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I. Preface

This thesis was written in 2017 and is based on the thoughts and effort of many people. Therefore I would first like to thank those who have made this thesis possible. A year before the master work started, I knew I wanted to write my thesis in collaboration with Petrolink. Quite some time was spent trying to figure out a good topic that could both be academically relevant for my studies while at the same time being significant for the company.

My gratitude goes to Prof. Jayantha Prasanna Liyanage, my faculty supervisor, for great help in defining structure and direction for the thesis. Furthermore, a special thanks to my supervisor Prof. Jan Frick for providing crucial guidance and support along the way. Also, thanks goes to Jan Verweij, Operations Specialist, Sarah Berge, Senior Process Engineer and Terje Mikalsen, Lead Simulator Instructor in Petrolink for good belief, guidance and sharing of valuable time, knowledge and experience. Also I would like to thank everyone at Petrolink taking part in the interviews. Thank you for your time, interest and your honesty.

This thesis tittle has a challenge connected to it. “Integrated Governance System for a Service Provider: Process orientation and Interoperability with clients, business partners and suppliers” are easy pronounced but it is very difficult in practice. While some have been influential from the start, setting high targets and always expecting more, others have provided great support and backing and a few have kept the fire burning through intermittent words of encouragement and recognition. The road towards completion has been bumpy at times, where challenges have been met, but with great collaboration and help from colleagues, these have been overcome with hard work and expertise. Either if it was answering the questionnaire regarding the business process management system, discussing different issues concerning the topic, proof-reading my work, and/or general motivation to complete this thesis.

Finally, I would like to bring a great thanks to my family being a great support for me, encouraging and believing as well as being patience along the way. Also thank to friends who have supported me and put up with my busy schedule.

II. Summary

Competition in the oil industry is hard and the suppliers to the operating companies live in a world of demanding customers, strong security focus and pressed prices with reduced market volume and reduced margins. Petrolink has grown a lot since year 2000, both due to acquisitions and organic. This has led to increased fixed costs, both in numbers of staff and office rental costs. In recent years, from 2013, the market has become significantly smaller and the company is now taking action to better manage its activities. The company has acquired a comprehensive enterprise management system, which will be used to visualize and optimize the work processes, including integrated functions for competence management and quality improvement. Petrolink believe that Business Process Management (BPM) helps organizations to understand and maintain complicated business workflow.

There are currently many vendors supplying software with systems for analyzing and managing business processes, Business Process Management System (BPMS) (Cantara, Sinur, Hill, & Iijima, 2010). After review and evaluation of various providers, Petrolink decided to invest in software developed by SoluDyne AS. SoluDyne offers a Web-based enterprise management system with modules that can be used individually or integrated with each other as needed. The solution can be installed at the customer or as a hosted SaaS solution. The relevant module from Soludyne in this context is named Advanced Process Oriented Steering (APOS) and has been developed together with, and used by Norsk Hydro Produksjon. This module was also used for some years after the merger of Statoil and Norsk Hydro but are now replaced with Statoils own governing documentation system.

The APOS module ensures compliance with external laws and regulations, standards and requirements in the work processes. Handle all tasks according to documentation management in relation to the work processes.

The core elements of APOS are Work Processes with Roles, Governing Elements, Job Functions, Role connection and Competency Requirements.

SoluDynes starting point is not to be a management tool, which analyzes lead times and tries to remove wastes, or tries to optimize the processes from the top to bottom of the organization. SoluDyne is a comprehensive enterprise management system, but is built to be on the customers

premises; focusing on the execution, i.e. the work processes and the roles. The processes that are modeled must be relevant to those who perform daily work and must be easy to find. Therefore, it is as easy to use as possible, and the system is visualized as much as possible using icons and figures.

The field of study in this Master thesis has been around Petrolinks EMS including the Integrated Governance System in Petrolinks BPM to effectively improve project execution and management in Petrolink. Since the company is dependent on their clients and the ability to deliver competitive services, it is crucial to manage the efficiency, quality and productivity of a delivery.

In order to achieve this without losing contracts to competitors, the company was in need of a tool to effectively improve their business. Implementing a process management system, was consider one step in the right direction in order to successfully manage these factors while also strengthening the organizational structure. Furthermore, you will see Petrolinks definition of clients' different core process phases in the development and in the operations & maintenance process areas together with Petrolinks process for alignment and interoperability with clients' core process phases named integrated governance system for service provider activities. Organizational interoperability is the focus in the project.

In this thesis, the focus has also been on process training simulators, competence requirements and training of the control room technicians. Personnel who have been trained on realistic field situations in a simulation setting will immediately recognize threatening situations, recall procedures and take appropriate actions in the field to safeguard personnel, facilities and other assets.

A digital revolution is underway between humans and machines in the operating environment. Several industries are already in the midst of transforming its business processes to utilize the opportunities of digitization. In the future, a stimulated simulator provides a digital twin representation of the process plant and consists of a duplicate of the production system, non-intrusively integrated with a dynamic process model providing a realistic and accurate digital twin of the facility. It is now becoming possible for machines to automatically initiate control instructions as well as proactively provide information to the control room technicians. Today's buzz word is digitalization; fifteen years ago it was integrated operation. Both are very good initiatives driving the industry to achieve improved efficiency. This revolution will be a game changer and modernize the industry to become a more service oriented industry who will be competency driven. Petrolink will certainly be a part of this future.

When evaluating the degree of goal achievement for the two main goals. The first goal was to analyze the effects of implementing the Integrated Governing System within the areas of Competence Assurance and Simulator Training management in Petrolink. This involved looking at how the employees worked as engineers and managers inside a project and how they interacted with the client when new workflows were presented. It was relevant to see if they would adopt their work in the future in according to the system, or rather neglect it as another irrelevant administrational bogus intranet based management site. The feedback and suggestions from the employees was seen as important to analyze in order to understand what they have previously missed, what they thought of the newly implemented system, and what they thought needed further improvement. After first feedback round, everybody interviewed gave a positive feedback and the simulator group has already started structuring the governing documentation, revising and convert the internal procedures in the simulator center used today to work process and flow sheets. This design work is just started so the completed work will be followed up after delivery of this thesis. The analysis of the answers given from the group can be concluded as very positive. They all agreed they will adopt their work in the future according to the system. In fact, they have already decided to implement and use the system. Everybody believes in an effect increase and will work with the system for gaining this. When Petrolink have implemented the work processes and flow charts into the system and the group has started using APOS, the feedback will be analyzed. Following the Pilot period and if the result are giving an beneficial result, Petrolink will start converting all governing documentation into the system and start measuring the efficiency.

Regarding the second goal of this thesis, that was to analyze the basis for introducing process-oriented management and identify possibilities for increased profitability and efficiency in the start-up phase of a larger project. Process-oriented management adds to continuous improvement, which will lead to a better implementation of activities. The basis organization can benefit from such a tool in their daily work, through reduced costs, higher efficiency and better management of day-to-day activities.

We analyzed the basis for introducing process-oriented management and identified possibilities for increased profitability and efficiency in a start-up phase of a larger project. The project in question was a project where Petrolink delivered among other activities, the initial simulator training of all control room technicians before start-up of the plant. Petrolink delivered on time and on budget on all main activities. Based on these findings it is defined key factors for increased profitability and efficiency. Petrolink will validate the findings when the system is implemented.

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VI. Abbreviations

Master of Science in Technology and Operations Management (MTOM)

Business process management (BPM)

Business Process Management System (BPMS)

Advanced Process Oriented Steering (APOS)

Enterprise Management System (EMS)

Work flow Management Systems (WfMS)

Health, Safety, Environment and Quality (HSE&Q)

Integrated Operations (IO)

Total Quality Management (TQM)

Business Process Re-engineering (BPR)

Enterprise Resource Planning (ERP)

Architecture of Integrated Information Systems (ARIS)

Database Management Systems (DBMS)

Front End Loading (FEL)

Process Flow Diagram (PFD)

Piping and Instrument Diagram (P&ID)

Final Investment Decision (FID)

Hydrocarbons (HC)

Operational Expenditure (OPEX)

Human Resources (HR)

Toyota Production System (TPS)

Plan, Do, Check, Act (PDCA)

European Foundation for Quality Management (EFQM)

Project evaluation and review technique (PERT)

Business Process Model and Notation (BPMN)

Universal Process Notation (UPN)

Organized Job Training (OJT)

Computer Based Training (CBT)

Central Control Room (CCR)

Ultra High Frequency (UHF)

Operator training simulators (OTS)

Distributed Control System (DCS)

Key Performance Indicators (KPI)

Define, Measure, Analyze, Improve and Control (DMAIC)

Augmented Reality (AR)

Information Technology (IT)

Operations Management Systems (OMS)

Norsk Sokkels Konkurranseposisjon (NORSOK)

Artificial Intelligence (AI)

Virtual Reality (VR)

Man Technology Organization (MTO)

Human Factors (HF)

Heat, ventilation and air conditioning (HVAC)

Safety and Automation System (SAS)

Emergency Shut Down (ESD)

Process Shut Down (PSD)

Defects Per Million Opportunities (DPMO)

1 INTRODUCTION

Digitalization, Internet of Things, Big Data, Artificial Intelligence and Virtual Reality are some examples of rapidly developing areas of technology with high impact on how industrial processes will be operated in the future.

Normal operations are usually already highly automated and will be even more automated in the future. Tasks like fault detection, diagnosis and process optimization are becoming more and more complex. Many of those tasks can be best handled by interdisciplinary teams with broad expertise and knowledge about process, plant, operations, maintenance, networks, sensors and actuators. Collaborative process operations make it possible to efficiently bring disciplines together internally to focus on the problem at hand and also bring in vendors and expertise from outside to do interoperability and work smart.

Business Process Management (BPM) can be defined as "supporting business processes using methods, techniques, and software to design, implement, control and analyze operational processes involving people, organizations, programs, documents and other information sources" (Van der Aalst & Van Hee, 2004), and is a management philosophy, not a technology (Hill, Pezzini, & Natis, 2008).

BPM is a field in operations management that focuses on improving corporate performance by managing and optimizing a company's business processes (Panagacos, 2012). It can therefore be described as a "process optimization process". It is argued that BPM enables organizations to be more efficient, more effective and more capable of change than a functionally focused, traditional hierarchical management approach (Ko, 2009). These processes can impact the cost and revenue generation of an organization.

Lately, BPM receives much attention from major operating companies in the oil & gas industry, specialists and scholars alike. Software vendors use the fuzz and provide new labels on new and existing software products; IT-consultancy companies increase their services with BPM consultancy and implementation. BPM and Work flow Management Systems (WfMS) are considered as promising IS/IT strategies. The product is a technology leader within Process Management, focusing on strategic management, process steering, knowledge management, and quality improvement.

Business processes in a business can be divided into two ways; by level or by core competence. By dividing into levels, it distinguishes between operational processes, management processes and strategic processes (Anthony, 1965).

As a policy-making approach, BPM sees processes as important assets of an organization that must be understood, managed, and developed to announce value-added products and services to clients or customers. This approach closely resembles other total quality management or continual improvement process methodologies and BPM proponents also claim that this approach can be supported, or enabled, through technology. As such, many BPM articles frequently discuss BPM from one of two viewpoints: people and/or technology.

The product provides support for the entire organization, from analysis and strategy development to implementation and measurement of results. Mission, vision, strategies, strategic and operational objectives with critical success factors, key performance indicators and action plans are broken down over the overall organizational level into various units.

1.1 Introduction to the Topic

Within the oil & gas industry, the market is constantly growing more competitive, forcing companies to continually adapt to changes. Companies need to remove waste and improve the business efficiency. One way of managing these challenges is to implement an integrated governance system in the organization focusing of the management system implemented and expand this with the element of interoperability with clients, business partners and suppliers together with Lean and Six Sigma thinking.

This project is industry-based and while working with Petrolink, this thesis attempts to address a company need, as well as enhance theoretical and academic learning.

To fulfil the scope and objectives of this project, an in-depth analysis of the subject area was conducted. Reference is given to chapter 5 for the analysis.

1.2 Thesis Structure

This paper is divided into 8 chapters and structured to maintain a good progressive flow of the thesis. This chapter gives a short introduction of what the topic is about, the background of choosing issues and the main goals of this thesis. Chapter two gives a brief view of the theory and fundamentals and explaining the importance of a process management system in a business like Petrolink. The third chapter goes into the depths of the theory covering enterprise management systems, process management, business process management, Business oriented architecture, workflow management system and the ideology behind it. It also present the methodology used during the study and explain why these methods were chosen. The chapter is also the basis for chapter four and five focusing on the results and the discussion. Chapter four and five discuss the methodology described and analyze according to the presented theory. Chapter six discusses the results from the previous chapters and tries to interpret the full meaning of the outcome. Also the methodologic approach will be evaluated by looking at the advantages and disadvantages of the methods used in the thesis. The last two chapters will discuss the theme and draw a conclusion of what was discovered in the thesis and seek a plausible answer to the topic. Furthermore, a list of references used in the thesis and the attachments will be displayed at the end.

1.3 Main Goals

One of the main goals of this thesis is to analyze the effects of implementing the Integrated Governing System within the areas of Competence Assurance and Simulator Training management in Petrolink. This involves looking at how the employees working as engineers and managers inside a project and how they interact with the client when new workflows are presented. It is relevant to see if they will adopt their work in the future in according to the system, or rather neglect it as another irrelevant administrational bogus intranet based management site. The feedback and suggestions from the employees is important to analyze in order to understand what they have previously missed, what they thought of the newly implemented system, and what they think needs further improvement.

Another goal of this thesis is to analyze the basis for introducing process-oriented management and identify possibilities for increased profitability and efficiency in the start-up phase of a larger project. Process-oriented management adds to continuous improvement, which will lead to a better implementation of activities. The basis organization can benefit from such a tool in their daily work, through reduced costs, higher efficiency and better management of day-to-day activities.

This thesis will look at the different perspectives doing plant operation from a central control room, simulation training in a project development focusing on competency build-up and hands-on training to prepare the control room technicians for safe and efficient start-up of the plant and doing re-training in an operational phase with focus on competence stability and experience transfer within the different shifts teams. By doing so, a holistic view of the situation can be analyzed to further understand the correlations of a BPM system between organizational levels, client expectations, simulator responsible and instructors. This might be one of the most important learning, because if the studies show that the simulator section manages to reach a unison understanding of its processes, then a process oriented organization culture can evolve, bringing forth continuous development and improvement suggestions of the business and collaboration with the client.

It will also document how these goals were met based on theoretical literature and a case study. Evidently thesis goals will benefit Petrolink, clients, partners and contractors resulting in reduced costs, higher efficiency, and a better control over its activities.

2 PETROLINK

Petrolink is a leading supplier of asset management and operations services to the oil and gas industry. Through our comprehensive competence and experience we manage and support asset owners and operators in exploiting, enhancing and protecting values. Our track record also includes environmental initiatives, such as operations of facilities for carbon capture and renewables.

2.1 What Petrolink do

Petrolink enhance efficiency and reliability of operations, which in turn will reduce costs, increase production and make operations more predictive. The company pursues high professional standards in all work done with full attention to Health, Safety, Environment and Quality (HSE&Q) matters.

Petrolink services are production operations oriented:

- Accelerate time to production start-up
- Maintain high production performance and production
- Optimize production and improve recovery rates
- Reduce capital and operating expenses, improve safety and environmental performance
- Stimulate collaboration between operator, contractors, suppliers, vendors and other stakeholders
- Speed up information sharing and decision making
- Reduce operational risk and enhance technical integrity

Petrolinks comprehensive operational experience combined with strong engineering capabilities and system understanding provides for practical, user-friendly and cost-efficient solutions. In addition, the company always strives towards higher HSEQ levels, cost optimization and well-tuned interaction between people, organization and technology. The latter is a key driver in our Integrated Operations (IO) and digitalization efforts and offerings.

Petrolink is always ready to assist in maximizing asset values by seeking rational, efficient and robust solutions. Our approach is collaborative by combining client asset knowledge with our own operations experience, proven methodologies and best practices. We work in compliance with national and international rules and regulations as well as relevant standards and guidelines.

2.2 Managements responsibility in Petrolink

The management is responsible and liable for that the quality management system forms the basis for all activities within Petrolink. This includes:

- An active present of a superior engagement to ensure that the quality assurance system is established, implemented and maintained as prescribed
- That internal quality revisions are being executed regularly
- That necessary action is being taken when nonconformity is reported
- Continuous improvements through measuring, evaluation and correction

The management is committed to allocate necessary resources to quality related work, and the management is self-engaged in this work. It is management's responsibility towards the employees to lead thru action, ensuring that focus on quality in all activities in Petrolink has first priority. The management in Petrolink shall make sure and provide for that the quality policy is communicated, understood and followed by all.

Top management in Petrolink shall also make sure that quality bench marks for all relevant functions and levels in the organization are established. The quality bench marks shall be measurable and in line with Petrolinks quality policy.

Furthermore, top management in Petrolink shall make sure that roles and responsibility are defined and communicated throughout the organization, and that an adequate communication process is established.

