*) can be linked to the five step cycle in Statoil's governing documentation management. The author's opinion is that if Statoil develops an AM system the requirements in the documented information sub-clause will be satisfied.

8.1 Operational planning and control

Statoil governing documentation

- FR06: 3.3 Integrity and risk management.
- FR06: 3.4 Operation.
- FR06: 3.5 Maintenance.
- FR10: 3.4 Barrier management.
- FR10: 3.10 Technical and operational safety.

Gerhardsen specific documentation

- PDO: 9.2 Maintenance.
- OMC63: 2 Operating modell for Gudrun.

- OMC63: 4.1 General.

Comment: This clause is about implementing and controlling the processes required to achieving the requirements for risk and opportunities, the AM plans and AM objectives, and corrective and preventive actions (ISO 55001). ISO 55002 (cl. 8.1.1) further states that the organization should establish operational planning and control processes in order to support the AM plan.

Statoil have developed a common operating model for DPN. Every platform, including Gerhardsen, is organized and operated after the same requirements (OMC63: Ch. 2). FR06 (Ch. 3.5) states that every offshore asset shall have a maintenance program, including testing, inspection and corrosion management. In addition, there needs to be developed operational targets and measures implemented to achieve these targets (FR06: Ch. 3.4). Both FR06 (Ch. 3.3) and FR10 (Ch. 3.10) states that technical and non-technical barriers should be in place, maintained and monitored. As aforementioned, Gerhardsen uses Statoil common operating model, this also applies to the maintenance programme (PDO: Ch. 9.2).

As commented in ISO sub-clause 6.2.2, the Statoil Book require actions to address risks, objectives and KPIs, and in addition, Statoil require maintenance and financial plans. ISO 55001 (cl. 8.1) require actions to control the processes concerning the aforementioned requirements, and Statoil's common operating model ensure this. In addition, the requirements in ISO 55001 (cl. 8.1) can also be achieved by FR06 that require maintenance plans, barrier management and operational targets. Statoil's requirements should be consistent with the Operational planning and control sub-clause in ISO 55001.

8.2 Management of change

Statoil governing documentation

- FR05: 2.5.1 Integration management.
- FR20: 3.7 Management of change (MOC).
- FR16: 4.5 Change management and continuous improvement.

Gerhardsen specific documentation

- PAS: 2.2.2 Management system.
- PAS: 6.4 Changes to the project basis.

Comment: ISO 55001 require the organization to assess the risks associated with every planned change before it is implemented. These changes include organizational structure, processes or procedures, AM policy, new assets, supply chain constraints and demands for product and services (ISO 55002: cl. 8.2.2).

The management system's functional requirements in Statoil (FR20: Ch. 3.7) states that management of change (MOC) shall be applied to every change in the organization to ensure

acceptable risk. MOC will also be applied when executing a project in Statoil (FR05: Ch. 2.5.1), and the change consequences (e.g. HSE, risks, quality and regulatory) shall be identified through the whole life cycle of the project. Furthermore, FR16 (Ch. 4.5) sets requirements that include that changes needs to be early communicated to those involved with the change. The consequence for HSE, including consequence for people and the organization, shall be assessed before the change is implemented. PAS (Ch. 2.2.2 and 6.4) states that changes in the Gerhardsen project needs to be handled according to the projects procedures for MOC.

It is clear that Statoil focuses on identifying the risks and consequences of every planned change, and hence Statoil's requirements is consistent with the requirements of ISO 55001 (cl. 8.2).

8.3 Outsourcing

Statoil governing documentation

- FR09: 2 The Supply Chain Management Function
- FR09: 2.3.4.4 Supplier Relationship Management
- FR09: 2.3.4.5 Risk Management
- FR20: 3.4 External requirements and standards.
- FR20: 4.3 Service providers and contractors.
- OMC01-004: 2.4.3.4 Company representative for M&M contracts.
- OMC01-004: 2.4.5 Partner-operated Licences.
- SB: Procurement: We are committed to – p70.

Gerhardsen specific documentation

- OMC63: 5 Integrated Operations (IO) for Gerhardsen.

Comment: ISO 55001 states that when an organization outsources any activity that can have an impact of the AM objectives, the associated risks needs to be assessed. The organization needs to document how these outsourced activities will be controlled and integrated into the AM system. One also needs to determine the processes for information sharing.

