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FACULTY OF SCIENCE AND TECHNOLOGY

MASTER'S THESIS

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Summary

This Thesis has focused on Visualization and Simulation Technology in oil and gas industry. It contains the common usages and the implementation process of this new advance technology. 3D Visualization Technology has just been introduced since last decades in Exploration & Production of oilfield development. Aker Solutions has introduced the new innovation technology product solutions, which is 3D simulator software for training, planning and testing purposes in relation to operational projects within their business areas. Aker MH AS, Drilling technologies department, Stavanger, has opened the master thesis topic of product management, which the author had this opportunity to write academic report about this product services. The first intention of this thesis topic are to find out where Aker Solutions stands in the industrial for simulation services and how this product is positioned going forward. However, to adapt this thesis into industrial assets management discipline the objectives included the usage benefits and mapping future solutions of the product mainly for the topside operational of Oilfield development particularly at offshore platforms. The structure of Thesis consists of the technology status reviews, an analysis and evaluation of product usages, the benefits of the product and future solutions for oil and gas industry. The work process of the product is called Visioneering®, which is a combination of visualization technology and engineering process. The concept of this technology work process is to provide the simulation services for operation performance improvement by reducing risk in the operation, ensuring process reliability and lowering offshore operation costs and downtime. This thesis also illustrates the basic of oilfield operational process of drilling, maintenance, modification, subsea, and installation of Aker Solutions for better understanding of the product usage.

Preface

This Thesis is submitted as the final part of my Master degree in Offshore Technology – Industrial Assets Management at the University of Stavanger (UiS). The Thesis has been prepared during the spring semester of 2014. Aker Solutions, Drilling Technologies Department is the company that provides the Thesis title of their product management.

I would like to take opportunity to thank Aker Solutions for providing resources and training facility for me to explore the real working environment and important information knowledge, which support me throughout the Thesis preparation. I would like to thank thesis supervisors, Kasper Hansen who gave a great opportunity chance for the thesis topic and Narve E. Endresen who is my mentor of technical knowledge within oil and gas industry. Moreover, Aker Solutions has provided me a very excellence E-learning courses that demonstrate the knowledge and information within organization business areas and also basic Exploration and Production in Oil and Gas Industry.

Lastly, I would like to thank my Faculty supervisor of University of Stavanger, Professor Jayantha Prasanna Liyanage who not only is advising and supporting on my thesis but also gave two important lectures of Decision Making and Human Factors during my Master Degree, which are the methodology analysis of this enclosure report.

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1. Introduction

In this chapter, the background of the thesis is described as the closure of the author's master degree in Offshore Technology – Industrial Assets Management under the discipline of engineering, operations and management of production systems, processes and assets. The aim of thesis study is to explore new innovative technology solutions by described the processes and benefits of this technology for the value creation in the Oil and Gas industry.

1.1Thesis background

Today, upstream exploration and production in oil and gas industry are developing under the condition of efficient economics and risk factors. To achieve this condition, collaboration and real-time integration must include in all phases of the oilfield lifecycle, which starts at the designing stage and continues along planning, constructing and producing until the end stage of scraping.

Visualization and 3D simulator technologies are new and innovative systems for Exploration and Production of oilfield project lifecycle. The cost of operation in drilling rigs is very high due to time-consuming operation with several possible HSE Challenges. Drilling companies try to avoid the high expense of operation and the solution is to execute the operation in virtual reality process to identify the possible problems that might happen in real situation and to reduce risk of unexpected outcomes for example, waves crashing, heavy machinery, blind spots and equipment failure. One aspect of risk reduction is making correct decisions under time constraint and pressure conditions. In actual situation, it is unable to always provide the desired specialist or transport experts on site every time decision is needed. This is major problem that would insult in increased project risk and costs. The typical solution would be to not bring the experts to the risk, but on the other hand bring risk to them. Other critical challenges of oil and gas industry are decreasing recovery cost of drilling, operation and technology, and in the same time maximize production. Aker solutions has launched the product of 3D simulator software technology for training, planning and testing purposes in relation to drilling operation in the projects. This technology process is called Visioneering®, a combination of visualization technology and engineering. The 3D simulators have been used in process of planning, organization and project execution for testing, training and quality assurance in every step of the operation. The main goal is to reduce risk in the operation, ensure reliability and importantly lower offshore operation costs and downtime.