A simplification of the main aspects of the management system is the 4-element "Plan, Do, Check, Act" approach.

Petrolinks EMS is an electronic system available for all employees on Petrolinks Intranet pages built around Microsoft Sharepoints software and solutions supported with software programs compatible and integrated on the Sharepoint platform .

The System is based upon and fulfils requirements of the following standards:

- ISO 9001:2008 - Standard for quality management systems (QMS)
- ISO 14001:2004 - Standard for environmental management systems
- BS OHSAS 18001:2007 - Standard for occupational health and safety management systems

Petrolinks management system is subject to annual verification and audit by a Certifying Authority. In addition internal audits are executed according to Tenderer's corporate HSE&Q plan. Finally, system verification and audits are conducted by our clients from time to time.

The system certificates (ISO 9001, ISO 14001 and OHSAS 18001) are issued by a Certifying Authority, KIWA Teknologisk Institutt AS.

3 THEORY AND FUNDAMENTALS

It has not been easy to get an overview of all the different directions presented in the literature regarding management systems and work flow management systems, thus to choose which theory to present in this chapter.

3.1 History

From the eighties and nineties, there are two major business trends that relate to BPM: Total Quality Management (TQM) and Business Process Re-engineering (BPR) (Deming, 1982). In the same period there was a rise in the implementation and use of new types of information systems like Enterprise Resource Planning (ERP) systems, Workflow Management Systems (WfMS), advanced planning systems and more. What started as the automation of a company's internal processes soon focused on digitization of supply chains (Davis & Spekman, 2003). TQM and BPR enjoyed widespread attention during the late 1980s and early 1990s before being overshadowed by ISO 9000, Lean manufacturing, and Six Sigma. Today Lean thinking has grown to be the leading systematic change initiative. Lean is defined as a process of eliminating waste with the goal of creating value for enterprise stakeholders. Waste is any activity that absorbs resources and adds no value (Nightingale, 2005).

Since early 1990's, there has been a shift from the agricultural- and industrial- based economy to a more service- and knowledge-based economy (Takala, Suwansaranyu, & Phusavat, 2006). A consequence of this is that we see a huge increase in the proportion of knowledge workers among the labor force. The first author who refers to the term knowledge workers was (Drucker, 1959). He defined knowledge workers as "workers that work with intangible resources". In 1994 Drucker rephrased his definition of knowledge workers to: "high level employees who apply theoretical and analytical knowledge, acquired through formal education, to developing new products or services". Others that refer to the term, knowledge workers are (Bennet & Bennet, 2003). Their definition is: "knowledge workers are individuals whose work effort is centered on creating, using, sharing and applying knowledge". In other words, knowledge work is human mental work performed to generate useful information and knowledge (Kendall, 1999).

The term process comes from the Latin word processus or processioat, which translates as a performed action of something that is done, and the way it is done. A process is therefore, a collection of interrelated tasks and activities that are initiated in response to an event which aims to achieve a specific result for the consumer of the process. Processes are the basis of all activities that involve concepts such as time, space, and motion. A business process, however, is the same as a process, but with one major difference, namely with the emphasis on the word business. Business processes consist of nucleus tasks and activities that are connected with each other, and are categorized and grouped.

Core business processes are the main processes and occur in a far more abstract context as they are utilized to illustrate how a business carries out many different set of operations. These processes consist of minor activities within the business process itself. The minor activities or processes are called sub-processes. Sub-processes can also trigger other processes. In a business process management system such as SoluDynes, the workflow architecture is built to support the Core business processes with management processes and support processes.

In the beginning of 1980's, Professor August-Wilhelm Scheer founded IDS Scheer. The company focuses on BPM and is commonly considered as a frontrunner of today's BPM industry (Rosing, et al., 2015). In 1991, the Company also launched the Architecture of Integrated Information Systems (ARIS) concept. The concept allowed company data to be associated with information flows, function, and control while at the same time being supervised for business clarity and better control within the organization. In 1987, John Sacman, an American business and IT consultant, published his initial framework named "A framework for Information Systems Architecture" (Zachman, 1987).

3.2 Business Process Management

Based on the above it can be stated that the nature of knowledge work is more complex than the type of work that was typical to the industrial age and therefore also more difficult to manage and control.

Even though knowledge work has been a central focus area in both practice and science, many groups are still focusing on constructing more effective business processes by trying to automate step-by-step activities, tasks and processes with BPM-systems based on the old paradigm. However as said by John Seely Brown, "Processes don't do work, people do" (Brown & Gray, 2017). A clear case for more awareness for the way that knowledge work is carried out is made by Keith Harrison-Broninski in his important work, Human Interactions:

The Heart and Soul of Business Process Management (Harrison-Broninski, 2005). In this book, he states that “organizations should be actively engaged in managing the collaboration between knowledge workers within and outside of the organization”.

It started among scholars about whether it is better to gradually improve processes, as is prorogated with TQM (Valentine & Knights, 1998), or to radically change them as is proposed by BPR evangelists Thomas H. Davenport, Michael Hammer and James Champy (Davenport, 1993), (Hammer & Champy, Reengineering the Corporation: A Manifesto for Business Revolution, 1993). It has taken a while before both these methodologies started to get integrated and added to by both science and business. They found that a directed approach and top management commitment, plus the establishment of cross-functional teams, are all critical.

In their review and evaluation of BPM, Lee and Dale found that BPM is intended to align the business processes with strategic objectives and customers’ needs, which requires a change in a company’s emphasis from functional to process orientation (Dale & Lee, 1998). Zairi on the other hand states that BPM is a structured approach to analyze and continually improve fundamental activities such as manufacturing, marketing, communications and other major elements of a company’s operations (Zairi, 1997). This definition is more comparable to TQM than to BPR.

If we look at the given definitions we see a clear evolution from TQM and BPR although later definitions take a more Information Technology related perspective. For example; Paul Fremantle, Sanjiva Weerawarana and Rania Khalaf defines BPM as the systematic automation of ongoing business processes by integrating core systems (Fremantle, Weerawarana, & Khalaf, 2002). This needs a different perspective on software applications, from monolithic to a set of components and services that are then assembled into new processes. Wil M. P. Van der Aalst, Arthur Ter and Mathias Weske find that Business Process Management includes methods, techniques, and tools to support the design, enactment, management, and analysis of business processes (Van der Aalst, Ter, & Weske, 2003). In this way it can be considered as an extension of classical WfMS and approaches.

We realize large changes during the last decades in Information Technology and Information Systems innovations. 50 years ago, when establishments were reliant on computers for a few critical functions, to today’s reality where Information Systems has become a critical information utility we cannot be without. There has been a huge step forward.

One of the most important and foremost innovations is that of Database Management Systems (DBMS). A DBMS is software that permits an enterprise to centralize data, manage it efficiently, and provide access to the stored data by application programs (Laudon & Laudon, 2000). The feature of being able to store and access data efficiently made it possible during TQM projects to make statistic calculations on large available data sets. DBMS were also one of the key enablers behind the development of ERP systems during the late eighties and early nineties.

The essence of an ERP system is to automate all the business processes within an enterprise by handling all data via one database (Ravesteijn, 2011). The data and application layer of ERP systems are separated to be able to easily configure the application to the customers' needs, thus making ERP more flexible. While (Hammer & Champy, 1993) saw ERP as a key-enabler to successfully changing processes and others find that BPR is a key success factor to the implementation of ERP, it turned out that in practice this is a one-time effort. After the implementation of ERP it is very difficult to change or adapt processes. This is why after separating the data and application layer the next step was to separate the business process from the application (Van der Aalst & Van Hee, 2004), which finally resulted in a new type of software product called WfMS that aims at the automation of business management processes.

BPM is an approach to managing processes developed from BPR (Davenport, 1993). BPM attempts to improve processes continuously. It is argued that BPM enables organizations to be more efficient, more effective and more capable of change than a functionally focused, traditional hierarchical management approach.

Hence it is important to understand the relationship between the BPM and Value Chain and how BPM can facilitate creation of an environment that will provide the organization with a competitive advantage through Value Chain Analysis.

Review of various studies within the subject also gives clear trends on the benefits of this approach; Through case studies, quantitative studies and statements, it has been investigated the effect of process-oriented management on organizational performance. Common findings are that organizations get faster improvements, increased customer satisfaction and quality, reduced costs and increased financial performance (Kohlbacher, Gruenwald, & Kreuzer, 2010). Other studies have looked at projects that have failed. Lack of support and understanding of management, expectation of immediate improvements, and focus only on long-term or short-term gains and focus on details instead of the overall picture are moments that can be considered as an initially good project (Ramias & Wilkins, 2011).

If we turn time back a little bit, Michael Porter through his book ‘The Competitive Advantage’ introduced the concept of the Value Chain (Porter, 1985). He suggested that activities that are efficiently managed within an organization will add relative value to the service and products that the organization produces, and all these activities should be run at optimum level if the organization aims to gain any real competitive advantage. If they are run efficiently the value obtained should exceed the costs of running them i.e. customers should return to the organization and transact freely and willingly.

Organizations that want to actively engage in managing collaboration between knowledge workers need to create an (or adjust their) organizational design that is able to support knowledge workers in a proper manner. Enterprise architecture describes in a systematic way the structure of an organization from various perspectives. Perspectives that can be distinguished are: activity architecture, information architecture, data architecture, software architecture and technical architecture (Robinson & Gout, 2007). The first view elaborates on the activities and processes of an organization whereas the information architecture described the information required and generated during the execution of the activities. Supporting the activities, process and information gathering are the software and data architecture; the latter storing the data in such a manner that it can be used by the software, information and activity architecture. An overview of the technical solution making all of this possible is shown in the technical architecture.

3.3 Business Process Management System

BPM often involves software systems that are used to model and visualize processes, associate activities and automation of workflow. Since the year 2000 all these trends seem to converge into new types of information systems, that some call Business Process Management System (Smith & Fingar, 2007). A BPMS can be defined as “a generic software system that is driven by explicit process designs to enact and manage operational business processes” (Van der

Aalst, Ter, & Weske, 2003). Van der Aalst found that Business Process Management includes methods, techniques, and tools to support the design, enactment, management, and analysis of business processes. In this way it can be considered as an extension of classical WfMS and approaches. In these definitions BPM clearly is based on the industrial-based view of the economy in which activities and processes are clearly defined and standardized as much as possible. Based on the current status of many BPMSs it is possible to conclude that a BPMS solution needs to be able to analyse and model processes within and across organizational boundaries, execute the modelled processes, measure their performance and use this as an input to optimization. This in essence means that support of processes by a BPMS starts in the design phase.

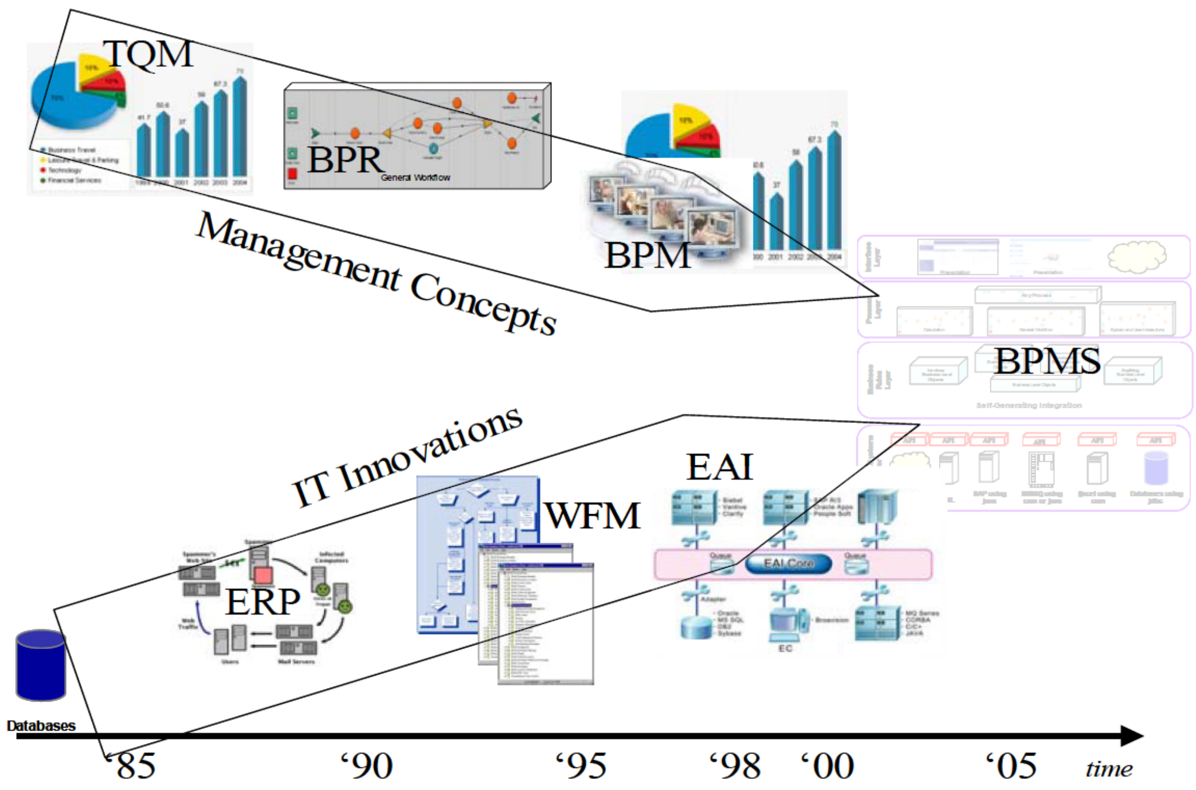

Figure 1 – Emergence of Business Process Management Systems (Ravesteijn, 2011)

A BPMS is a set of information system technologies for improving productivity, efficiency and management of business processes. In this perception, the information system is defined as a combination of software, data and technical structure. The functionality of a simple system is mainly analyzed by object-oriented or structured analysis of the current system, while context architecture is often the result of domain analysis. The domain analysis executed follow Arango's methodology by first studying existing BPMS reference architectures after which the bottlenecks/gaps and the sources of these gaps are recognized. The last step is to identify which of the existing architecture can be reused and which additional architecture is needed to close the identified gaps. Providing structure and internal validity the technology-to-performance chain defined by (Goodhue & Thompson, 1995) is used as for method for analyzing bottlenecks.

The last, and with regards to the domain analysis most important, category is literature discussing overall BPM system reference framework. There is a limited amount of research available that in a sophisticated manner analyzes BPMS reference architectures. (Shaw, Holland, Kawalek, Snowdon, & Warboys, 2007). In the same paper, the authors propose a BPMS reference framework: the BPMS pyramid architecture. Existing out of twelve different building blocks the framework indicates three different components within a BPMS.

A software application is a necessity for a BPMS model because for the model to be exactable it has to be modeled in a medium that allows the subject and the model influence each other as part of the same system. BPMS have access to the elements of BPM tools such as: a library of best practice business processes; manual graphical manipulation of configurations; automated change of application configurations; links to communications systems; and possibly, integrated project management and change control (Holland & Kelly, 2002). BPMS can be designed to automatically choose between process reconfiguration options as well as to facilitate manual choice. The blocks below software application signify that the software application that runs the BPM in a BPMS requires both a technical architecture to enact the model on and a software language that encodes the model in a form that is executable on a technical architecture.

4 METHODOLOGY

Continuous improvement is the main focus for optimizing processes, improving products and correcting the causes of defined problems. Once you have established a stable operation you must use continuous improvement tools to determine the root cause of inefficiencies and apply effective countermeasures.

One of the choices is to use Six Sigma who is a very rigid methodology. There are many versions of Six Sigma today, but the common denominator is often a "need" for black-belt specialists who lead the process of improving the processes (Rummler, Ramias, & Rummler, 2009).

A detailed academic literature review through the University of Stavanger library services, online journals and papers was done early in the project. See chapter 5 for a comprehensive view and analysis of the literature review.

In terms of the empirical study, it was imperative to review company requirements in contrast to the empirical evidence of those actually involved in performance management in the company. To get this breadth in opinions and variety of context, the first step was to research governing documents, functional requirements and work processes related to performance measurement and management. This was followed by interviews with simulator instructors and project managers in Petrolink. The first turned out to be an especially valuable source for understanding the practical application. This thesis will also, as a case study, analyze how Petrolink implement and handle competence and training of control room technicians with use of a process training simulator in a project development phase including development of the simulator training program versus in an operational phase and the effects this has on the simulator instructors.

To do so Petrolink have tested out the enterprise management system from SoluDyne and their Business Process Management System named Advanced Process Oriented Steering (APOS). The business concept for APOS is to improve the steering and control of your own business. This is achieved by applying the company's Best Practices for the selection of methods and managing requirements.

4.1 Governing documentation and Management processes

This thesis will, as a case study, analyze how Petrolink implement and handle competence and training of control room operators with use of a process training simulator in a project development phase including development of the simulator training program and maintenance of the simulator versus in an operational phase and the effects it has on the instructors and maintenance personnel.