FR20 (Ch. 4.3) states that the requirements to how contractors and service providers shall use Statoil's governing documentation needs to be stated in the contracts. OMC01-004 (Ch. 2.4.3.4) require the Statoil representative to administrate the Modification and Maintenance contracts in a way that ensure the interests of the company. The Statoil representative also needs to follow up and ensure Statoil's interests in every DPN partner-operated licences, and understand and manage risks through other operators. FR09 (Ch. 2) states that the mission of the supply chain management is to connect the business with suppliers. Furthermore, the Supply Chain Management function in Statoil will manage their suppliers with a comprehensive approach, continuously develop and improve the processes between Statoil and the Suppliers, and evaluate its external and internal exposure to risk (FR09: Ch. 2.3.4.5). The Statoil Book (p.70)

states that Statoil only uses suppliers who operate consistently with Statoil's corporate values. It is not required to use Integrated Operations in Statoil, however, Gerhardsen's target is to develop a generation 2 type IO. This will ensure information sharing between vendors and Statoil.

The main goal of FR09 is to connect Statoil's business with suppliers and manage the relationship. This is consistent with the requirements in ISO 55001 (Ch. 8.3) as it require the management of the outsourced activities. The knowledge and information sharing aspect in ISO 55001 is handled by Gerhardsens approach to Integrated Operations. The assessment of the risks associated with the outsourced activities is covered by the Supply Chain Management function in Statoil. However, it is difficult to find requirements for competence, awareness and documented information in the outsourced activities in Statoil's governing document (Statoil Book, FR and OMC). The conclusion of this sub-clause is that Statoil is more or less compliant with the requirement in IOS 55001.

9.1 Monitoring, measurement, analysis and evaluation

Statoil governing documentation

- FR06: 3.4 Operation.
- FR06: Maintenance.
- FR09: 2.3.4.1 Master data and best practice performance.
- FR10: 3.6 Performance management and monitoring.
- FR20: 3.11 Monitoring.
- OMC01-000: 4.3 Monitoring
- SB: Monitoring – p43.
- SB: Follow-up – p44.
- SB: Safety: How we work – p57.

Comment: ISO 55001 require the organization to determine what needs to be monitored and measured and the methods required to do so. One also needs to determine when to monitor and when to analyse and evaluate the results. The outcome of the evaluation needs to concern the asset and asset management performance, and the effectiveness of the AM system. ISO 55002 (cl. 9.1.1.2) proposes that the organization should set performance metrics (qualitative and quantitative), assess to which extent the AM policy are met, evaluate compliance with legal and regulatory requirements, and address the quality of financial information.

FR06 (Ch. 3.4, 3.5) states that measures shall be implemented to achieve the operational targets, and the operations and maintenance process shall be monitored by the use of benchmarking, indicators and analyses addressing safety, production efficiency, availability, product quality and cost efficiency. Furthermore, FR06 (Ch. 3.5) require the effectiveness of maintenance to be analysed in order to verify that the maintenance strategy is effective. FR20 (Ch. 3.11) states that risk based monitoring will be conducted to ensure that the management system is effective

and that it is compliant to requirements. The Statoil Book (p.43) explains that monitoring in Statoil is conducted to manage risks and drive performance. Monitoring is about ensuring quality and effectiveness of the business. Regarding safety the Statoil Book (p.57) states that Statoil monitor risks related to the environment, and monitor the occupational health of the employees.

Statoil's governing documentation is addressing the establishment of indicators, the asset performance, the effectiveness of the management system and the compliance with requirements. Furthermore, Statoil monitor processes to manage risk and this is compliant with ISO 55001 (cl. 9.1) requirements. Statoil have a comprehensive approach regarding the monitoring and measurement process and if Statoil implements an AM system, the monitoring processes should already be in place. Especially FR06 shows compliance with ISO 55001.

9.2 Internal audit

Statoil governing documentation

- SB: Monitoring – p43.
- SB: Follow-up – p44.
- SB: Verification – p45.
- SB: Internal audit – p45.
- SB: Control bodies – p 51.