1.2 Thesis Purposes and Objectives

The First objective is to compile the information of process, practical knowledge, previous results, and advance technology in early development stage of the selected product management from Aker Solutions and arrange these resources into common configuration as academic report. This new product had been developed for few years and still is developing to create more values for the industrial service.

The Second objective of this thesis is to identify the usage areas of Visualization technology and 3D Simulator in oilfield project lifecycle. The purpose of this objective is to explore common usage of visualization technology and illustrate the areas usage of this new technology that Aker Solutions has already been used currently in the oil and gas operation processes in drilling rigs operation, subsea operation and maintenance, modifications and operations.

The Third objective is to define the benefits of Visualization technology in oil and gas activities. There are many benefits of applying this technology into oil and gas activities and the purpose is to explore the advantages of using this technology to the project lifecycle management from the conceptual phase to decommissioning phase.

The Fourth objective is to map the future solutions and make recommendation on Visualization Technology for future oil and gas industry.

1.3 Thesis Scope

The Thesis focuses on the technology of Visualization and 3D simulator of Aker Solutions mainly in Drilling Technologies and Maintenance, Modification and Operation business areas. The product has been developed in early stage and currently is being carried on to the next stage. The technology process behind the simulators is called Visionerring®, which is a combination of visualization technology and engineering work process. The thesis mainly reviews the brief methodology of visualization technology in oil and gas industry and explores the new technology. However, these products are being developed and explored for optimization of simulation services. The common configuration was arranged by the knowledge of this technology usage and product management under the discipline of engineering and management of process and production system. Currently, in Norway, Visioneering® and iPort Centre have implemented in three usage areas of Drilling

Technologies, MMO and Subsea which drilling and MMO simulation facilities are based in Stavanger and Subsea simulation facilities is based in Oslo.

1.4 Thesis Methodology

The research methodology is based on literature reviews, data and information analysis and evaluation of project execution case study. Scientific literature reviews came from research under University of Stavanger library databases that used a range of information sources for example, digital journals, SPE (Society of Petroleum Engineers) papers, academic and commercial abstracts and Internet search engines. The data analysis method is used to evaluate the implemented project study from the actual company against the academic knowledge from the author and knowledge from researching data to explore the usage benefits and opportunities of the product services. MTO (Man, Technology and Organization) analysis is the other main method that uses to analyze worker skills, interfaces between human-machine and collaboration within an organization in term of decision making and work management.

1.5 Thesis Limitation

Aker Solutions has involved in many contracts and projects in the past and at the present, the thesis delimitation is based on existing projects that Aker Solutions had implemented this technology into work process for planning, training and executing of the project performance optimization. Since the author has aimed on the defining usage areas and benefits of this technology within the industrial assets management discipline, therefore the architecture of simulators software will be not revealed. Also the principle of operational processes in exploration and production are showed in basic understanding of how the technology has helped the organization to improve operation process in term of reducing risk and optimizing the performance. Aker Solutions is a worldwide company that has training facility in different locations in almost every continent around the world. The limitation of accessing to the data information and experience the actual product is only delimited in Stavanger simulation facilities (iPort). Therefore, the evaluations of product and project execution are analyzed in two usage areas of Drilling operation and MMO.

The Thesis delimitation is also based on requirements and regulation of University of Stavanger, which is subjected as 30 ECTS Master Thesis Offshore Technology. The thesis has to be handed in before 15th of June 2014, which length of preparation was about four months.

1.6 Structure of the Thesis

There are 10 Chapters in this Thesis structure, which are divided into four parts.

Part 1 Introduction and Status Reviews

This part consists of chapter 1 and 2, which give a brief introduction of the Thesis objectives, purposes, and the methods used and also review the technology and application products in the past and at the present of the real world industrial market.