To do so Petrolink have tested out the EMS from SoluDyne and their BPMS named Advanced Process Oriented Steering (APOS). The business concept for APOS is to improve the steering and control of client business. This is archived by applying the company best practices for the selection of methods and managing requirements.

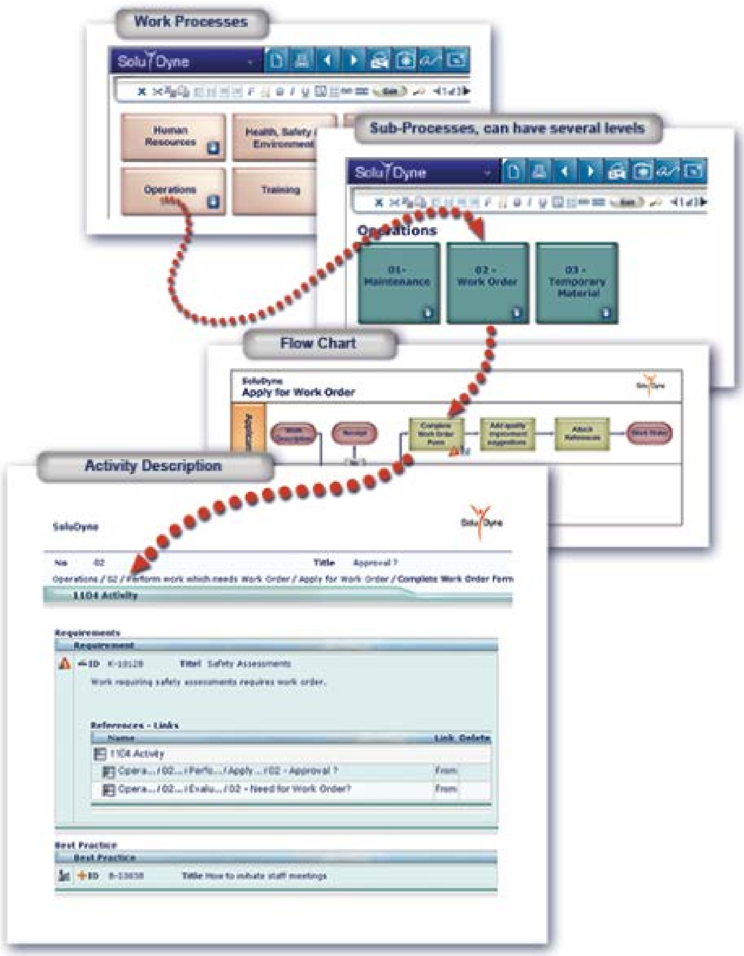

Figure 2: Advanced Process Oriented Steering (Soludyne, 2017)

Based on the definition of the Petrolink governing documentation system, the system ensures standardization and the deployment of best practice across the company. The governing documentation system is a set of principles, policies, and work processes used by the organization to ensure that it can fulfill all tasks required to achieve its objectives.

Main objectives are to:

- contribute to safe, reliable and efficiency in the organization enable us to comply with customers' requirements
- support business performance through high-quality decision making, fast and precise execution, continuous improvement and continuous learning.

Petrolinks governing documentation system ensures that the work processes are focusing on the core value process supported by the supporting processes management and support. All work processes have their own process areas with sub processes and flow charts.

4.2 Core Value Process

The Core Value Process is intended to give relevance to Front End Loading (FEL). FEL is, in simple terms, the practice of taking sufficient time in the early phases to properly assess the opportunity and to identify value drivers, risks and uncertainties prior to committing to major expenditure.

The first three phases focus on value identification to ensure that the "right Project" is selected, which will in turn maximize the Project's value. In these early phases the potential to influence value is high and changes to Project set-up can be made with a considerably smaller effort than in the execution phase.

The last phases focus on value realization where the defined actions must be executed efficiently. As the Project is already defined, only minor improvements to the value created by the Project can be achieved.

4.3 Decision Gates

Gates are milestones placed at the end of each phase, where a key management decision is required before an opportunity/ project can progress. Gates provide an appropriate level of control and value improvement for Projects to ensure that:

- Only realistic Projects that can be proven economically are progressed, ensuring the best utilization of Company resources
- Projects maintain or improve their stated targets, improvements can be detected at an early stage and action measures can be put in place
- Value is protected by ensuring appropriate FEL

Gates facilitate the decision driven philosophy, focusing work on providing the elements to support decision-making, rather than on the completion of peripheral activities.

In addition to end of phase gates, there may be specific cases where intermediate decision events within Project phases are required if circumstances justify it and the associated risk has been identified and accepted (e.g. decisions for anticipating the procurement of long-lead items, or scheduled investment decisions required by contractual commitments with Partners and/or Governments, occurring before the end of a phase).

4.4 Client Core Process Phases

Petrolink have, as part of this thesis, compiled the Client Core Process Phases in the Development and Operations & Maintenance process area. The core process is divided into 9 phases. The Client Core Process phases are the decision process for investment projects and are a structured and comprehensive approach to project identification, planning and execution.

Each phase has its own set of activities and deliverables. The phases are:

- Evaluation including Appraisal
- Concept Selection
- Definition
- Execution
- MC & Pre-commissioning
- Commission
- Start-up and Production Stabilization
- Production Operations & Optimization
- Production Operations and Preparation for De-commissioning

4.4.1 Evaluation including Appraisal

The Evaluation phase targets the economic assessment of the opportunity. The discovery results are analyzed and elaborated to prepare reservoir models, identify the preliminary development concept alternatives and quantify the expected economic value. See Attachment 1 for Mandatory activities and deliverables.

The project should demonstrate that opportunity development is economical and in line with Company Strategy:

- Project scope & objectives should be clearly defined
- The main outstanding uncertainties should be identified and their potential effect investigated
- A wide set of preliminary alternatives should be evaluated using a multidisciplinary approach

During the Evaluation phase, appraisal activities could be started in order to further investigate whether the asset development meets Company economic value requirements.

The need for appraisal activities is assessed by the Project Manager and supported by the Project Team, on the basis of the Asset Value Potential. See Attachment 1 for Mandatory activities and deliverables.

At the end of this phase, the Decision Support Package for Decision Gate 1 (DG1) is prepared and delivered to the Gatekeeper for review of the Project recommendations and deliverables and decides the course of action. Two main scenarios can be encountered:

- High potential asset: in this case the asset is clearly above the minimum expected profitability level; appraisal activities should be initiated within the Evaluation phase and can be useful to support the Concept Selection phase
- Low potential asset: in this case it is not evident whether the potential of the asset is above the minimum profitability level; appraisal activities are critical to respond to Gate 1 and have to be completed before accessing the Gate

The review is to address compliance with the principles of the Directive on Capital Project Management and two distinct overarching questions:

- Do we understand what we are getting ourselves into?
- Have we looked wide enough at our options and at possible outcomes regarding uncertainties

we do not control?

The review is to take a full perspective (technical, economic, commercial, organizational /operational and (socio-) political) in addressing the following:

- The business case for undertaking the project.
- The "license" of the project, i.e. its alignment with Corporate Strategy, Corporate Directives and (local) legislation.
- The "frame" of the project:
    - The option table of the project
    - The outcome table of the project

While the decision making process looks at the overall Project lifecycle to understand its value, The gate approval commits funding and resources only for the next phase and until the next gate is reached.

4.4.2 Concept Selection

The primary objective of the Concept Selection phase of a development project is the identification of the optimal development concept, i.e. the technically feasible asset development solution that maximizes project value. See Attachment 2 for Mandatory activities and deliverables.

The project should demonstrate that the optimal development scheme has been selected showing the rationale behind concept alternatives generation and selection:

- Business objectives, requirements and constraints in Concept Selection should be highlighted
- A set of comparable and distinguishable alternatives should be generated
- Each concept should be developed and evaluated with a multidisciplinary approach
  The economic accuracy of the selected concept should be ±25%

At the end of this phase, the Decision Support Package for Decision Gate 2 (DG2) is preferred. The review is to address compliance with the principles of the Directive on Capital Project Management and one overarching question:

- Have we selected the best concept with the best associated strategies?

The review is to take a full perspective (technical, economic, commercial, organizational

/operational and (socio-) political) in addressing the following:

- The business case for undertaking the project
- The "license" of the project, i.e. its alignment with Corporate Strategy, Corporate Directives and (local) legislation
- The continuum in logic from the previous phase
- The quality of each proposed conceptual decision
- The completeness of associated strategies.
- The realism in the range of expected outcomes.
- Technology development.
- Project specification (i.e. PFD´s, P&ID's, feedstocks/products specifications etc.).

4.4.3 Definition

The primary objective of the Definition phase of a development project is the refinement of the development concept and preparation of project plans to ensure a successful execution. See Attachment 3 for Mandatory activities and deliverables.

The project should demonstrate that asset development and project execution have been thoroughly defined and the relevant activities planned to support final project sanction:

- A coherent development strategy should be fully defined considering all project aspects
- Detailed plans for execution should be prepared to ensure project coordination and alignment with business objectives
- Major contracts should be ready for award immediately after project sanction
- Project economic accuracy should be ±15%

At the end of this phase, the Decision Support Package for Decision Gate 3 (DG3) is prepared and delivered to the Gatekeeper for review of the Project recommendations and deliverables (Decision Support Package) and decides the course of action.

The review is to address compliance with the principles Directive on Capital Project Management and one overarching question:

- Have we put everything in place to ensure success? Is the project ready for the Final Investment Decision (FID)?

The review is to take a full perspective (technical, economic, commercial, organizational /operational and (socio-) political) in addressing the following:

- The business case for undertaking the project
- The "license" of the project, i.e. its alignment with Corporate Strategy, Corporate Directives and (local) legislation
- The adequacy of the project specification
- The resourcing of the schedule
- The availability of permits, infrastructure and logistics
- The alignment of stakeholders and availability of skills and numbers of the team
- The completeness of the execution strategies and all plans
- The accuracy of estimates of costs, time and risks

4.4.4 Execute incl. Pre-commissioning and Commissioning

Development and Operations is regulated through the Handover Process. Once the decision to execute the Project has been made at the Project Sanction Gate, it is a given fact that at some later date the Production phase will be entered to. See Attachment 4 for Mandatory activities and deliverables.

At the end of the Execution phase a package of facilities completion data, certification and consents and approvals must all be in place and deemed suitable prior to commissioning and production start - up. The composition of this data package (Handover Package) and the formal process for Hand - over will be Project specific, and will depend on technical, Contractual and Authority requirements.

The process of Handover starts with the endorsement of the Handover Package by Operations and it ends with the Acceptance of facilities and wells and the assessment of the operations crew. The Commissioning Team is in charge for carrying out handover activities. The level of involvement of both Development and Operations personnel in the Commissioning team during the handover process is variable and strictly related to work progress. Before the introduction of Hydrocarbons (HC), all activities are carried out under Development responsibility while after the introduction of HC into facilities (HC in):

- • Operations Manager has the responsibility for the commissioned system(s) / unit(s) / area(s)

- • Continuous Production Operations Processes are started, wells and facilities are brought into production

Costs directly related to Production Operations can be technically accounted as OPEX and Hydrocarbons are sold generating revenues.

At the end of these phases, the Decision Support Package for Decision Gate 4 (DG4) is prepared and delivered as part of the Handover package to Operations.

The review is to test the readiness of people, hardware and systems for the introduction of hydrocarbons or being energized. In order to protect people and assets as well as the environment, the approach of the review is more strict and formal than other gate reviews; this review is more like an audit.

Verification of compliance on paper should be accompanied by verification on site, complete with spot checks.

The review is to take a full perspective (technical, economic, commercial, organizational/ operational and (socio-) political) in addressing the following six “chapters”:

- Project and Asset Management
- Healt, Safety, Security, Environment and Hazard Management
- License to Operate
- Operability and Maintainability
- Risk Management
- Audit and Review

4.4.5 Production Operations & Optimization incl. Start-up and Production Stabilization

The First Period Production phase is characterized by the ramp up of production rates up to stabilized and repeatable conditions such that sufficient data is available in order to evaluate the Asset and commence continuous operations. During First Period Production continuous processes take place and discrete processes are activated in order to resolve problems and to check operations consistency. See Attachment 5 for Mandatory activities and deliverables.

Continuous production processes include both specific and support production activities. Wells are progressively tied-in and the Development Project Manager sanctions Project Close Out.

Discrete processes are run in order to correct abnormalities, to activate troubleshooting and to check operations consistency. The activation of discrete processes can be triggered by two possible events: Warnings and Production Checks.

A Warning occurs when the existence of a problem is detected during production. This might require different types of intervention, depending on the level of complexity of the encountered problem and the need for professional areas studies.

Production Check (Time limit to Gate) takes place whenever the set period for criticality verification is over. Production check gives start to a discrete process for the technical and economic Asset evaluation that leads to Gate 1 through an Asset Assurance Review.

At the end of this phase, the Decision Support Package for First Period Gate (Gp1) is prepared and delivered to the Gatekeeper for review of the recommendations and deliverables (Decision Support Package) and decides the course of action.

First Period Gate is not strictly speaking a gate review. It is conducted when the operate phase is considered to have achieved 'steady state' and before the project management team is demobilized. The thinking is all about:

- Is the technical and economic evaluation based on appropriate and precise data?
- Are full life targets (OPEX, Production Profiles, HSE&Q, HR) consistent with the same as defined at gate 3?
- Is the evaluated baseline (OPEX, production profiles) still in line with the Company objectives?
- Are HSE objectives met (safety standards, emissions…)?
- Is the organization in line with production objectives?
- May improvements/ new development projects be activated to increase Asset value?
- How has the Development Project been integrated in the Existing Asset

The objectives for Gp1 are:

- To establish whether the development project has reached its sanctioned technical and management objectives

- To set the reference overall Asset baseline (integration of project in the existing Asset) in terms of economic value (production profiles, OPEX, reserves), HSE and HR objectives

Key Gate questions to be evaluated are:

- Has the production baseline been consolidated in terms of OPEX, production profiles, HSE, HR, etc.?
- Is the production baseline (OPEX, production profiles) acceptable?
- •Are HSE objectives met (safety standards, emissions…)?
- •Is the organization in line with production objectives?
- • What is the status of commercial and legal agreements?
- • Are service contracts in line with production, maintenance and well operation needs?
- • Have all the mandatory Assurance Reviews been conducted?
- • Are stakeholders aligned with the proposed baseline?
- • May improvements/ new development projects be activated to increase Asset value?
- How well does the installed hardware live up to our expectations?
- Any specific lessons on (new) technology?
- Reservoir performance: How do the wells and reservoir perform compare to the plan?

4.4.6 Production Operations and Preparation for De-commissioning

The Production Operations and Preparation for De-commissioning phase starts once the Asset baseline value has been defined. This phase is typically related to the longest period of Asset lifecycle, when Operations Manager manages and optimizes production given changes in reservoir conditions (pressure & produced fluids), facilities conditions, organization, HSE requirements and regulations, etc. See Attachment 6 for Mandatory activities and deliverables.

Continuous production processes are focused on managing the Asset to maximize its value through continuous improvements. As in the previous phase, Warnings and Production Checks give start to discrete processes. Activities following a warning are structured in the same way as in the previous phase. The main difference being in problem characteristics and is often related to the management of changes due to Asset ageing.

Production Checks represent the start of sequential checking activities aimed at evaluating overall Asset value or specific processes (HR, HSE&Q, etc.). Following each evaluation process, Production Management verifies whether the Asset is still of value to the Company and what improvements, if any, are possible. Depending on the outcome of Asset evaluation, improvement initiatives might be adopted.

Possible improvements include:

- New Development Projects
- Optimization interventions

In case the Asset is no longer valuable to the Company and its value cannot be enhanced through improvements, following an Assurance Review, a decommissioning proposal is submitted to the gate.

At the end of this phase, the Decision Support Package for De-commissioning Gate (Gp2) is prepared and delivered to the Gatekeeper for review of the recommendations and deliverables (Decision Support Package) and decides the course of action.

De-commissioning Gate is not strictly speaking a gate review. It is conducted when the operate phase is considered to have achieved 'steady state' and before the project management team is demobilized. The thinking is all about:

- Has the residual economical life been correctly evaluated?
- Are Company stakeholders aligned with the decommissioning proposal?
- Are all existing obligations and contracts been considered?
- Have the commercial and legal implication derived from agreements been evaluated?
- Is the decommissioning budget in line with the abandonment fund?

The objectives for Gp2 are:

- To define residual Asset life, based on:
    - Residual Theoretical Production
    - Residual economic producing life
    - Laws and regulations affecting approval by authorities
    - Constrains for dismissal of HR
- To sanction facilities and wells decommissioning

Key Gate questions to be evaluated are:

- Is decommissioning decision consistent in line with Internal strategy?
- Are stakeholders aligned with the decommissioning proposal?
- What is the status of obligations and contracts, in consideration of the decommissioning proposal?
- What is the status of commercial and legal agreements?
- Is the estimate of decommissioning cost in line with the updated abandonment fund?