Comment: ISO 55001 states that the organization needs to conduct internal audits to help the organization assess if the asset management system conforms to its own requirements and the requirement of ISO 55001. The Statoil Book (p. 44) states that follow-up activities in Statoil consists of spot checks to ensure compliance with governing documentation. Furthermore, the Statoil Book (p.45) explains that Statoil performs verification to confirm that Statoil's own requirements have been fulfilled, e.g. verifications of products and processes to ensure compliance with standards and requirements. The term internal audit in Statoil can be linked to Management Review in ISO 55001 (Statoil Book, p.45). Bottom line, ISO 55001 require internal audit and Statoil's governing documentation provide internal audit.

9.3 Management review

Statoil governing documentation

- FR20: 3.10 Learning and improvement.
- SB: Follow-up, forward-looking and action-oriented – p32.
- SB: Monitoring – p43.
- SB: Follow-up – p44.
- SB: Internal audit – p45.

Gerhardsen specific documentation

- PAS: 3.3 Project steering committee PSC.

Comment: ISO 55001 states that it is the top management's task to review the asset management system to ensure its sustainability and effectiveness. The review shall include status of previous management reviews, changes in external and internal issues, nonconformities, continual improvement, and changes in the risk profile.

The owners of governing documentation in Statoil shall evaluate the documentation's contribution to safe, reliable and efficient operations. The Statoil Book (p.45) explains that internal audits in Statoil are an independent, consulting activity that is performed to evaluate and improve the effectiveness of Statoil's performance and management system. Top management (e.g. CEO and BoD audit committee) performs the internal audits in Statoil. Internal monitoring in Statoil consists of three categories: follow-up, verification and internal audit (Statoil Book: p.43). Even though none of these monitoring categories can be fully linked to Management Review (ISO 55001: cl. 9.3) by themselves, the categories in combination is compliant with the requirements in ISO 55001.

10.1 Nonconformity and corrective action

Statoil governing documentation

- FR06: 3.4 Operation.
- FR10: 3.8 Nonconformities.
- FR10: 3.8 Incident investigation.
- FR20: 3.9 Manage nonconformities.
- SB: Security: How we work – p59.

Comment: To be an ISO 55001 compliant organization, one needs to react to nonconformities and incidents, take actions to control the nonconformity and deal with the consequences. The organization also needs to consider the need for actions to eliminate the cause of the nonconformity. In addition, the organization needs to document the nature of the nonconformity and the result of the corrective action.

FR20 (Ch. 3.9) in Statoil states that nonconformities shall be identified and handled to avoid recurrences. Furthermore, FR06 (Ch. 3.4) states that if there occur a business interruptions, the root cause shall be analysed and actions shall be taken to prevent reoccurrence. Statoil's governing documentation is quite consistent with the nonconformity requirements in ISO 55001 (cl. 10.1).

10.2 Preventive action

Statoil governing documentation

- FR06: 3.5 Maintenance.

Comment: FR20 (Ch. 3.9) states that nonconformities shall be identified and handled, and FR06 (Ch. 3.5) states that the consequences of failures relating to assets, HSE, systems and production shall be known. There shall be selected failure management strategies for the most serious failure modes. This is consistent with ISO 55001 (cl. 10.2) which require the organization to identify potential failure in asset performance. The Statoil governing documentation is consistent with the requirements in the Preventive action sub-clause in ISO 55001.

10.3 Continual improvement

Statoil governing documentation

- FR06: 3.4 Operation.
- FR09: 2.3.4 Continuous improvement.
- FR10: 3.9 Improvement and learning.
- FR20: 2 The management system function.
- OMC01-000: 4.4 Further development and continual improvement of the management system.
- SB: Safety: How we work – p57.

Comment: ISO 55001 states that the effectiveness and sustainability of asset management and the asset management system needs to be continually improved. OMC01-000 (Ch. 4.4) states that leaders shall ensure that the management system works and is compiled at every level in the Statoil. In addition, FR20 (Ch. 2) states that Statoil shall constantly evaluate improvements to the management system. This is consistent with the requirements in ISO 55001 (cl. 10.3) and this is further backed up by FR09 (Ch. 2.3.4), Statoil Book (p.57) and FR10 (Ch. 3.9). However, even though continual improvement is included in Statoil's high-level documents, it is not always included in the work processes that describe how to actual perform activities in Statoil. Bottom line, Statoil focuses on continual improvement of their management system, and if implementing an asset management system, Statoil simply need to update their procedures to include the AM system.