Part 2 Analysis and Evaluation of Industrial Product Usages

This part consists of chapter 3, 4, 5 and 6. The industrial product of Visualization Technology is reviewed and analyzed by author knowledge within Industrial Assets Management. Aker Solutions is the industrial company that the author has chosen to be case study. The previous and ongoing company projects that had been executed with this implemented technology are being analyzed and evaluated.

Part 3 Benefits of the Product and Future Solutions

This part consists of chapter 7 and 8. This structure part illustrates the product implemented outcome and the opportunity to expand these benefit results to be the future solutions for other operation in oilfield development. The benefits are defined by the previous implemented real industrial project study. The future solutions are established based on the evaluations of case study and benefits of the product.

Part 4 Discussion and Conclusion

This part consists of chapter 9 and 10. This part is the conclusion of the thesis that discusses about the analysis of further improvement of the product from the study and concludes all the results of evaluation and analysis of all chapters from previous parts.

2. Status Reviews

2.1 Literature Reviews

Literature reviews show the evolution of visualization technology over the past decades. The reviews have indicated the development and purpose of usage application in oil and gas industry and also have shown challenges of the technology interfaces.

2.1.1 Visualization Technology Overview

Computer graphics have played an important part in most of oil and gas Exploration & Production industry since 1980s (Slatt et al., 1996). Furthermore, this technology has continuously developed since then until the present, start with two dimensions (2D) slices represented oil reservoirs to three dimensions (3D) modeling and simulating (Dopkin and James, 2006). In the past, there were many challenges in obtaining a large amount of data being used in Exploration & Production of oil and gas processes. However, at the present technological development could solve those challenges of large amount of Data. The industry has developed the computer graphics of workstations which now it has presented in 3D models as next generation of graphics computers with remote sensors and real time analysis to increase their business performance and production optimization. Visualization of seismic data was first introduced to the oil and gas industry in the early 1990s and continues developed until today, which were presented in the large screen (Figure 1). Nowadays, large screen visualization comes close to duplicating the human perception system that can observe at about a 160˚ field of view, showing 8 to 9 million pixels (Giertsen, 2003).

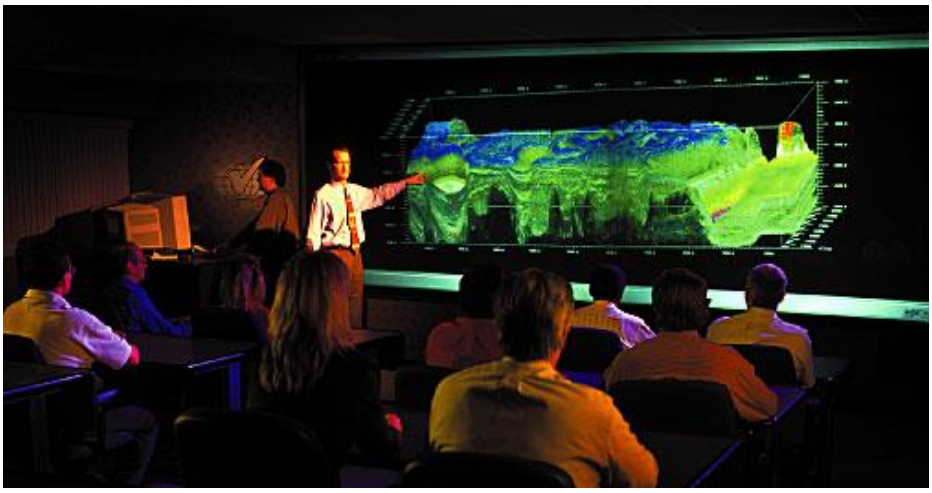


Figure 2.1 Visualization 3D Volume Seismic *(OGI, 1999).*

This technology also called virtual reality centers (VRCs) rooms with feature such as 3D and stereoscopic images, becomes very helpful in E&P operations and in oil facilities projects (Petrobras, 1999). These VRCs give specialists and experts the ability to comprehensively and quickly interpret the large volumes of data and significantly reduce cycle time in prospect generation. The processes in VRCs incorporate amount of real time increased dynamic data into operation models and high-resolution reservoir models by high performance computerize systems.