4.5 Management Methodologies

Six Sigma is a structured, data driven methodology for eliminating waste from processes, products, and other business activities while having a positive impact on financial performance.

The Six Sigma concept was developed by Motorola as a quality practice. The name refers to the goal of reducing the number of defects to six times the standard deviation. All improvements are being made based on the needs of process customers, which may be internal and external. An important point is that the methodology is suitable for improving both formal and non-formal processes. Six Sigma has found to be effective in all sorts of enterprises and organizations (Snee & Hoerl, 2003). The concept consists essentially of four steps; gather management on the right goals, mobilize improvement teams, accelerate improvements and manage lasting improvement. Implementing and use of Six Sigma often requiring a major cultural change in the organization, and that data collection and analysis are often challenges,

Another key methodology is the concepts of lean, including work processes by direct observation of work activities, studying work flow, and examining processes to systematically are about eliminating wasteful activities. The Lean principles look at the great whole and try to identify activities that do not provide value creation and eliminate as many of them as possible.

Toyota Production System (TPS) was brought together as a management system in 2001, named the Toyota Way. Lean thinking and Lean as a management philosophy comes from the manufacturing system of the automotive manufacturer Toyota, and can bring big savings in the number of treatments, costs and time. This involves changing perspectives from looking at isolated departments, activities and roles to see the entire value chain for the product to the customer by observing practices that were delivering superior performances. (Sayer &

Williams, 2007).

Lean is a process of eliminating waste with the goal of creating value for enterprise stakeholders. Waste is any activity that absorbs resources and adds no value. Today Lean thinking has grown to be the leading systematic change initiative as described by Professor Deborah Nightgale at MIT. (Nightingale, 2005).

Types of waste are:

- Mistakes which require recertification
- Production of items no one wants
- Processing steps which really are not needed
- Employee or goods movement/transport from one place or another without any purpose
- People in downstream activity waiting because upstream activity has not delivered on time
- Goods and services that do not meet the need of customer

The term kaizen also comes from Japan, meaning directly translated "change for the better", i.e. improvement. Kaizen is associated with continuous improvement (Imai, 1986); all aspects of an organization can be improved and it can always be better. Kaizen can be summed up as "continuous improvement of everything, at all levels, constantly, forever" (Goetsch & Davis, 2016). Tools used for continuous improvement are Kaizen checklist, five-step plan and five-M checklist. Kaizen's Continuous Improvement process is also defined as one of the 14 principles of the TPS.

TQM with its house of quality, Industrial Engineering tools such as linear programming and Monte Carlo analysis, The Plan, Do, Check, Act (PDCA) Cycle, The European Foundation for Quality Management (EFQM) Excellence Model, Quality Engineering practices and project management principles are all tools involved with the implementation of the TQM concept in organizations.

Methods offered in the marked today are typically; process charts, functional flow diagrams, Project evaluation and review technique (PERT) analysis, data flow diagrams and integrated definition methods.

BPR was conceived by Dr. Michal Hammer, a former professor of computer science at the

Massachusetts Institute of Technology (MIT), as he presented the BPR concept (Hammer, 1990). The idea is to see all activities that lead to a product under one; focus on the outcome and what needs to be done to get there (Wolf & Harmon, 2010). It involves mapping processes in the organization, so to separate what can be improved. The graphic production is the key to focusing on business processes.

4.6 Advanced Process Oriented Steering

The APOS module is the main component of SoluDyne, and is a tool for describing what to do and how to do it. Continuous improvement of Best Practice is the business concept for APOS. Companies with large areas of activity have historically allowed wide individual freedom to develop local standards and methods. The performance of a joint activity for the entire company will therefore normally have different local varieties. The variations increase with the number of businesses one operates. E.g.: Previously, Norsk Hydro's production platforms all had different local methods for entering turbine housing while it was operating. Now they have only one common method of entry.

Wide variation in Requirements and Methods for repeatable activities has normally led to increased resource use for control and follow-up – The scope of the control simply becomes too large.

The business concept for APOS is to improve the steering and control of your own business. This is achieved by applying the company's Best Practices for the selection of Methods and managing Requirements. There is considerable evidence of improvements in the industry based on developing a Best Practice.

APOS is a graphical representation for specifying business processes in a business process model based on the BPMN standard (OMG, 2014) and (Recker, 2008) but is simplified to make it's easier to understand. APOS is built on several levels; at the top lies the main process of management processes and support processes, with several levels of sub-processes describing the processes in greater detail. The sub-processes are visualized in flow charts, which show the activities and choices that are part of the process. The flow chart is divided into roles, which link activities against the various roles in the organization. Some believe this is an inappropriate representation, such as Mike Gammage (Gammage, 2011), and there are alternative solutions like Universal Process Notation (UPN) (Tibco Software Inc., 2017). In roles, related tasks and responsibilities are clearly displayed to get the most unambiguous understanding of the process. The lower level is the management elements, and consists of requirements, best practices and local additions (adaptations that apply to certain projects), in addition to competence requirements and governing definitions. Relevant requirements and best practices will be linked to the activities for equal practice for all who will perform the activities. One of the purposes of such a system is also to ensure the most standardization and equalization of activities.

APOS benefits that one can manage the business through joint work processes regardless of organization, with the user in the center; it is easy to find out their work processes with corresponding requirements and best practices. APOS is also an effective tool for transferring experience and developing best practices. APOS highlight the interaction, roles and responsibilities of an organization, and provide a common platform for improvement.

4.7 Competence Assurance

A systematic strategic planning approach, which is firmly grounded in reality, is an essential requirement for long-term corporate success (Grünig & Kühn, 2011). One of the important concepts which unify between strategic planning concept and performance management concept is integrated performance planning. Integrated performance planning is a holistic process based approach by which an organization defines its future state or a vision of the future. This concept emerges as the recent organizations realize that the condition of business becomes more dynamic, higher price volatility, higher uncertainty of supply and demand, shorter market lifecycle, harsher market competition, and fast-growing technology. In addition, it also plays key roles such as providing guidelines for each of the decisions to ensure the actions taken are aligned with corporate strategy, creating commitment to organization members to work through the same direction/ objectives and becoming a yardstick to manage the future performance of organization. In this thesis the focus is on the areas of Offshore Control Rooms, Competence Assurance and Simulator Training. Petrolink offer custom-made courses and programs to make training flexible and efficient. The training may take place in-house or at customer's facility. The training services ranges from familiarization courses within production operations to full organization of competence assurance, gap analysis and training plans and programs, leading to fully trained and competent process plant operations personnel.

Methods applied include traditional process classroom training, Organized Job Training (OJT) program, simulator training, Computer Based Training (CBT), and comprehensive follow-up including evaluation and recommendations to maintain and develop new capabilities. Combination of theoretical, practical and simulation training has proved to be both cost-efficient and time-saving. Our experience provides for earlier plant start-up, optimized operations, improved regularity and thus reduced production-loss due to down-time, and fewer system failures caused by operator errors. Process simulator training may be provided on Petrolinks' generic process simulator or on in-house customer specific simulators.

4.8 Training Simulators

Training Simulators are used to provide realistic operator training in a realistic plant training environment. Training simulators uses the actual control and safety applications of the plant, running in operator stations. Plant models simulate the feedback from the plant in real time or fast/slow motion. The training simulator applications include functions for backup and reload including recreation of historical information and snapshots. Dynamic process simulators in the process industry have a wide range of use and are an important tool for such as:

- Providing knowledge to the users
- Maintaining competence through training
- Training emergency situations
- Stress handling
- Team training
- Preparing for abnormal operational actions
- As an engineering tool

In the oil, gas and energy sector, the use nearly occurs for the mentioned means without exceptions. The simulators are with advantage build in facilities similar to the central control room and it is meant to serve as a training tool, this with an exception regarding the engineering tools. The engineering tools are often models used without regard to the facility.

Training Simulators are used to provide realistic operator training in a realistic plant training environment. Training simulators uses the actual control and safety applications of the plant, running in operator stations. Plant models simulate the feedback from the plant in real time or fast/slow motion. The training simulator applications include functions for backup and reload

including recreation of historical information and snapshots. Offsite training facilities can be connected to the live plant to give information from the real operating situation.

The use of simulators has its benefits throughout the whole carrier of a process technician working in a control room. From the start of a career as a central control room technician, it has means for applying the correct behavior and knowledge. For the experienced technician it plays a role in training and maintaining the level of competence. It serves also as an important tool for training in handling critical situations and preventing major accidents at all times.

5 ANALYSIS

Since the company is dependent on their clients and the ability to deliver competitive services, it is crucial to manage the efficiency, quality and productivity of the deliverables.

5.1 Management Systems

In order to achieve this without losing contracts to competitors, the company was in need of a tool to effectively improve their business. Implementing a process management system, was consider one step in the right direction in order to successfully manage these factors while also strengthening the organizational structure. See figure 2 below for a picture from Petrolinks BPMS with main work processes shown, supported by management processes and support processes.

Furthermore, you will see Petrolinks definition of clients' different core process phases in the development and in the operations & maintenance process areas together with Petrolinks process for alignment and interoperability with clients' core process phases named integrated governance system for service provider activities. Reference is given to methodology chapter 4.4 for a description of the different core process phases.

Figure 3 shows a drill-down of the study case, simulation training from OR&A / Preparation for Operations activities within Petrolink divided into the different core process phases in the development process area at client. The red arrows show the study case, where the training frame is set in the operations philosophy document as early as in the evaluation phase. In the concept selection phase the training simulator is described as part of the operations philosophy document and in the definition phase the simulator is a natural part of the competence assurance and training plan document. Early in the execute phase followed by a detailed operational training development activities followed by the execution of all simulator courses defined securing a safe and efficient start-up of the process plant.

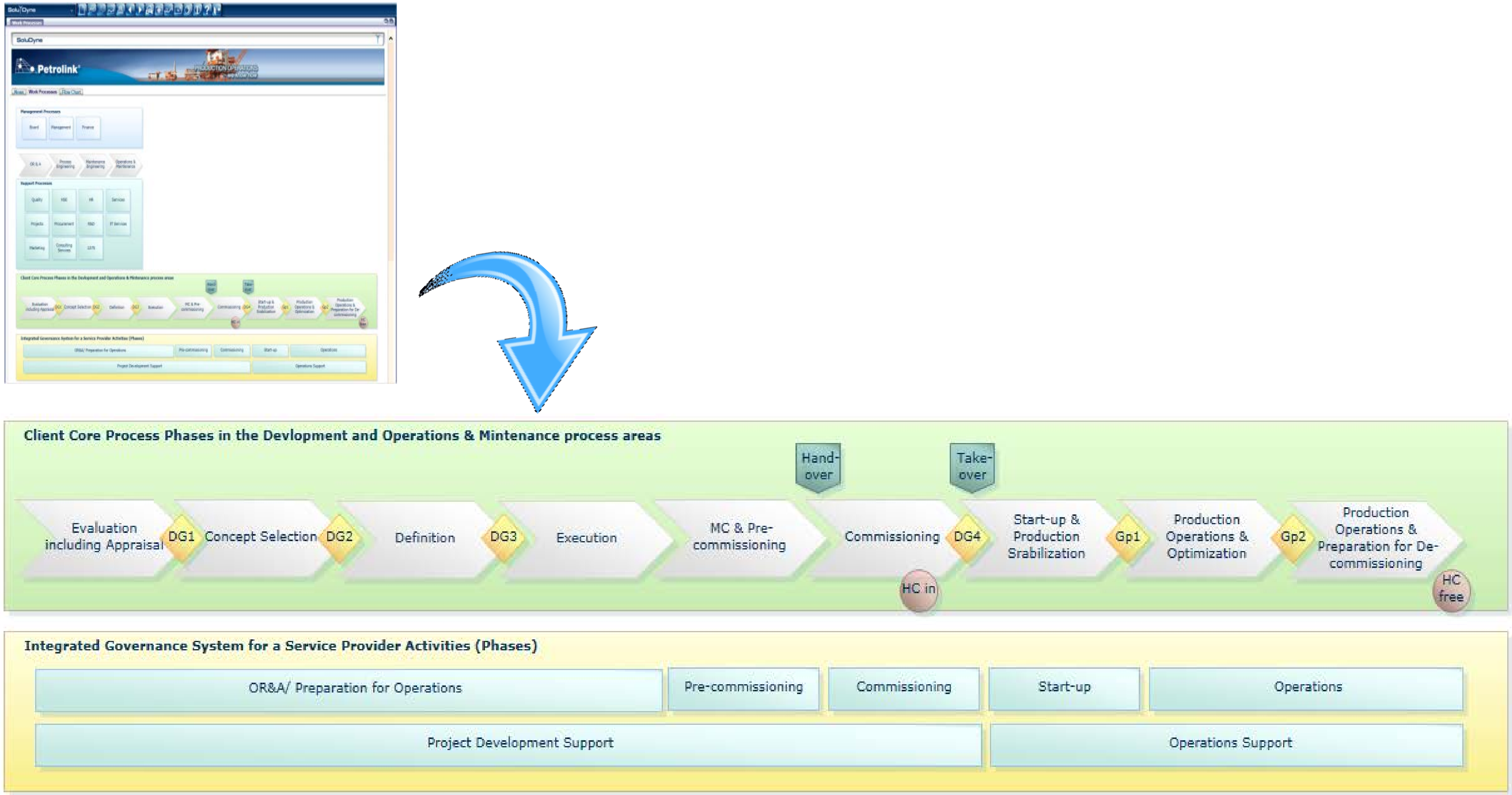

Figure 3: Client Core Process Phases and Integrated Governance System in the Development and Operations areas (Nedrum, 2017)

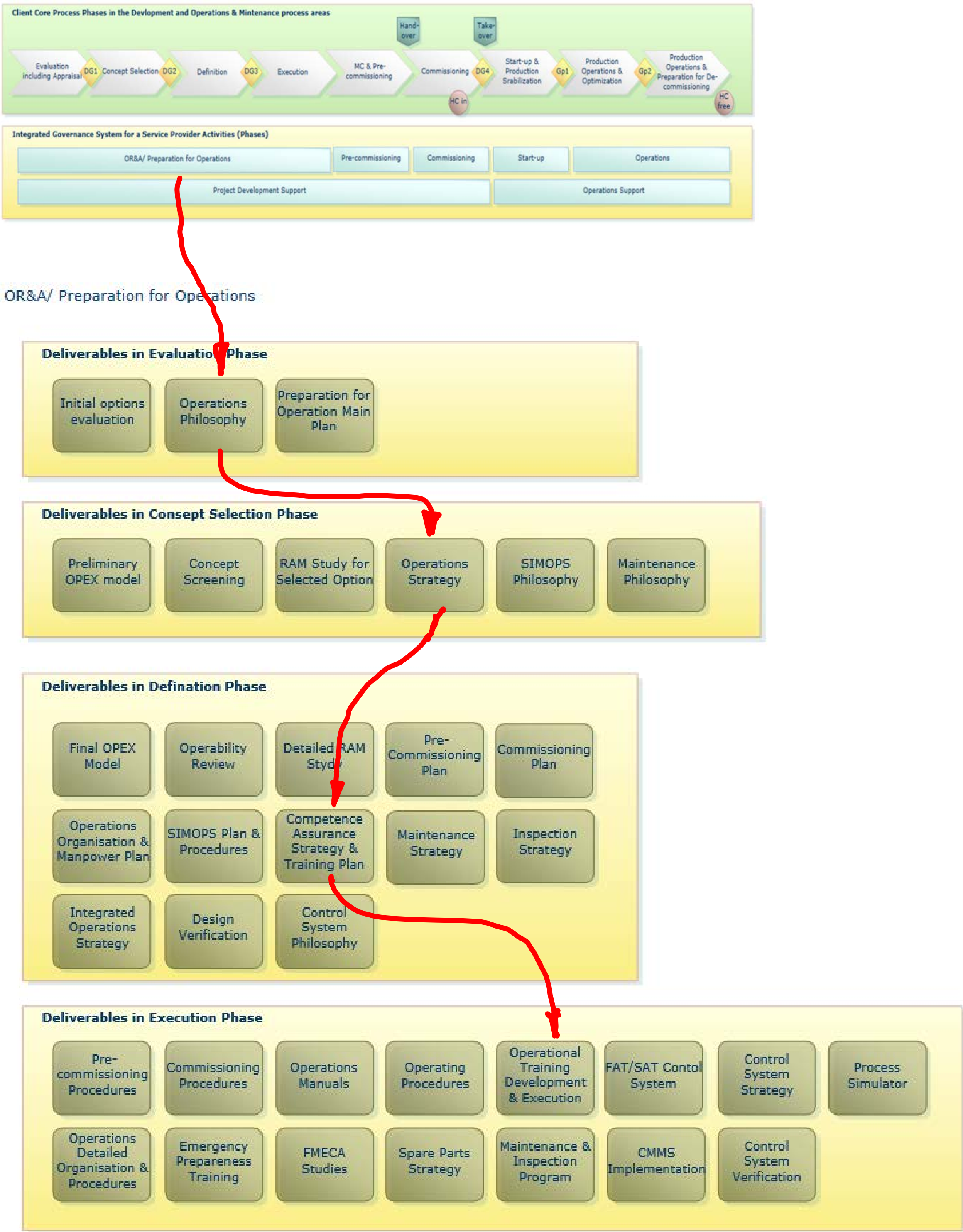

Figure 4: Case study model in the Development Area (Petrolink, 2017)

Before the BPM was implemented, the documents explaining governing processes and work procedures were located in Share Point, which could be accessed through an intranet link. By finding advancements and better solutions on how to work, the company hopes to become more efficient while quality costs decrease.