Appendix E – The NCS and the PSA's responsibility

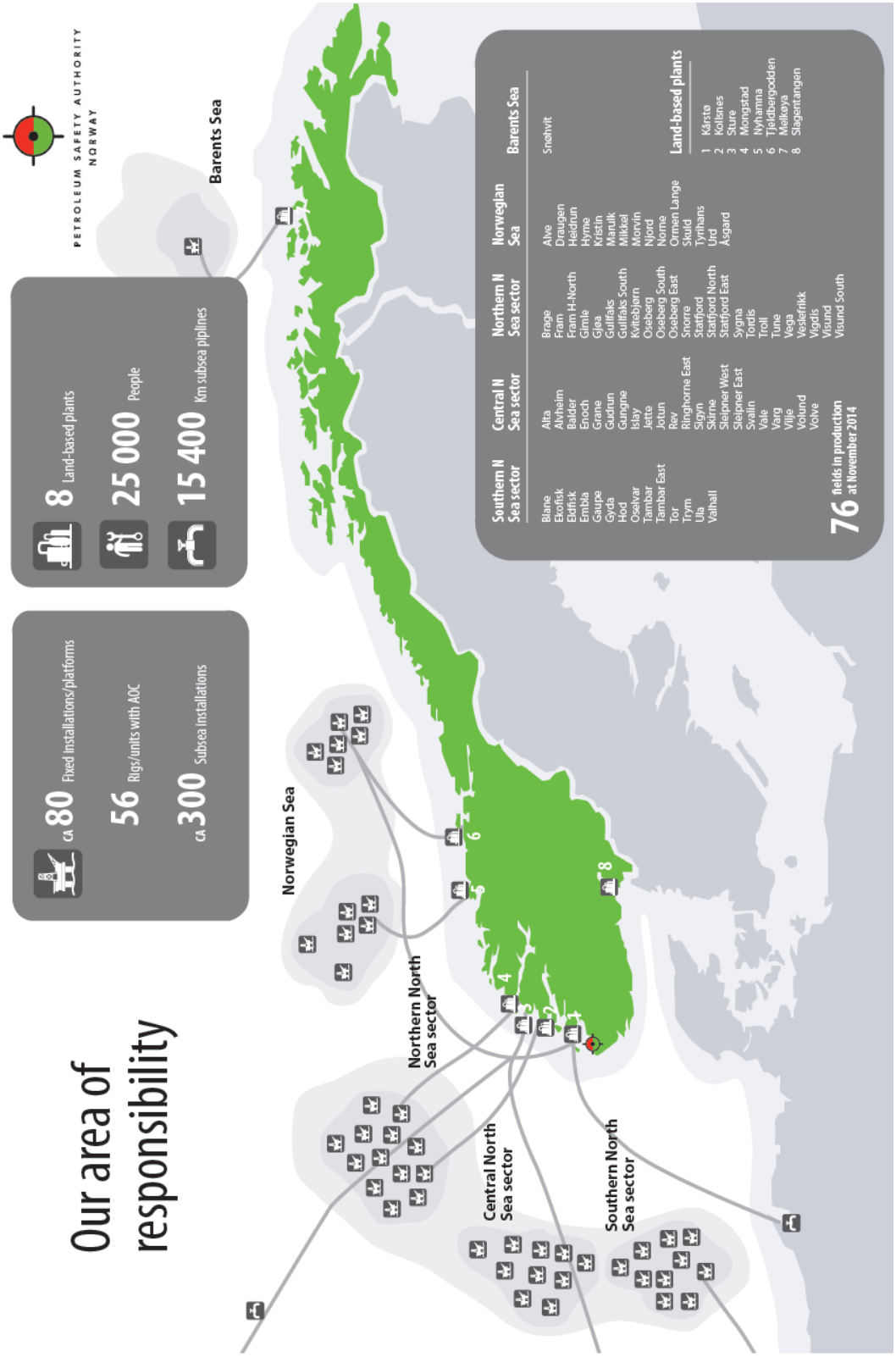

Figure 40 – PSA's area of responsibility (PSA, 2014)