2.1.2 Development of Visualization Technology System

The advances in graphics and hardware simulation technology have significantly developed recently therefore, the cost of computer systems that operate visualization systems has reduced from the past. There are also more visualization software and more variety of modeling programs available in the market that offer better quality and capability of these varies programs range from common animations through advance 3D spectacles.

The development of visualization has affected the costs of system to be minimized. The models and the environment were captured in real to create detailed component design, operating procedures, field simulator, live visualization, field databases and accessibility studies (Calum MacKinnon, 2003). The use of those systems produced can optimize the required training and provide an integrated solution in concept of execute right from the start of a field development project where the systems just form the information database for the project field. This system development is used during the FEED stage of the project to visualize the layout of field development and improve the design of equipment and component. Moreover, the system is used during the engineering phase for accessibility checks and development of installation method development in the procedures. Training and safety assessment procedure can be done before execute in real at offshore by using the visualization system to improve the safety performance and efficiency of the operations and maintenance.

2.1.3 Challenges of Visualization Technology

There were many challenges in applying Visualization Technology to E&P in oil and gas industry during the past decades. The following challenges are the main factors that had the effects on the early development stage of Visualization Technology.

a. Human Perceptions and Expectation

There are many levels of expectations in virtualization computer graphics in reality for instances, the quality levels of virtual reality have to be as similar as realism. According to Johns (2000), the main realism factors are scene realism, consistency of virtual environment data with real world experience and meaningfulness of experience. However, those challenges in realism of virtual reality world have to deal with different levels of perception of the users when they experience from virtual workstation and then go out to the real workstation. Human perceptions are different depends on background and knowledge experience of each user and specialist. Therefore, visualization has to create a method that everyone can understand and be able to interact and represent the information according to their experiences and responsibility roles.

b. Visualization Information Data

Oil and gas applications always deal with a large amount of information data that are complex and difficult to interpret in production life cycle of E&P (Johnson, 1999). This challenge always occurs when geoscientists use the data to interpret and visualize for the consistent model of subsurface and also when engineers plan and implement the methods for drilling process improvement and simulation process of virtual world before the real world facility exists. The difficult task will be visualizing the data from both areas in the real time constraints. However, interpreting a reservoir model does not need to visualize the entire model and not all engineering processes are needed to visualize in real time condition. Most of the E&P applications do not require specific real time constraints (Russo et al., 2004), only some applications that require follow up and correction in deep-water horizontal well, subsea equipment installation, simulation of offshore structure and emergency scenarios application. To be able to reach this challenge, the visualization systems are needed to reflect the state of field development (early exploration, exploration & drilling appraisal and production) that contain complex data and information.

c. User Collaboration

In oil and gas exploration & production process, it is important to have well communication between group of users who are involved in different stages of field development and also the authority of decision-making (West and Hubbold, 2001). In the virtual environment, all the users from different fields are needed to collaborate between each of them especially in real time process. The background knowledge, experience and skills of users are typical different

Therefore, the visualization system has to create a standard method that every user can understand without any background and be able to share information and experience during work task.

2.2 Oil and Gas Exploration & Production Visualization Applications

Exploration and Production of oil & gas comprise of workflows with pipeline processes and related disciplines of Geophysics, Geology, Reservoir, Production Engineering, Economic and Business Administration throughout the E&P life cycle of exploration, appraisal, development and production (Sousa, 2012). To main goals of E&P today are to improve exploration success and to increase recovery from new and existing fields using advance operating systems. The challenge is a lack of ability to visual, touch and feels the sub-surface reservoirs and recovery process. Moreover, in the case of deep offshore E&P field development project, there is specially challenging and complex in terms of financial investment, interface management, work process packages and aggressive execution schedule or project lifecycle phase (Cain and Deliac, 2006). Therefore, the visualization applications were developed for the ability to visualize in every E&P sequence activities started from 3D geomodelling and seismic interpretation, installation of the production facilities offshore platform and transportation of crude oil and rich gas.