5.1.1 Six Sigma and Lean

If we compare the characteristics of TQM to those of BPR, see table 1 below, it is clear that although there are many similarities, such as for instance their focus on processes and the support needed by management and employees to change a company's culture, there are still important differences. Total quality management has a more continuous process improvement perspective (Armistead, 1996; Hackman and Wageman, 1995) with a focus on learning (Jarrar and Aspinwall, 1999) were as business process reengineering is rule-breaking and radical, aimed at the development of entirely new processes (Hammer and Champy, 1993; Kettinger et al., 1997), and with a focus on added value for the external customer (Kettinger et al., 1997).

We can conclude that TQM and BPR are the two most influential management concepts of the last two decades. An integration of these two can be found in BPM.

Both Six Sigma and Lean are extremely admirable process improvement methodologies; however, they are each distinctly different in their primary approach to process improvement and they also are different in the opportunities they tend to focus on. "I will make the disclaimer that they are both extremely solid process improvement methodologies that can solve most purposes" (Perez, 2007).

Category	Six Sigma	Lean
Primary Area of Application	Quality	Speed
Tools Used	Statistical techniques & tools, varying from very simple to complex.	Simple methods via elimination of waste & organization.
How Improvements Made	Reduction in number errors via the reduction of variation by utilizing data to identify root-cause of errors	Reducing the amount of time between steps, activities, and cycles. Shorten the cycle time of the process by elimination of the 8 types of waste from the process.
Sub-Methodologies	DFSS, DMAIC	5S, JIT
Origination	Motorola	Toyota
Delivery Personnel	Highly-trained professionals proficient in the Six Sigma practices	Floor personnel, production mangers & leaders, business support partners, & leadership

Table 1: Six Sigma and Lean compared (Perez, 2007).

Each methodology has its own merits and both are incredibly effective for process improvement, it is evident given their results in the business world and their popularity is a reflection of this. However, of the two I do have a personal favorite based on my experience in using both, training in both, and as an observer post implementation.

Very few of the publications reviewed early in the project provided a comprehensive view of integrated governance system practice, each was centralized around a specific outcome the author wanted to achieve. Furthermore, many of the publications refer to the same base literature, which shows a consistency of the science over the years in spite of having witnessed continued development and a lack of consensus in some aspects. Additionally, interviews and workshops with colleagues and contacts enriched the study providing a valuable hands-on perspective.

5.2 Case Study

Similar to the situation in the transport sector with the introduction of self-driven cars, the way industrial processes are operated is dramatically changing. Today's sophisticated digital automation programs are able to handle most situations. Cheap sensors in connection with powerful artificial intelligence algorithms like recognition or vibration monitoring can increasingly replace human sensing. A single operator can take responsibility for lager and lager plant sections or even many plants.

This chapter focuses on the analysis of my case study on control room work processes and the training of control room technicians in a changing environment.

5.2.1 Technicians in the control room

The day to day control and optimization process normally is managed by one or two technicians located in the central control room (CCR) offshore. From this room the technicians optimize wells and process trains in accordance with the production & injection plan, monitor critical systems and equipment and handle alarms, emergencies and shutdowns.

In some cases they manage dozens of wells and facilities that daily produce several hundred thousand barrels of oil equivalents. The decisions they make to optimize production are most often based on their own judgment and knowledge of the operation at hand.

The control room technicians are supported by field technicians that they guide through Ultra High Frequency (UHF) radios. The field technician manually measure readings of critical instruments and valves, regulate manual controls, carry out first line preventive maintenance, in-service inspection, prepare and start up equipment and systems after shutdowns, manage work orders, plan maintenance work and participate in the safety team.

Support from onshore functions is limited and normally only available five days a week from 8 a.m. to 4 p.m., meaning that decisions of key importance to production as well as safety are made without support from the engineers that have developed the plans which the operators are implementing.

This situation is unsatisfactory as it is believed to lead to decisions that affect production, costs and safety negatively.

Today, there is a paradigm shift of technological development going on throughout the world. At the same time, the public safety, transportation and utilities sectors are trying to adopt and implement the best technological solutions to enhance productivity, efficiency, quality, sustainability, and health & safety. Integrated industrial information systems gather operational data to enable collaboration across locations, disciplines and organizations (Pfeffer, et al., 2015). They make real-time data easily available to the appropriate individuals.

It looks like the Energy segment including oil and gas are planning and prepare for implementing new technology in the physical work environment with the intention of increasing efficiency, improving safety and well-being, and at the same time reducing fatigue among their workforce.

However, the reality is often far from ideal. Reports has shown that enormous amounts of data are being collected but only a small portion is in fact being used as a basis for operational decisions (McKinsey Digital, 2015). This is shifting as the information infrastructure becomes available which allows better decision making. See figure 5 below.

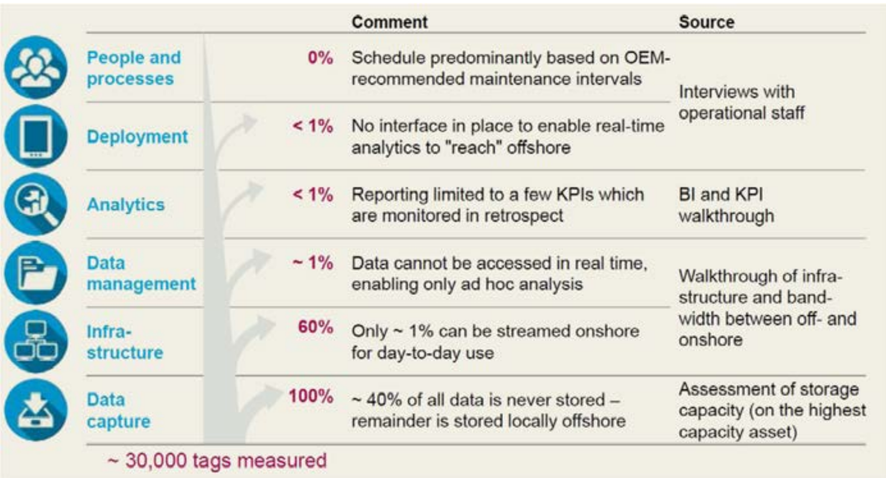

Figure 5: Case example of data driven decisions (McKinsey Digital, 2015)

New big data methods in combination with smart algorithm and artificial intelligence can predict disturbance in the process long before this affect production. Based on this, it can enable the way we operate the plant and change the maintenance program from being calendar based to become predictive. Remote operation is becoming more widely used. Often it makes sense to bring in highly specialized remote expertise and sometimes even the whole plant is operated remotely. Many offshore platforms outside Norway are already being operated remotely and Norway will follow. Control rooms have turned into networked communication and information centers where collaboration and workflows come together. The control room technicians need a supportive work environment that helps them to stay observant and carry their jobs as performant as possible (Nimmo, 2015).

5.2.2 Data availability

Modern process plants are complex and highly coupled systems. A consequence is that a problem in one part of the process will tend to propagate across different subsystems and plant components. The advanced automation system in use adds complex dynamic interactions between the different plant components, making it difficulty obtain a clear assessment of a potential problem. Knowledge workers in process operations still spend too much time searching for data in information silos or proprietary tools. Many companies also lack the organization and work processes to support multi-disciplinary collaboration, and therefore tend to execute work based on a relay race approach instead of as a collaborative effort. Unfortunately, interoperability between personnel from different disciplines, locations and organizational boundaries is often hindered by the fact that information needed to solve the problem at hand is hidden within numerous information silos.

Collaborative efforts of a multidisciplinary team are needed in order to effectively troubleshoot, diagnose or optimize process dynamics and break down information silos distributing data to systems in need of information.

Companies in the oil, gas and energy sectors are realizing that they need to improve the way they work in order to stay competitive in an increasingly volatile market. The efficient trend is sweeping across the sectors, and enterprises are taking engagements to increase workforce effectiveness regarding the introduction of digitalization. Companies is now making plans in order to reach a level of digital support to the workforce whether they are in the control room, in the plant, or work remotely. Information previously hidden within the control and data acquisition systems are now being made available through improved systems and network layers. Web based applications are presented to support consolidation of data from different systems and tools, making these easily accessible from a common place. Easy access to data and a common work environment is the first phase to secure effective collaboration supporting process operations. Developments in analytics and visualization methods also help the workforce to make sense of the amount of data available.

Other trends are also building up under new collaborative approaches to working. A typical example is the video conferencing technology that has matured and is today a functioning easy to use tool in the meeting rooms and collaboration centers.

Several companies now have remote operation centers which support the local control rooms with continuously open video links between locations. High quality video conferencing technology is also available from mobile devices or personal work stations, enabling operators to get instant access to remote expertise via video conference whenever they need it. In combination, the introduction of digital technology for easy access to information, independent of location, and the proliferation of video conferencing to support remote collaboration, is blurring the boundaries between local and remote operations.

5.2.3 Automation Systems and Simulators in Production Operations

Modern automation systems can not only cover most aspects of normal operation but also handle abnormal situations. Advanced control techniques such as model-predictive control and state-based control (Hollender, 2010) allow the automation of very complex tasks, such as the start-up of a plant. Automatic control performs better than a typical human operator. The control room technician is less and less involved in the inner control loops with direct contact to the process. The tasks shift more and more to supervisory control (Sheridan, 1992), where the operator manages and supervise a large number of control modules. Being less involved in direct process control also means fewer possibilities for keeping the same level of competence as initially gained, and by that use more time on re-training.

To be able to take over the control when automation fails, the operators need higher qualifications and a very good understanding of the technical process systems, the automation system and the control modules. Simulator training is necessary to develop a feeling for the process. Control room technicians should also be deeply involved in the optimization of the process plant, because such an activity keeps them involved and helps to build up the required competence level to operate the plant safely and efficient.

The future for process training simulations is exciting. Imagine the growth of more enterprise simulators which connect all of a company’s training simulators into a common simulator platform. Expect a higher extent of fidelity simulations development that will likely change the use of training simulators into more of an engineering and asset development tool integrated with the 3D model of the installation where control room operators and field personnel can cooperate and interact in real time using glasses and holographic technology to optimize and effective the plant operate. Finally, the growth of remote login features allows trainer and trainee access to the common simulator platform from any location where sufficient bandwidth and a remote plugin are available.

5.3 Competence and Training Strategy

The competence requirements in the different control room positions are a problem that we will face as personnel in retire. One way of transferring knowledge is by looking at the simulator training with new eyes. Introducing Virtual Reality as a motivation of learning focusing on collaboration with field technicians together with gamification will attract new technicians into the new control rooms, this together with more in-depth technical training, education in analysis and decision methodology, and best in class experience transfer will help the next generation of operators to become excellent operators. Use of human centered design and a very good competence assurance system is the way forward to meet these demands.

5.3.1 Purpose

The purpose of the development of a "Competence & Training Strategy" is to describe the plans to train operational personnel for Operation Readiness in the commissioning, start-up and operation of the offshore platform, wells and facilities. All competency requirements, development and implementation of new requirements, will be based on existing operating company competency management system. This includes maintenance of competence requirements to ensure continuous operations organizational capabilities. The strategy is also developed for the purpose to ensure that competence and training programs are made up in compliance with governmental and platform specific competence requirements.

The Competence & Training Strategy applies to all preparation and development of competence and training activities in preparation for commissioning, start-up and operations phase of the asset. The strategy presents recommendations for scoping, managing, evaluating and communicating to users the process of developing competence analyses and training programs.

5.3.2 Competence and Training Requirements

The competence and training requirements are outlined based on general competence requirements and competence requirements with introduction of new work duties. Training requirements and training topics are described for the purpose of having efficient methods for closing the competence gaps. This includes realistic training and role plays.

5.4 Training Simulators

Petrolink ensure that operations personnel have the required understanding and skills for safe and efficient operations of facilities, systems and equipment.

This is done by training the control room technicians in a variety of process and utility systems by using recognized simulation tools. Understanding and confidence about operations are efficiently strengthened through using generic and plant specific process simulators as training tools. Operations personnel who have trained on realistic field situations in a simulation setting will immediately recognize threatening situations, recall procedures and take appropriate actions in the field to safeguard personnel, facilities and other assets. Furthermore, training in safety and emergency response to manage unexpected events and to protect and limit threats to personnel, environment and facilities are also done by use of the training simulator and its facilities. This because the 1st line Emergency Response Center is normally established in the Central Control

Lack of experienced staff, potential environmental impact, regulatory requirements and litigation risks imposed by improper facilities operation have made training simulators the best training tool for training of control room operators for startup of any new oil and gas installation.

Operator training simulators (OTS) used on specific installations is often stimulated systems but can also be emulated solutions. Stimulated simulators are a true copy of the distributed safety and automation system on the specific installation and process models simulating and replacing the reel process and utility systems including fire and gas, other safety systems and emergency shutdown/ process shutdown systems. Stimulated systems require more servers, each programmed for a specific application in the training simulations integration. Emulated training simulators consist of only a few physical servers and the balance between servers simply being emulations of servers and server processes.

Emulated simulators are simulators that do not mimic the real design and functions of an integrated safety and automation system, also called a Distributed Control System (DCS). Emulated simulators cannot be used to test automation, validation procedures or do project verification processes and may not include an emulation of the actual control systems used by the control room personnel being trained.

Emulated simulators is primarily used by oil and gas companies for situational evidence training and gives trainees a basic understanding of the workflow processes of the generic oil and gas industry and shall not be used as basis for the competency assessment of control room operator trainees. If used, the DCS should be accurately imitated.

5.5 Training programs

Each training program offers a systematic and in-depth coverage of operator fundamentals and unit-specific systems, as well as practical hands-on exercises. Petrolink offers three standard course programs. Each course comes with instructor, instructor manual, student manual and student evaluation program, if required. Petrolink is ready to conduct courses anywhere in the world for any period of time. Note: Custom clearance for technical equipment demands thorough planning the programs can be tailored to suit any operator involved in the upstream and/ or downstream oil and gas sectors.

All the training material is modular, and courses can easily be adjusted to meet specific training goals and/or requirements. The instructors have experience as both field technicians and control room operators from wellhead platforms, oil and gas production facilities, gas treatment plants, LNG plants, petroleum refineries and petrochemical facilities. They have strong communication, presentation, and classroom management skills. Capabilities and performance of the instructors are maintained through our internal assessment program.

With the shift away from traditional control rooms towards integrated collaborative control centers, tomorrow’s operators will require a very different skill set, with much more emphasis on cooperation coordination, analytics and management. to be able to attract the best operators and offer them an environment which allows them to bring consistently high performance in 24/7 work settings, the integrated control centers should be designed by experts from an early stage. New digitalized infrastructures tear down information silos and make world-class remote expertise available. Optimizations which were previously possible are coming into reach. Below is a typical training program.

5.5.1 Basic Process Knowledge and Simulator Course

This training is suitable for all personnel who wish to gain a basic understanding of the production processes in the upstream and/or downstream oil sector. By combining theoretical and practical training, participants are provided with a complete and effective learning experience.

5.5.2 Basic Simulator Course for Control Room Operators

The overall objective is to gain practical hands-on experience on a basic level for existing and future Control Room Operators in all the facets of the upstream and/or downstream production processes.

5.5.3 Advanced Simulator Course for Control Room Operators

The overall objective is to gain practical hands-on experience at a high level for Control Room Operators in all the facets of the upstream and/or downstream production processes and its control and safeguarding systems. A full assessment to determine the participants' actual competence may be part of this program, if required.

Complete simulator process training in a virtual environment can be made available in cooperation with the customer. This particular training option allows simultaneous interactive training of the process technician crews to accomplish both "technical" and "human factor" training objectives.

5.6 The Value of Collaboration

Collaboration provides employees with better ownership over their areas of work. As employees are more engaged in the enterprise via collaboration, they are more likely to report change requests and non-conformances, leading to an overall improvement in the way the enterprise operates.

If structured correctly, the company can foster collaboration in the form of user/stakeholder feedback, but also deeper engagement. Extended and structured collaboration is needed in order to solve many of the problems that the company is faced with today (Morgan & Rasshid, 2003). Extended and structured collaboration focuses on engaging stakeholders by ensuring that the whole enterprise can participate in the activities of the BPMS program by providing comments and feedback in a structured manner.

By delegating responsibilities across the enterprise, it is possible to root the BPMS program in the way employees approach their everyday work-related activities. Employees are then naturally involved in creating and updating BPMS, which implements a sense of enterprise-wide consistency. As consistency permeates projects, programs and initiatives throughout the enterprise, the ownership that employees feel towards the BPMS will help attain consensus both on an enterprise scale as well as in individual projects, programs and initiatives.