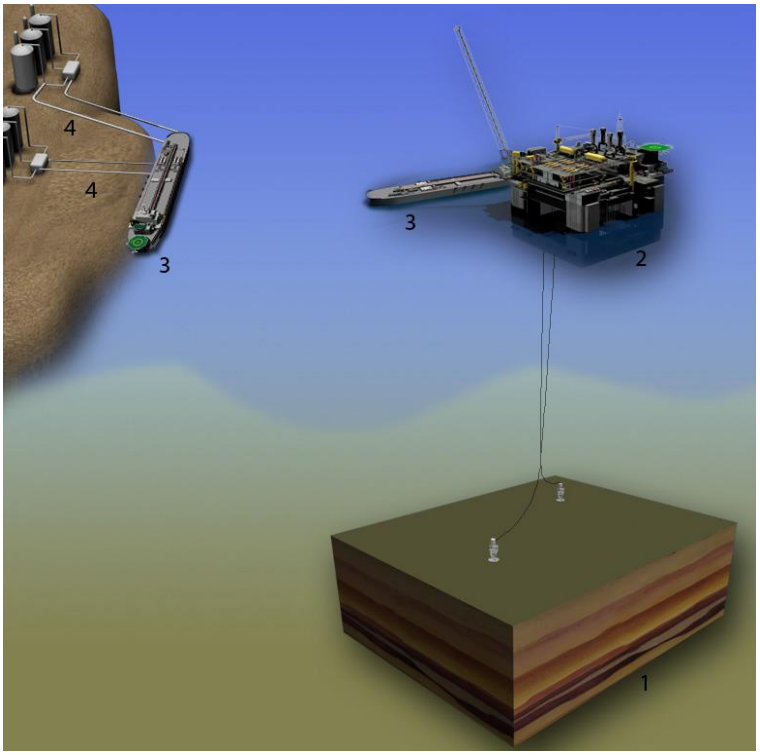


Figure 2.2 E&P Sequence of Activities *(Russo et al., 2004).*

The figure 2 shows the typical E&P sequence of activities, start from 1) reservoir, 2) production offshore platform, 3) transportation ships and 4) pipelines and production facilities. Visualization technology could be applied in every sequence of E&P activities by using 3D geomodelling and seismic interpretation to identify characteristic of reservoir and building the 3D model of offshore facilities based on the actual platform with simulation applications software of production process activities. Transportation and pipeline network can be simulated through the visualization applications.

2.2.1 Geosciences Application

Geosciences activities were the first ones of oil and gas industry that apply 3D visualization technology. The objective of applying this technology is to elaborate the subsurface model that represents the best reservoirs for the exploration process.

3D Seismic Interpretation

The consumption of drilling wells for crude oil is depended on the decision to drill that should be taken in concerned way based on the information and knowledge of the geologic conditions of the area of both surface and subsurface. 3D visualization applications have shown the benefit usage through improvement of accuracy, completeness and efficiency of interpretation and reservoir modeling (Zamel et al., 2001). 3D seismic has selected to be the method of drilling spots by displayed the subsurface ultrasonography, which generates seismic logs that provide approximate image of subsurface. Recently, 3D seismic interpretation has developed from traditional seismic interpretation 2D interpretation slices to 3D volumetric interpretation. Visualization technology has been developed as a tool to understand and characterize surface and subsurface phenomena by constructing visual images out of numerical data in three dimensions. Visualization also helps geoscientist to analyze large quantities of data faster and adjust the opacity and color of the seismic volume in three dimensions for isolation of data attributes like porosity, phase or velocity which may predict the presence of hydrocarbons by rendering data transparent. Moreover, by this visualization technology geologists are able to do modeling scenarios on a 3D map to explore the possible outcomes and results of various activities.

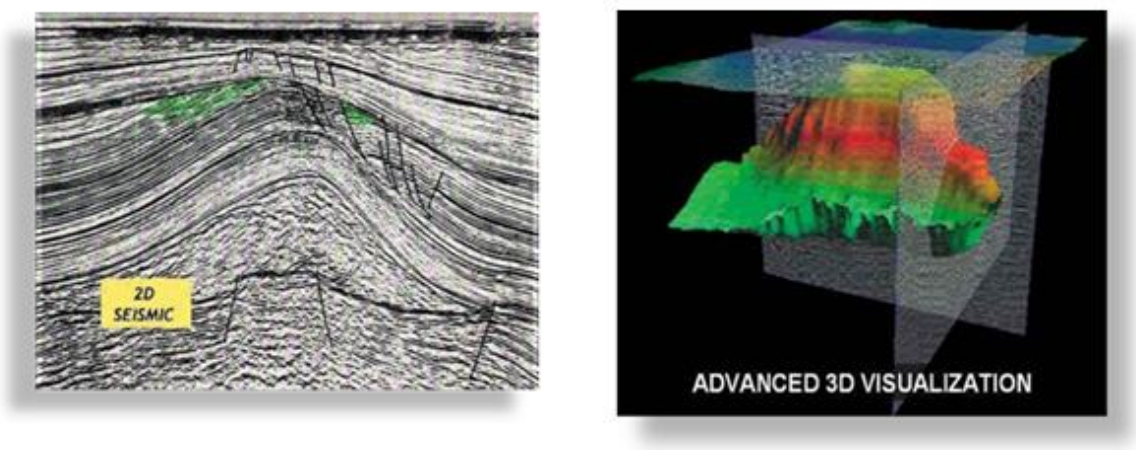


Figure 2.3 Advanced 3D visualization of seismic (right) and traditional 2D seismic image (left) *(Exploration, 2012).*

2.2.2 Drilling Application

E&P industry has leveraged new visualization technology to reducing lifting and finding costs by developing the use of data visualization and real time monitoring. Drilling operations are the one of sector that involve with non-productive time caused by mechanical failures, weather, and logistical problems (Purdy, 2011). The visualization applications enable geoscientists and engineers to generate more comprehensive field data and geologic model for drilling operation and well completion.

The practical example of drilling application that helps planning available data, surveillances real-time data and captures knowledge information is "eDrilling". eDrilling is a new and innovative system for real-time drilling simulation, 3D visualization and control from a remote drilling expert center (Rommetveit et al., 2008). The drilling data of surface and downhole are presented in real time to monitor and optimize the process. Drilling simulator is integrated in the system to automate different drilling processes dynamically for evaluation, quality check and corrections and diagnosis of drilling conditions. The application creates virtual Welbore with visualization of the downhole process to enable collaboration of all drilling activities in real environment. The typical drilling well platform is located offshore somewhere around 200-300 Km from the onshore drilling center support. There are many revolutionized communication between onshore and offshore for example, Closed Circuit Television (CCTV), remote control support, Video conferencing and wireless video and audio communication (Herbert et al., 2008). The application supports the real time decision making by create virtual mirror process that simulated throughout the drilling processes, which give

the important information of temperature condition, friction status along the drillstring and wellbore, cutting transport conditions and pre pressure a head of drill bit. Moreover, the application system also establish 3D visualization of Well to enables the operator to get true overview of well that displayed in 3D graphic together with relevant real time information.