With the help of collaboration, it is possible to maintain a repository spanning many different languages effortlessly. This is because of the focus on enabling collaboration across not only country borders, but also an extended and structured collaboration across different business units inside the organization. With the focus on extended and structured collaboration, it is possible to delegate tasks for the program.

Furthermore, such a focus confers greater employee satisfaction with work processes and greater employee involvement in daily work as well as process transformation. A lack of consensus in the enterprise among all the relevant stakeholders and employees is one of the main challenges in implementing business transformation initiatives. Consensus is created across the whole enterprise by making it easier for employees to read, understand and get involved with the big picture in an intuitive way. In this way, it is easier for each employee to see their own area of responsibility, and ensure that things are being done. Change is then implemented proactively instead of reactively.

5.7 Process Performance

Key Performance Indicators for process operations in areas such as asset management, control performance, alarm management, energy efficiency and overall equipment performance are important parameters to be measured. Managing those Key Performance Indicators (KPI) are not a classic control room technician task but it becoming more and more important to ensure good production performance. Disciplines such as operations, maintenance and operations support need to go hand in hand to achieve best results. Many of the tasks can either be performed by centralized service centers or can be outsourced to specialized external service providers.

Typical goals are increased throughput, efficiency and uptime for the asset. This is achieved by a structured approach to revealing the sources of process variations and upsets and the current handling of these. By reducing process variations, the operational process flexibility, plant regularity, safety and integrity will be increased, while outside specification production, energy cost, environmental impact, operator stress and equipment wear will be reduced.

Typical KPIs related to production are production potential, deviation in potential, production efficiency and production loss, where production potential states the maximum volume a reservoir is able to deliver through wells, process and export system, within a given time period. A deviation in potential is a change in production potential in relation to production potential caused by changed circumstances or an event. Production efficiency is the ratio between production and production potential and production loss is the volume associated with an activity or an incident that results in reduced production potential within a period of time.

5.8 Today's challenge

In recent years, we have experienced a continuous sharpening of the competition with a corresponding pressure on the margins. Having had a seller's market, where the customer had to pay attention to what he was offered, we now have a buyer's market in most volumes markets. Globalization, digitalization, Interoperability with clients and long-term thinking will doubtless dramatically enhance this trend in the coming years.

Research suggests that employee trust in management is negatively affected when change is introduced, and that the most effective remedy for the negative effects of change is employee involvement (Morgan & Rasshid, 2003). Additionally, the upcoming ISO 45001 standard for Occupational Health and Safety (OH&S), and several other standards for management systems, all stress the importance of involving all stakeholders when implementing a management system. For enterprise architecture management, stakeholder involvement is crucial in order to make sure that the change initiative is meeting with expectations, and for ensuring that the architectural requirements are clear whilst also being able to share the results of the architectural process with stakeholders.

5.9 The Control Room Technician Role Will Change

Almost all process control of an offshore process plant has been taken over by the process control and data acquisition system given that the control room technicians now have a very complex work situation. They supervise large numbers of control loops and must be able to rapidly diagnose complex situations, collaborate with various support teams and also field technicians and maintenance personnel. They also decide when it is time to bring in external specialists and manage the integration of them. To make use of their full potential, they need a work environment that really supports their work.

Today, control room technicians make hundreds of decisions every day, decisions that have a great impact on efficiency, quality, sustainability and safety. Recent research indicates that the physical working environment and the automation process do not always provide effective solutions to the above mentioned factors. A challenge is to design the more collaborative environments that will engage interoperability and replace the traditional control rooms. The more alert, stimulated and harmonious the control room technicians are, the better decisions they make. As we have seen over the last decade, those centers will no longer be physically close to the process, but they need to be much better integrated with remote service communities in own company, service providers or suppliers to get the efficiency, quality and safety. The information presented has to be as good as possible. New collaboration centers must be implemented to work through different steps in modernization before the entire technology and organization is ready to utilize all benefits.

The involvement of experienced control room designers is even more important in the design of next generation collaborative operations centers. It requires a totally new approach and future integration thinking. As the traditional way of building control rooms becomes old-fashioned, new best practices will have to be defined. The new centers will contain fewer technicians and the role will evolve from reactive to predictive problem solving and analytic operating. The new technician role requires better qualified staff and places higher demand on the working environment and the tools available. In a modern intelligent collaboration center, the working environment is the key to real control.

Control room technicians’ well-being is a key success factor for safe, productive, and reliable operations (CGM, 2016). It will be more important in the future to have motivated, stimulated and more alert technicians to operate increasingly bigger parts of the production process. The space around the operator will be more connected to many other functions that were previously often separated from traditional control room operations. More frequent interactive communication with different remote service personnel to jointly solve troubleshooting and optimization task will require a work environment to support this kind of work as if they were working in the same room. These new workflows, still rare today but which will be the norm tomorrow, have completely new requirements concerning room layout, different working zones, screens, cameras, analytical decision tools and remote collaboration workspaces. One important reason that workflow is of pressing concern for the new control rooms is the introduction of new information technology and artificial reality.

It is also the case that working in 24/7 environment reduces the life probability of the employees. There is ongoing research to understand how we can establish an environment that can be adapted to each individual operator giving him or her individual health improvement. Personal light adjustments with cold and warm light possibilities, ergonomic adjustments to operator anthropometrics, integrated personal communication, alternated posture, and personal air quality in the workplace are only some of many other factors that the companies CGM and WEY Technology take into account in the intelligent Extended Operator Workplace model.

Figure 6 below shows a typical integrated control station that is much more than an advanced motorized operator desk (WEY Technology AG, 2017). This station is a complete health improvement micro-environment that can be adapted and even automated to change for each individual operator depending on individual needs. For example, the distance between eyes and screens and the lighting can shift from warmer to colder light during the day. These are examples on how technology can be used to support the health and well-being of the operator. New research, big data analytics and prediction systems will make it possible to create a data-driven day-by-day improvement program for the technicians. Control rooms in the future will turn big analyzed data into actions by utilizing quality data and decision tools available and will, by doing so, yield benefits by becoming faster, safer, more competitive and more profitable.

Figure 6: Modern extended operator workplace (WEY Technology AG, 2017)

Figure below shows an example of a collaboration center from an operating company. Several control rooms, each with technicians working on shift 24/7 were swapped by the new collaboration center hosting only two control room technicians who calls on remote expertise if needed.

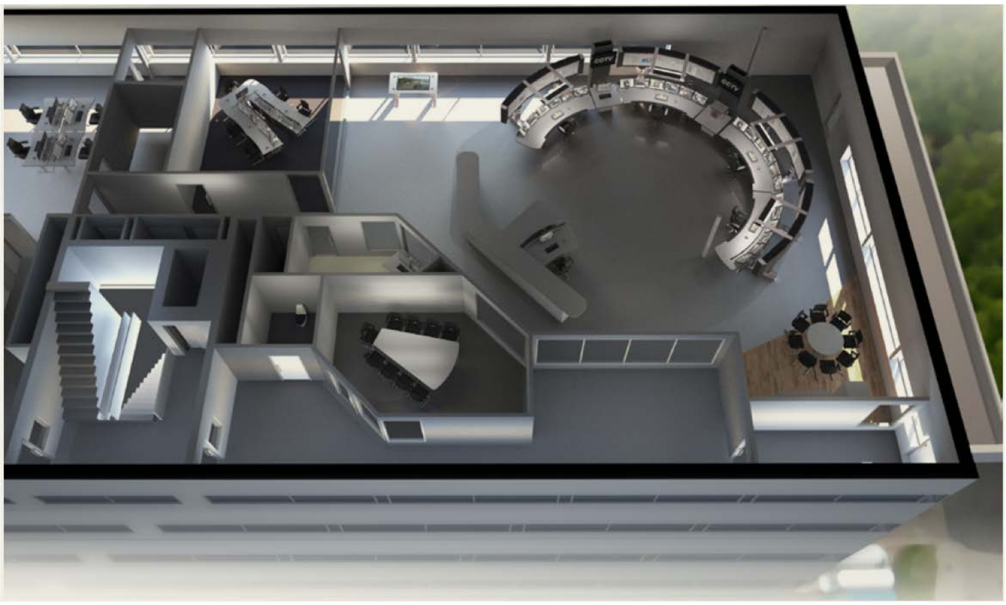

Figure 7: Newly designed collaborative operations center (CGM, 2016)

5.10 Training Value of Process Simulators

Like other fields of training, use of simulation in the oil and gas industry is owing to the multiple factors covering technological, financial and training needs of the time. Some of these factors are as discussed in the following lines:

- Owing to technological advancements, simulation technology is available for process plant operations at a very cost-effective price.
- Simulators are coming closer to the real thing; in fact, whole of the system fitted in the control room onboard a platform can also be installed as a simulator in a purpose built scenario.
- One can plan a training schedule as per convenience and the simulator will be available for use; unlike the real process where up time and efficient production is vital for the economy of the asset.
- One can run and speed up the plant on the simulator as per training requirements without worrying about cost or time constraints.
- Conditions and environment in a simulator can be programmed and repeated again and again to improve the learning outcome of training.
- Simulation gives chance to apply the theoretical concepts to demonstrate their practicality.
- One can choose area of operation for maximum training value and increasing confidence and morale of the trainees.
- Performance on simulators can be recorded and played back to the trainees for carrying out analysis, providing feedback and pointing out mistakes done during the exercise.
- One can load a pre-defined scenario and run the exercise at accelerated pace as and when demanded by training requirements and time constraints.
- Conditions in simulators are known and repeatable so that performance in these conditions can be graded and assessed with uniformity. Exercises can be stopped and delayed so that particular learning points may be emphasized by the instructors.

The only way to encounter the next generation of operators to work in the control rooms is an holistic approach to the control room environment. Acoustic disturbance will play a key role.

Collaborative process operations make it possible to efficiently bring people and companies together to focus on the problem at hand. Big data and artificial intelligent tools support teams and make them as efficient as possible. Previously isolated control rooms and simulators become networked control centers for the Industry 4.0 high performance work force. Work environments must support collaboration at all levels and support high performance work around the clock.

It is yet too early to conclude that Petrolink as a business is now process oriented. There is still a lot of work to build SoluDyne, and the implementation of the system will take a long time. Processes must be mapped and modeled, users to be cursed, and the tool must be used in the daily work before one can conclude that Petrolink has become a process-oriented organization. To draw some parallels with previously mentioned criteria for a process-oriented organization, (Ramias & Wilkins, 2011) are referred to, in relation to SoluDyne expectations as a tool: Good overview of the main processes. The quality project has elaborated the main processes, and Petrolinks Delivery Model has been prepared. This describes only the top level of the processes, but will act as a template for further development of SoluDyne. The process management system must be part of the day-to-day operations. By integrating SoluDyne with many of the common tasks, and providing a simple and easy-to-read overview, SoluDyne will be a useful tool in our daily work. The control must be process oriented. Successful implementation of the system requires management engagement, and management must also be set up to use this tool in its daily work. This may be in the preparation and implementation of strategies and goals, or process ownership and allocation of roles. Petrolinks ability to change will be greatly increased with the introduction of SoluDyne. The system adds continuous improvement by using input from all users, and a direct link to processes can provide a more direct ability to change and improve the organization.

One can see from these criteria that Petrolink will eventually approach process orientation, but it will still take some time before one can say that the business as a whole is process oriented. This requires a comprehensive culture of holistic thinking, continuous improvement and ability and willingness to develop and improve the organization.

6 RESULTS

The presentation of SoluDynes APOS module followed up with interviews with simulator instructors and project managers in Petrolink was conducted during the second half of the project. Feed-back and result from the discussions was solely positive. They all welcomed the initiative and supported the way of thinking. As a group, the simulator instructors and operation specialists including the senior process engineer have already started to design and structure the work processes and sub-processes related to day-to-day operation of the simulator center and to the development of simulator training programs in a development project. The process of re-writing the internal simulator procedures to prepare them for implementation in APOS as flow diagrams has also started. Reference is given to chapter 3 and chapter 4 for respectively methodology and analysis. This reaction of a change management issue is promising for the future of Petrolink as it shows willingness by the employees to improve and change the way of working using structured processes leading to better services for our clients.

It must be noted that Petrolink has been using the competence assurance module in SoluDyne for many years already and this, for sure made it easier understanding the framework and structure of the software when introduced to the pilot group.

The feedback and suggestions from the employees was given verbally and are seen as important in order to understand what they have previously missed, what they thought of the newly implemented system, and what they thought needed further improvement. After first feedback round, everybody interviewed gave a positive feedback and the simulator group has already started structuring the governing documentation, revising and convert the internal procedures in the simulator center used today to work process and flow sheets.

This design work is just started so the completed work will be followed up after delivery of this thesis. The analysis of the answers given from the group can be concluded as very positive. They all agreed they will adopt their work in the future according to the system. In fact, they have already decided to implement and use the system.

Regarding the second goal of this thesis, that was to analyze the basis for introducing process-oriented management and identify possibilities for increased profitability and efficiency in the start-up phase of a larger project. Process-oriented management adds to continuous improvement, which will lead to a better implementation of activities. The basis organization can benefit from such a tool in their daily work, through reduced costs, higher efficiency and better management of day-to-day activities.

We also analyzed the basis for introducing process-oriented management and identified possibilities for increased profitability and efficiency in a start-up phase of a larger project. The project in question was a project where Petrolink delivered among other activities, the initial simulator training of all control room technicians before start-up of the plant. Petrolink delivered on time and on budget on all main activities. Based on these findings it is defined key factors for increased profitability and efficiency. Petrolink will validate the findings when the system is implemented.

The findings of work processes defined key factors for increased profitability and efficiency are:

- Create system of accountability for your team (Project ownership and responsibility)
- Set standards for communication (What information is important to communicate? intervals?)
- Encourage collaboration within the project team (Good work environment , team building)
- Improve meeting culture (Ask the right questions during meetings, so that your time together isn't wasted.)
- Use the best work management tools

After analyzing the case study, I have concluded that a stimulated training simulator provides the most realistic simulation used for training of the control room operators. When the company decides and agrees to build a training simulator, the simulator manufacturer will work with the client to define the scope of the project. Developers are likely to request design documentation packages about:

- Design specifications and equipment lists, reservoir compositions, chokes curves and control valves characteristics
- P&ID and / or PFD for the project
- Cause and effect documentation, narrative equipment control and integrated control systems, specifications and narratives
- Documents to ensure flow and flow

- Any backflow documentation available
- Operating procedures developed

The physical and virtual servers are built, packaged and programmed according to the facility specifications. Topsides and subsea models are designed to mimic the physical flow properties of the process and flow guidance.

Stimulated simulators are best built after the causes and effects diagrams and operating procedures for oil and gas the plant have been developed, but sufficiently well before commissioning, to complete effective operational training programs.

The benefits of building a stimulated training simulator for control room technicians and the operations engineers are:

- Verification of the equipment design and validation of the cause and effect diagrams
- Validation of commissioning, startup, operating and intervention procedures
- Training of technical personnel and training with assessment of operational competence
- Operating characteristics of the facility inclusive of hydrate formation problems, choke performance slugging issues, well productivity and flow characteristics at minimum through maximum flowrates
- Unusual or unexpected conditions which may create startup problems
- Initial competencies of the control room operators who will operate the facility via built in scenario exercise tools and instructor provided operator competency assessments.

When it comes to the implementing of the Integrated Governing System within the areas of Competence Assurance and Simulator Training management in Petrolink, a combination of Lean and Six Sigma methodology is concluded suits Petrolink best. Lean shares the same approach to the analysis of work as many other improvement methodologies, like TQM, BPR and Six Sigma but it differs from them in how it is used. Rather than specialists using scientific methods to design better systems, Lean builds superior performance by developing the problem solving capabilities of the front line, supported of a hands-on management system.

Processes have to be designed with Lean and then controlled with Six Sigma, this because Lean is all about taking a systemic approach & way of thinking reducing waste and save time while Six Sigma is all about project management and quality. This help getting the best of both worlds.

Lean can be summed up by wanting to remove all activities that do not have value in the customer's eyes, while Six Sigma seeks to reduce variation, defects and errors to a minimum. The combination of these provides a methodology that can remove waste that do not create value for the customer in the processes, and reduces variation where there is a problem. The phases used are named DMAIC which are an abbreviation of Define, Measure, Analyze, Improve and Control (George, 2002).

Petrolink have also adapted the PDCA four-step management method used in business for the control and continual improvement of processes and products. This Plan, Do, Check and Act method are a part of the Improve phase of DMAIC.

By combining these two philosophies it gives us a unique flexibility reducing waste that do not create value for Petrolink and our customers and reduce variation, defects and errors.

7 DISCUSSION

Six Sigma and Lean are both unique methods to minimize variation and waste respectively.

Most Six Sigma focused companies get the majority of the benefits from the basic Lean tools, like 5S, JiT, visual controls and standard work. In these cases much of the Lean toolkit becomes synonymous with Six Sigma. Six Sigma has unique benefits in improving complex repetitive processes, where a structured project based approach (DMAIC) can be used.

An observation from the case study is that enterprises find it hard to react rapidly to market dynamics. Decision-makings and implementation of required transformations is made difficult by the complexity in business and the fact that for most people enforced change is viewed negatively. Enterprises of all kind meet disruptive trends in many different areas, and must deal with often conflicting internal and external drivers for – and against – change. Many end up spending lots of effort on firefighting and damage control, and become reactive rather than proactive.

The concept of co-creation with customers can be found in many books. Prahalad said that we must abandon the conservative concept of company-centric value creation, establish a new paradigm of value co-creation between companies and customers, and fundamentally change the business activities to align with it (Prahalad & Ramaswamy, 2013). Furthermore, the concept of design thinking (IDEO.org, 2017) that is drawing attention, helping not to get an idea only from technologies, but go out into the field, study the control room technicians, and create an idea from understanding the users.

To ensure that it develops and grows together with its partners and clients in a sustainable way, it is vital to continuously seek new business opportunities and create next-generation businesses.

If we can structure production operations that have, up until now, been dependent on human qualities such as experience and gut feeling together with augmented reality (AR) technology can help control room technicians to make a decision, we are able to use the time saved by the structuration for activities that generate more value.

8 CONCLUSION

When interviewed the pilot group, the feed-back was that everybody believed in an effect increase and will work with the system for gaining this. When Petrolink have implemented the work processes and flow charts into the system and the group has started using APOS, the feedback will be analyzed. Following the Pilot period and if the result are giving an beneficial result, Petrolink will start converting all governing documentation into the system and start measuring the efficiency.

An inclusive approach is needed to manage the business effectively. Continuous improvement programs can be applied to different types of work environments. Managers need to evaluate the degree of standardization involved in the organization, and the process choice, and can then decide upon the appropriate methods to use to best implement improvement practices. They can evaluate the usefulness of programs by monitoring a set of routines and behaviors that are seen as being essential to organizations of all types for implementation. It goes without saying that continuous improvement does not come without sufferings and struggles, and without active participation of everyone in the organization.

A business's processes are at the very core of its being, as essential to its life as our blood, flesh and bone are to our own lives. Despite this, business processes are often not given the attention they deserve when business performance is put under scrutiny and ways of improving that performance are investigated. Yet the truth is that looking at an organization's processes are utterly vital if you are going to make the organization more profitable, more competitive, more cost-efficient and better in every respect. Understanding an organization's processes really is the key to understanding everything you need to know about the organization.

By implementing BPM in the activities defined by Porter's Value Chain Framework, as introduced in chapter 1, the organization will not only ensure smooth functioning of a activity but also a seamless integration between all the activities. I believe an organization can achieve Competitive Advantage by studying the fundamentals of Michael Porter's Value Chain Framework, and implementing the principles of the BPM.

It is important, though, to bear in mind that there is always a pressing practical reason for looking hard at, and thinking about a business' processes. This practical reason is the continual need to make the organization more successful and cost-efficient. The truth is that understanding the organization’s processes is the key to gaining accurate insight into what it is doing now, how it is operating and responding to customer demand and - most important of all – what and how processes might be changed or modified to improve the organization’s performance.

Good processes must deliver value to someone outside of the process, create value for the organization operating the process and align with corporate values and strategy.

As businesses constantly strive for competitive advantage, a return to a pragmatic, rigorous and structured focus on improving process performance & service is a good process. If aligning Information Technology (IT) to that process and not the other way around seems to be building a consensus amongst forward looking businesses. In line of work within the simulator section, when the customers demand a product of high quality, delivered at a reasonable price and at a fashionable time, Petrolink deliver.

8.1 Operations Management Systems

Petrolink has extensive experience in developing, implementing and improving processes in Operations Management Systems (OMS) for upstream companies.

An OMS is the structured framework of policies, processes and procedures implemented to ensure execution of required activities to achieve objectives. Objectives can relate to cost efficiency, productivity, HSE&Q, regulatory compliance and more.

Management Systems are typically published through the company’s selected tool, and are process based, document based or a combination of these two. Petrolink and its partners has developed and implemented more than ten OMS for upstream companies, and our experience from these projects are documented in our upstream Blueprints - process and governance reference models. These models support and increase quality and speed documenting processes and development of OMS.

The following are main objective for the Operations Management system:

- To define the principles, the governance and control structures to ensure compliance with legal and regulatory regulations, Company’s corporate requirements and the achievement of the Company's business objectives.

- To define the organizational structure as well as roles and responsibilities within the company.
- To provide an overview and detailed information about the work processes for employees, managers, authorities and other relevant stakeholders.
- To define the important decision making criteria and the processes leading up to critical decisions.
- To define important interaction and management within the company and with external stakeholders.
- To ultimately protect Company's business interests and ensure prudent operations with the licenses that the Company participate in.

The OMS should be designed to establish a common foundation and understanding of how the Company is organized to conduct its business through its work processes, its assets and employees and business partners. The OMS will form the basis for planning, execution and governance of all work and activities carried out by the company, involving both employees and business partners.

Petrolink have the expertise and competence assuring the OMS is easy to understand by the employees as this is essential for a satisfactory function of the system.

8.2 Development of operating processes and procedures

Development of operating processes and procedures must be done in accordance to Norsk Sokkels Konkurranseposisjon (NORSOK) Standard Z-001 and Company's additional requirements. In addition Petrolink use established internal procedures to develop operational documentation.

8.3 The Way Forward

Work with clients to get maximum interoperability and collaboration in all aspects of cooperation to secure efficiency and value creation. This must also be done with partners and vendors.

Statistics indicate that offshore platforms are running at 75 to 95 percent of its potential – the efficiency spread provides a view of the improvement potential. Use of sensors, analytics and AI can quickly improve operations and unlock the production potential of offshore assets. We also observe that there are learnings from e.g. petrochemical plants and manufacturing that apply big data and advanced analytics to operate assets at their maximum capacity.

Complete simulator process training in a virtual environment will be made available in cooperation with the customer. This particular training option allows simultaneous interactive training of the process technicians to accomplish both “technical” and “human factor” training objectives.

Ongoing pilot using advanced analytics on a mature asset where there were indications that analytics could help optimize production settings:

- Utilized machine-learning and Artificial Intelligence (AI) to analyze historical data from more than 5000 sensors for correlations and causalities.
- Identification of variations and limitations in human factors and between control room teams
- Identification of control parameters that influence hydrocarbon flow
- Machine learning to identify and resolve several bottlenecks that were constraining production
- By predicting operational setting and bottlenecks, the operators were able to provide a 1-2 percent gain in production
- Also support prediction of incidents, hours in advance

Typical areas of improvement when introducing Virtual Reality (VR) technology can be:

- Simulator training and OJT/ efficient operation of plant using digitalization tools in control room and in field (plant 3D model - VR – AR – Hololens)
- line maintenance for operators (Maintenance work procedures)
- line maintenance for maintenance personnel (Maintenance work procedures)
- line maintenance for spesialists (Maintenance work procedures)
- Operating procedures (preparation for start-up, start-up, normal operations (alternation of equipment in operation / stand-by or routine operations), run-down of process plant or part of it, preparation for maintenance)
- Inspection procedures (In-service Inspection by operators, Inspection by inspectors)

Yokogawa, a Japanese distributed control system provider, uses the phrase "Co-Innovating tomorrow" as their corporate slogan. The slogan represents Yokogawa's strength of character to achieve growth and create a sustainable future. They are building long-lasting partnerships with customers and partners. As an example, Yokogawa have been a very good partner with Petrolink when they was located in Norway and they rented office space from Petrolink until the pulled out of Norway with their process control system division .

8.4 A New Generation of Control Room Technicians

Generation shifts impact business markets as the new generation control room technicians enters the market. One challenge will be to attract the next generation, often referred to as the generation Y, gaming generation or multitasking generation, into the control room working environment.

A revolution is underway between humans and machines in the operating environment. It is now becoming possible for machines to automatically initiate control instructions as well as proactively provide information to the control room operators. Process plants now depend on the assistance provided by smart machines that can reproduce the techniques of well-trained, experienced human operators in processes that require high levels of skill, such as the startup and shutdown of production lines and product changeovers.

With the entrance of the next generation control room technicians, man–technology–organization (MTO) and human factors (HF) contribution in the early phase of design layout will be even more vital. We have to consider the needs, requirements, behavior and values of the next generation of control room technicians that need to be attracted to the collaboration centers for the future.

The only way to encounter the next generation of control room technicians to work in a collaboration center is to increase the focus on working environment. The design of the work place itself will play a role if the future. Communication devices, navigation keyboards, acoustic disturbance, screens, both work station and big screens, and light arrangements is other areas of concern since we know that interrupting each individual own rhythm can have overwhelming consequences for shift operators. Heat, ventilation and air conditioning (HVAC) and air quality also matter in order to increase control room technicians performance at work.

8.5 Digital Divide

To stay competitive Petrolink need to react rapidly to market dynamics. Decision making and implementation of required transformations is made difficult by the complexity in business and the fact that for most people change is viewed negatively.

Coherent knowledge about the business must be captured, managed and analyzed. Consensus is required among all relevant stakeholders and employees to ensure successful implementation of transformation initiatives. Consistency in the change process must be maintained across the organization. All information communicated must be transparent, relevant and easy accessible for everybody.

A stimulated simulator provides a digital twin representation of the process plant and consists of a duplicate of the production system, non-intrusively integrated with a dynamic process model providing a realistic and accurate digital twin of the facility.

Traditionally, dynamic simulators have not been used widely within the industry. However using new standard of simulation technology is perfectly suited to a wide range of activities during the project design, commission and operating phases of a development project.

One game changing component is virtual commissioning where issues that would otherwise be highlighted during commissioning can be identified and addressed prior to commissioning and which enables the facility to be commissioned well before the production system is available. This will also enable potential issues which may arise during the commissioning phase to be identified and rectified in the design, reducing the associated costs and time delays.

Another game changing factor is virtual start-up. For any new offshore project there is a requirement to bring the asset online safely and as quickly as possible. Reduced engineering, commissioning and start-up periods directly affect when an asset can making reductions to project schedules, while extending the level of design integrity, innovation and design quality, presents a difficult challenge (Bains, 2017). Dynamic simulation models together with a 3D model of the plant can play a key role in helping to meet these challenges. By training on the simulator on operating procedures such as startup and operation of the plant while, at the same time communicate and collaborate with the process technicians in the field, The field technicians uses VR technology to collaborate and by that they get drilled in startup and operations of the plant event before commissioning commence.

Having developed and become more accessible over latest years, the technology can be applied to a increasing variety of industry applications. For the process industry, including offshore oil and gas, dynamic simulation solutions comprise of an integrated Safety and Automation System (SAS) communicating with a model of the process facility, which is designed to reflect actual plant process dynamics and to provide realistic feedback to the integrated safety and automation system.

The HMI and control logic will be a replica of what the control room technician experience as it was in the real world and the field technician would see in the field,

Dynamic simulation solutions for the future can be used throughout the lifecycle of a project, from an initial standalone process model built to perform verification studies of the process and control system design, to commissioning and operating procedure verification, “virtual commissioning,” and collaborative training together with the Operations and Maintenance crew in the field.

In the initial design phase, the process model can be integrated with the control system configuration at various stages during the control system development. That allows it to be used as a tool to provide enhanced verification of the integrated safety and automation system configuration, in addition to the traditional acceptance testing. This can include verifying alarm and trip settings, providing initial controller tuning values and enhanced verification of control and safety and Emergency Shut Down (ESD) and Process Shut Down (PSD) logic. As more data becomes available, the dynamic simulation of the process can evolve and support different activities through the typical phases of a project.

Operators are usually required to be certified by an assessor to ensure that they meet company standards for competence. Operator training solutions are increasingly used to support this, but realistic dynamic process simulation and operating scenarios are key to their effectiveness. Use of a training simulator enables operations personnel to gain experience in an offline, non-intrusive environment, and expose them to what they will experience in their actual control room. Technicians learn about control and safety system operating concepts, while gaining experience of their actual process in preparation to effectively handle incidents, process upsets, and the management of abnormal situations.

Training on a process-specific training platform raises skills levels, leading to faster and smoother start-ups, less downtime, less off-spec products, less supervision and increased energy efficiency.

Improved operator effectiveness also leads to increased plant-wide safety. Dynamic simulation can also replicate very unusual situations with transients, such as start-ups and shutdowns, that operators may rarely otherwise experience.

8.6 Digitalization

A digital revolution is underway between humans and machines in the operating environment. Several industries are already in the midst of transforming its business processes to utilize the opportunities of digitization. It is now becoming possible for machines to automatically initiate control instructions as well as proactively provide information to the control room technicians. Today's buzz word is digitalization; fifteen years ago it was integrated operation.

Norwegian digital strategies now develop around a holistic upstream. Digital Operating Model with distinct capabilities:

- From siloes to launching integrated operational improvement programs organized around clear change and benefit realization programs.
- From individual approaches and capabilities to implementing coordinated efforts
- Senior leaders within operations take a crucial role in realizing digital transformations.
- Senior executive aligns the overall business transformation and strategic objectives.

During a development project, a holistic approach should be taken based on a digital twin to enable collaboration and to process effectively the gathered data.

Digital Enablers for the development phase:

- Digital Twin - Holistic asset model for sub-surface and surface
- Open Collaboration Platform (automated workflows & data)
- Cognitive design based on AI and Machine Learning

The Digital Twin ensures one single source of truth model along the development phases to ensure an digital asset for an improved operation Digital Twin combines graphic, physical, commercial, environmental and operational data in one model, for cooperation of all project partners. Value creation by applying a digital twin are cost savings, shorter time to first oil, reduced risks, safer drilling and construction added value for operations.

Expect a higher extent of fidelity simulations development that will likely change the use of training simulators into more of an engineering and asset development tool integrated with the 3D model of the installation where control room operators and field personnel can cooperate and interact in real time using glasses and holographic technology to optimize and effective the plant operate.

8.7 Judgement

Petrolink judgement of what the company prefers ended on a combination of Lean and Six Sigma. The reason for choosing this is primarily based on two factors:

Unfortunately, it is relatively difficult to simply take a highly successful person from your team and turn them into a Six Sigma practitioner. Generally, as a pre-requisite some level of statistical technical aptitude is required to lead Six Sigma efforts because you will be utilizing techniques such as Defects Per Million Opportunities (DPMO) along with understanding how to read p-value tables as you perform hypothesis tests. The complexity of the system, albeit extremely effective is limiting for an organization.

Lean has such relatively simple concepts to understand that anyone in your entire organization can understand. Some of those elements could include we need to have an organized and clean workspace, we need to ensure we don't want time from one step to the next or we need to reduce unnecessary excessive transportation of material or goods from one place another which leads to excessive time and additional costs. At the surface level, and even a level below Lean is significantly simpler to implement.

What good are improvements if the good results are made for a short period of time? After putting resources into making change happen, you don't want to see your results go away. Six Sigma, because it is typically implemented by one or a few people who make their changes and then move onto the next project, are not there to help make the improvements and changes sustain. The reality is, every change needs to be hand-held post implementation for a few months afterwards to ensure there is a sustained change in behavior.

Lean, because it is an organic system which is not only implemented by ‘the people’ it is also owned by the people who lead to a level of accountability with a finger constantly on the pulse of the changes. Implemented changes as a result of Lean, utilizing Lean principles are there to stay for the long run.

Neither system is perfect. As a result there has been a popular movement to combine both into every process improvement implementation. In reality, Lean and Six Sigma should simply be seen as additional tools to a process improvement practitioner’s tool box together with all other tools giving Petrolink an our customers an long term benefit and improvement.