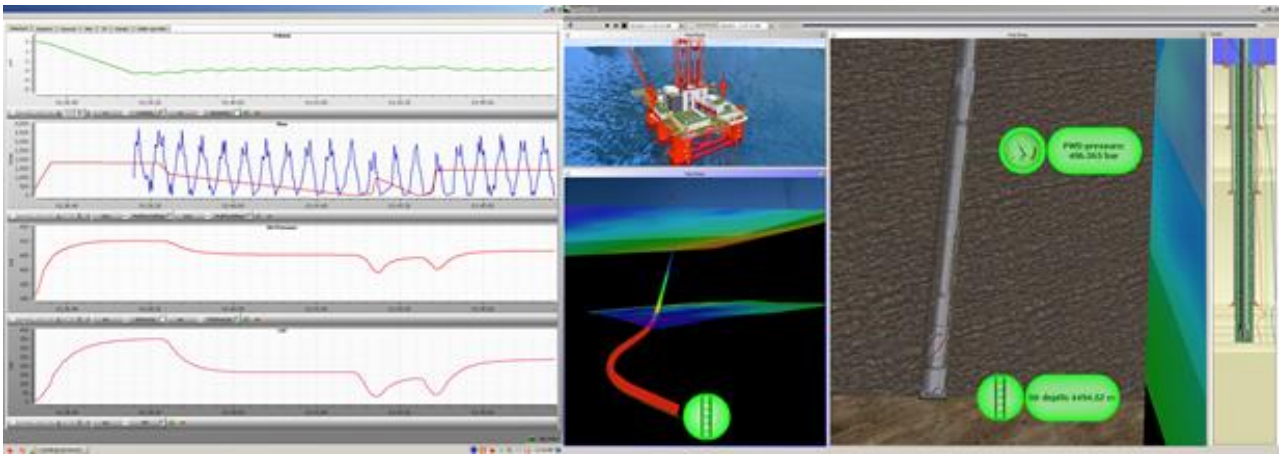


Figure 2.4 eDrilling Virtual Well.

(http://www.edrillingsolutions.com/index.cfm?id=225273)

2.2.3 Subsea Installation Application

There are many working challenges in the subsea environment for instance; subsea operations have to be done below sea surface by divers or Remotely Operated Vehicles (ROV's). When performing task in this remote condition, the operators at onshore have to establish an image of the subsea worksite by using CAD drawings and sketches under limited visual information available from the real time survey display. This is traditionally way that the operators have been done in the past decades where the subsea worksite is only based on the 2 dimensional perception of each operator. However, in complex subsea operations in deep water, 3 dimensional visualization systems has been developed to create subsea worksite by virtual model of the real subsea environment and also input real time data to present in animations for fully operational subsea worksite. This 3D system will let each operator share same perception of subsea environment (Calum MacKinnon, 2003).

Subsea 3D modeling is a design tool to develop the complex equipment and component used in subsea operation such as manifolds, ROV's, tooling and trees (Garmulewicz, 2005). The models could be simulated to establish a procedure that can demonstrate and verify in the operations in subsea environment. For example, ROV simulator is one of the applications that will create realistic virtual subsea world for the engineers and controllers to be trained and

familiarized in the operations before they do the real task at offshore. In the virtualization system, the real time inputs can provide enhanced spatial awareness as well as safety and efficiency performance in the subsea worksite. Moreover, the entire relative positions of the ROV systems, crane hook and subsea structures can be monitored in real time which could improve subsea navigation in low visibility conditions and also reduce operational risks like entanglement. Subsea visualization system is usually used from conceptual phase though to decommissioning phase, it also has provided a cost benefit in area of engineering design, marketing and some particular applications in oil and gas industry.