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B) Attachments

1 - Activities and Deliverables in the Evaluation including Appraisal phase
2 - Activities and Deliverables in the Concept Selection phase
3 - Activities and Deliverables in the Definition phase
4 - Activities and Deliverables in the Execute incl. the Pre-commissioning and Commissioning phases
5 - Activities and Deliverables in the Production Operations & Optimization phase incl. the Start-up and Production Stabilization phase
6 - Activities and Deliverables in the Production Operations and Preparation for De-commissioning phase

Attachment 1 - Evaluation including Appraisal phase

Mandatory activities:

- Discuss and clarify scopes for feasible concepts under consideration; identify execution and Contacting & Procurement (CP) strategies, and risks. On the basis of opportunity roadmap, to enable concept short listing, prepare milestone schedules for key options.
- Execute preliminary identification & deterministic analysis of project schedule risks
- Prepare Level 1 schedule for Concept Select phase
- Project overview
- "Way forward" recommendations
- Scope of work, budget, resources, time schedule, ...
- Summary of the Project's business issues
- High level presentation to the Decision Making Body covering Project's key areas
- Project context, boundaries, Business objectives, Key drivers and critical success factors, …
- Initial assessment of the Opportunity
- Preliminary development plan
- Executive summaries of development studies (reservoir, drilling, facilities, etc.)
- Analysis of local laws and regulations, environmental and operational conditions
- Analysis of the Petroleum Agreement constraints
- Analysis of the Lessons Learned and Risks from other Projects & Assets (from a Production Operations perspective)
- Preliminary analysis of Manpower requirements in terms of competences and skills
- Identification of criteria for OPEX estimate
- Organization chart for the next phase
- Resources, competencies and skills required for the next phase
- Preliminary analysis of commercial outlets and transportation options
- Initial commercial agreements
- Legislation and contractual factors of significant relevance to the project
- Identification of stakeholder and their requirements
- Impact assessment and strategy outline
- Identification and evaluation of major critical risks
- Analysis of potential showstoppers

- Value management activities for the next phase
- Health, Safety, Environment requirements and responsibilities
- Quality requirements and responsibilities
- An evaluation of potential project environmental and social impact
- lessons learned
- Assurance Review
- Other Assurance Checks

Mandatory deliverables:

- Spending Proposal and Concept Selection Terms of Reference
- Executive Summary
- Project Scope & Objectives Statement
- Project Execution Plan
- Field Development Plan
- Roadmap including a Critical Path Method schedule for the lifecycle of the project
- Organizational setup of project incl. project specific roles and responsibilities
- Concept selection report, documenting the decision quality of each decision
- Pre-feasibility study
- Operational Readiness and Assurance Philosophy
- Project Organisation Plan
- Transportation and Market Assessment
- Legislation Review
- Stakeholder Management Plan
- Risk Management Plan
- Value Improvement Plan
- HSE Plan
- Preliminary Quality Plan
- Strategic Impact Assessment
- End of Phase Feedback Report
- Assurance Review Report including Terms of Reference and Action Plan
- Other Assurance Check Reports (Peer Review, Peer Assists, etc.)
- Decision Support Package

Attachment 2 – Concept Selection phase

Mandatory activities:

- Discuss and clarify scopes, prepare WBS for short listed concepts under consideration, execution and CP strategies, and identified risks. To enable concept selection, update Level 1 project schedule(s), including schedule risk analyses, benchmarked durations, schedule contingency.
- Project overview
- “Way forward” recommendations
- Scope of work, budget, resources, time schedule, ...
- Summary of the Project’s business issues
- High level presentation to the Decision Making Body covering Project’s key areas
- Project context, boundaries, Business objectives, Key drivers and critical success factors, …
- Coarse analysis of long list alternatives
- Analysis of short-listed alternatives
- Selection and assessment of best alternative (including preliminary PDP/FPD)
- Definition of criteria for Concept screening
- Preliminary analysis of Manpower requirements in terms of competences and skills
- Analysis of identified concepts from operations and maintenance point of view (Operability and maintainability)
- Strength and weaknesses (for each concept) and recommendations
- Updated project organisation chart for the next phase
- Project manpower plan for the next phase
- Classification and categorization of Laws and regulations updated
- Identification of Authorities requirements updated
- Definition of Permits and Consents sequence
- Timing for issuing documentation
- Major criteria driving the agreements
- Analysis of commercial outlets and transportation options
- Advanced commercial agreements
- Full stakeholder management strategy, action plan and responsibilities
- Risk register update

- Preliminary control strategy, action plan, risk ownership for the preferred development alternative
- Identification and evaluation of risk for each development alternative
- Value management activities for the next phase
- HSE requirements, records and responsibilities
- Quality requirements, records and responsibilities
- Evaluation of any modification to the Environment produced by the Project
- lessons learned
- Assurance Review
- Other Assurance Checks
- Project charter, updated and endorsed
- Environmental authority documentation in compliance with country specific requirements.
- Execute preliminary identification & deterministic analysis of project schedule risks.
- Prepare Level 2 schedule for Define phase using critical path network.

Mandatory deliverables:

- Spending Proposal and Concept Definition Terms of Reference
- Executive Summary
- Project Scope & Objectives Statement
- Project Execution Plan, Updated
- Field Development Plan
- Roadmap including a Critical Path Method schedule for the lifecycle of the project
- Cost estimate
- Organizational setup of project incl. project specific roles and responsibilities
- Concept selection report, documenting the decision quality of each decision
- Final technology development report (i.e. including all pilot plant runs, 3rd party studies etc.)
- Reports of Value Improving Practices conducted so far
- HSSE study reports (HAZID, EIA studies, ALARP assessments, etc.)Spending Proposal and Concept Selection Terms of ReferenceFeasibility study
- Operational Readiness and Assurance Strategy
- Project organization plan
- Permit and Consents plan

- Transportation and market assessment
- Stakeholder Management Plan
- Risk Management Plan
- Value Improvement Plan
- HSE Plan
- Preliminary Quality plan
- Strategic Impact Assessment
- End of Phase Feedback Report
- Assurance Review Report including Terms of Reference and action Plan
- Other Assurance Check Reports (Peer Review, Peer Assists, etc.)
- Updated Level 1 project schedule(s) for Select phase covering short listed concepts
- Updated basis for project schedule document
- Level 2 schedule for Define phase including critical path network, schedule and range of outcomes with probabilities
- Decision Support Package

Attachment 3 – Definition phase

Mandatory activities:

- Discuss and clarify scope, prepare WBS for the selected concept, elaborated on execution and CP strategies, and identified risks. Update Level 2 project schedule, including schedule risk analyses, benchmarked durations, and schedule contingency.
- Project overview
- "Way forward" recommendations
- Scope of work, budget, resources, time schedule, ...
- Summary of the Project's business issues
- High level presentation to the Decision Making Body covering Project's key areas
- Project context, boundaries, Business objectives, Key drivers and critical success factors, …
- Field development scope and objectives
- Development philosophy and selected concept
- Geosciences, Drilling, Facilities, HSE, Logistics, Production Operations, Decommissioning, Local content
- Development Plans and schedules
- Execution, Commissioning and Handover strategy
- Organisation, resources, activities and systems
- Overall execution master plan and schedule
- Specific plans (HSE, quality, cost, construction, drilling, operations and maintenance..)
- Plan to mobilise operations & maintenance resources, systems, processes and procedures
- Commissioning & Hand-over strategy and plan
- Operations & Maintenance strategy & plan
- Classification and categorization of Laws and regulations updated
- Identification of Authorities requirements updated
- Definition of Permits and Consents sequence updated
- Timing for issuing documentation updated
- Finalised Procurement Strategy (Contracting, Purchasing and Material Management)
- Procurement plan for critical and long lead items
- Updated project organisation chart for the next phase
- Manpower and training plan for Production and Maintenance operations

- Major criteria driving the agreements
- Analysis of commercial outlets and transportation options
- Finalized commercial agreements ready to be executed
- Full stakeholder management strategy
- Action plan and responsibilities
- Preliminary control strategy, action plan, risk ownership for the preferred development alternative
- Identification and evaluation of risks for the preferred development alternative
- Value management activities for the next phase
- HSE requirements, records and responsibilities
- Quality requirements, records and responsibilities
- Evaluation of any modification to the Environment produced by the Project
- lessons learned
- Assurance Review
- Other Assurance Checks
- Project charter, updated and endorsed
- Authorities requirements, plans and relevant documents
- Resource loaded and critical path analyzed schedule
- Cost estimate including all backup data/information
- Organizational Setup ready for EXECUTE
- Project specification (P&ID level of definition based on closed out HAZOP and SIL studies)
- All pertinent discipline engineering deliverables in the areas of CSA, E&I etc
- Project supply plan incl. vendor information (technical, commercial offers, bid tabulation tables, etc.
- Include scheduling instructions in Invitation to Tender (ITT) for FEED contract(s).
- Finalize PDO activities

Mandatory deliverables:

- ITT for FEED contract(s) incl. scheduling instructions
- ITT for Execute contract(s) incl. scheduling instructions
- Spending Proposal and Concept Definition Terms of Reference
- Executive Summary

- Project Scope & Objectives Statement
- Project Execution Plan, Rev.1 including
- Risk Management Plan updated, covering the next phases
- Stakeholder Management Plan updated
- Project Assurance Plan updated, covering the next phases
- Field Development Plan
- Roadmap including a Critical Path Method schedule for the lifecycle of the project
- Cost estimate
- Operational Readiness and Assurance Plan
- Permits and consents plan
- Procurement Strategy & Plan
- Project Organization Plan
- Finalized commercial agreements
- Stakeholder Management Plan
- Risk Management Plan
- Value Improvement Plan
- HSE Plan
- Quality plan
- Strategic Impact Assessment
- End of Phase Feedback Report
- Assurance Review Report including Terms of Reference and action Plan
- Other Assurance Check Reports (Peer Review, Peer Assists, etc.)
- Finalized PDO Application ready for approval
- Updated Level 2 project schedule for selected concept and basis for project schedule document
- Level 2 resource loaded project schedule for Execute phase including critical path network, schedule and range of outcomes with probabilities
- Decision Support Package

Attachment 4 – Execute incl. the Pre-commissioning and Commissioning phases

Mandatory activities:

- Prepare Level 3 integrated project schedule including engineering, procurement, construction, (pre-) commissioning & start-up. Integrate master schedule with contractor schedules, Level 4 & higher.
- Produce forward looking progress indicators, monthly, weekly and/or more frequently if required.
- Frequent (preferably weekly) review and verification of contractor's progress and productivity performance during construction.
- Transition plan, covering (pre-commissioning), handover and takeover
- Agreed performance acceptance criteria
- Outline of the main conclusions and results reached for each of the phases involved
- Lessons learned reports- handover and takeover
- Analysis of all contracts administrated for each of the phases involved
- Classification and categorization of Laws and regulations updates
- Identification of Authorities requirements updates
- Definition of Permits and Consents sequence updates
- Timing for issuing documentation updates
- Updated project organization chart for the next phases
- Project scope updates
- Business objectives updates
- Key project drivers and critical success factors (characteristics, major constraints…) updates
- Stakeholder Management Plan updates
- Finalize Well information, Well head status and Completion schemes incl. program
- Reporting of well operations activities
- Drawing modified in accordance with final installation (red mark-up/ as-built)
- Maintenance procedures
- Summary of the results of the HSE Activities: the most significant and/or critical HSE issues are reported
- Definition of preliminary plans for production operations

- Final definition of the organizational structure for production and maintenance operations, including organization chart, roles and responsibilities, skills and competencies, manpower plan and training program.
- Confirmation that the construction activity has been carried out in accordance with the designed drawings and specifications
- Documentary confirmation of compliance with procured item specifications
- Confirmation that plant meets rules, and that all checks and tests needed to assure the integrity of the construction works have been carried out
- Update based on pre-commissioning results and Commissioning strategy (as
- generated from the commissioning philosophy)
- Commissionability & SIMOPS reviews (updates)
- Plan of operations leading to verify that the various process systems components of a plant are properly working and alignment of facilities systems to the start up scenario (to be consistent to start up and Operating philosophy/plans)
- Conceptual engineering study for the evaluation of Facilities Decommissioning & Wells Abandonment (DECAB) Costs, based on criteria minimising the impact on the environment and in line with internal HSE procedure International Standards, domestic laws and contract obligations. (Updates)
- Reservoir Management Plan
- Other information from: Drilling, Facilities, Production & Operation Procurement, HSE as input to Field Management Plan
- Update of Reservoir model, Reservoir development strategy analysis results and Production profiles for identified scenario and risk analysis
- Update of Reservoir monitoring plan and • Reservoir management strategy
- Update of Main features of the Handover Process, Roles and responsibilities for: Development Project Manager, Operations Manager and Operations Project Manager during Handover to Operations, Integrated Commissioning Team, Activities to be executed during the transition from Development to Production
- Operation Readiness Assurance (and review plan of Operation Readiness)
- Acceptance criteria
- Criteria for mitigation and handover of project risks
- Plan for co-ordination of simultaneous Drilling& Completion and Production operations

including procedures, role and responsibilities, risk assessment

- Identification of sourcing strategy and procurement planning
- Expediting, inspection and certification
- Intra-logistics (logistic aspects)
- Start-up, running production, maintenance, inspection and emergency procedures
- Pre-commissioning completion records of the execution of the cold tests on items
- Commissioning dossiers
- List of equipment or system shortcomings agreed between Development and Operations (Punch Lists)
- Documentation of Pre-commissioning conformity
- Procedures for managing SIMOPS (Permit to Work System, barriers, etc.)
- Set-up of operations to be performed during performance Test
- Produce facilities acceptance report in which Operations declares that developed Facilities are as per design requirements, both in terms of production and consumption
- Field data monitoring and performance analysis
- HSSE Management System
- Updated HAZOPs documentation of vendor packages
- Licenses, permits, EIA
- Update operations philosophy, strategies and plans (incl. training documents)
- Update Maintenance philosophy, strategies and plans
- Update Risk Management Plan
- Update Audit and review plans
- Equipment certificates issued by “Notified Bodies”
- Testing protocols (DCS / ESD systems)

Mandatory deliverables:

- Level 3 overall integrated project schedule
- Progress reports
- Construction progress report
- Permits and Consents Plan, UIpdated
- Project Scope & Objectives Statement, Updated
- Risk Management Plan, Updated

- Stakeholder Management Plan, Updated
- Well Final Report
- Well Operations Reports
- Well Program
- Red Mark-up/ As Built Drawings
- Maintenance Manual
- Operation and maintenance data and analysis
- HSE Summary Report, Updated
- HSE Plan, Updated
- Quality Plan, Updated
- Production Management Definition
- Production Plans
- Updated Final Field Organization Plan
- Material purchase orders/contracts
- Certification documents,as: (Construction Completion Certificate, Part Certifications, Mechanical completion certificates)
- Commissioning and Start-up Plans updated and Procedures
- Decommissioning & Abandonment study, Updated
- Field Management Plan
- Integrated Reservoir Study, Updated
- Reservoir Management Plan
- Updated Handover to Operations Framework Procedure
- List of modifications reports
- Manual of Permitted Operations (SIMOPS)
- Material management plan
- Plant operating manual
- Pre-commissioning completion records
- Ready to commissioning certificate
- Commissioning Punch Lists
- SIMOPS procedures
- Test run specification

- Tests Records
- Facilities acceptance reports
- Performance test reports
- Training reports
- Training certifications
- Well handover documents
- End of Phase Feedback Report
- Assurance Review Report including Terms of Reference and action Plan
- Other Assurance Check Reports (Peer Review, Peer Assists, etc.)
- Decision Support Package

Attachment 5 – Production Operations & Optimization incl. the Start-up and Production Stabilization phase

Mandatory activities:

- Evaluation of the Asset based upon both technical and economic drivers
- Summary of Professional Areas studies
- Final evaluation of Development project deviations in terms of time and cost along with activity assessment to provide feedback from the economic, management, technical and operational point of view
- Review of acceptance of Facilities results and analyzis
- Official acceptance of commissioned Wells
- Assessment report on competence requirement closure
- Objectives, scheduling and cost forecast for the current Phase
- Definition of staffing of internal and external resources, allocation of tasks
- Identification of occurred Warnings and problem solving implementation; Identification of Production Checks scope & objective and outcome
- Plan for managing HSE requirements and responsibilities
- Critical Risk analysis (identification, level assessment and prioritization)
- Evaluation and response of foreseeable consequences of residual risk
- Complete stakeholder management strategy and action plan
- Risk control strategy and action plan
- Update of technical documentation
- First Period Production Assurance Review report
- Comprehensive assessment of lessons learned from the Phase

Mandatory deliverables

- Historical schedule information from Execute phase
- Asset Technical & Economic Evaluation
- Provide input into project close-out and lessons learned reports.
- Facilities Acceptance Certificate
- Well Acceptance Certificates
- Production Operations Staff Assessment Certificates

- Phase Terms of References
- Production Operations organization plan
- Warnings and Production Checks Register
- HSEQ Plan
- Risk Register
- Emergency Response Plan
- Stakeholder Management Plan
- Risk Management Plan
- Technical documentation update
- Assurance Review Report
- End of phase Feedback Report
- Decision Support Package

Attachment 6 – Production Operations and Preparation for De-commissioning phase

Mandatory activities:

- Evaluation of the Asset based upon both technical and economic drivers
- Summary of Professional Areas studies
- Proposal of Asset decommissioning
- Decommissioning strategy
- Decommissioning costs estimate
- Identification of occurred Warnings and problem solving implementation; Identification of Production Checks scope & objective and outcome
- Plan for managing HSE requirements and responsibilities
- Critical Risk analysis (identification, level assessment and prioritization)
- Evaluation and response of foreseeable consequences of residual risk
- Full stakeholder management strategy and action plan
- Risk control strategy and action plan
- Update of technical documentation
- Running Production and Improvement Assurance Review report
- Comprehensive assessment of lessons learned from the Phase
- Definition of staffing of internal and external resources, allocation of tasks

Mandatory deliverables:

- Asset Technical & Economic Evaluation
- De-commissioning Proposal
- Phase Terms of References
- Production Operations and de-commissioning organization plan
- Warnings and Production Checks Register
- HSEQ Plan
- Risk Register
- Emergency Response Plan
- Stakeholder Management Plan

- Risk Management Plan
- Technical documentation update
- Assurance Review Report
- End of phase Feedback Report
- Decision Support Package