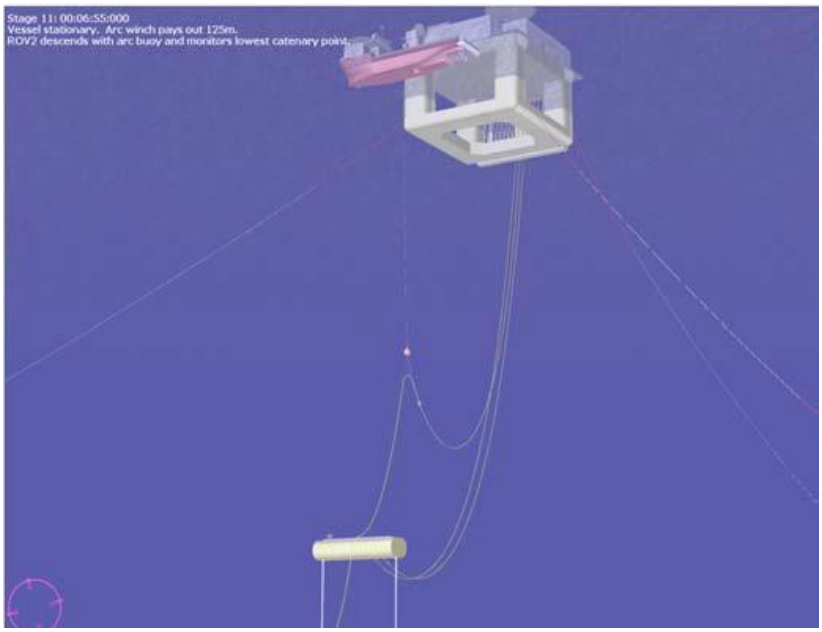


Figure 2.5 Typical Riser Installation Operations in Virtual Simulation *(Calum MacKinnon, 2003).*

2.2.4 Offshore Facilities Activity

Nowadays, offshore assets for example structures, pipelines, subsea facilities and FPSOs are modelled using computer graphic software to visualizing and performing both static and dynamics simulations of these structures, modifying maintenance work, monitoring pipelines and dealing with emergency scenarios.

Offshore processing plants are the world's largest and the most complex facilities in which, many upgrade, maintenance and modification projects involve so many workers who must be well trained, especially in safety operations for example, handling fires, high pressure leakage, toxic chemicals and other emergency incidents (Harry Daglas, 2012). Conducting training exercise at actual offshore site using actual equipment that might be on high risk of

damage is a challenge activity especially the operators who are new and unfamiliar with the equipment and site. Therefore, the visualization and simulator are used as off-site training exercise for realistic practice before the real activity is taken place. The use of 3D simulation is designed to help user to have better execution plan and procedures by simulate the proper training under the safety requirement on 3D environment. The offshore structure models are created from a combination of plant drawings, CAD geometry and laser scanning of the facilities. The 3D digital models are also comprised of the usage function of equipment such as cranes and movement of cranes interacted with human operators surrounding by the virtual environment. Then the operators are able to adjust themselves to the real operation under simulated environment when they are using equipment at offshore plant in practice.

In traditional ways, the planning depended on the operators' experience when they perform the tasks. 2D drawings were used together with inaccurate historical data which many time led to miscommunications and delays during the project executions. However, 3D simulation systems have introduced to solve this tradition ways by using the simulation technique to improve the procedures and planning scheduled. The different of maintenance and operations scenarios could be performed without having operators on the actual plant. Operators can experience the layout of offshore plant, pipeline, equipment, walking paths and evacuation routes by simulation program.

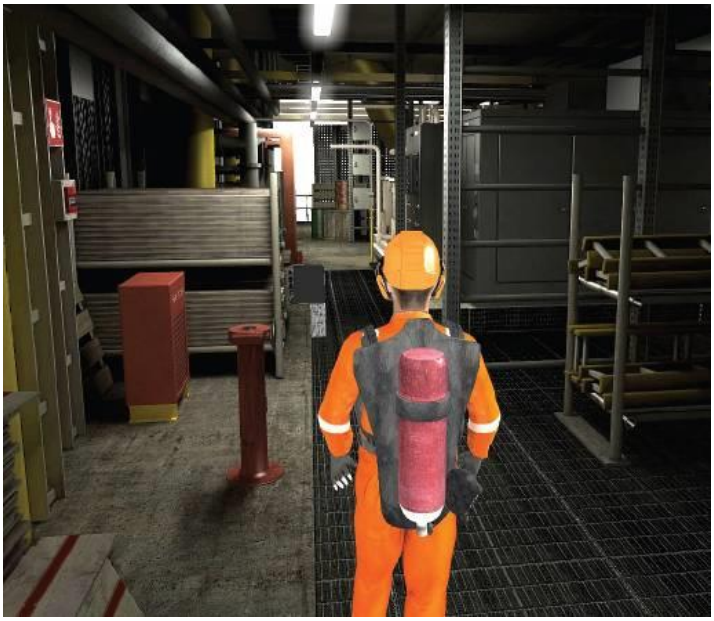


Figure 2.6 The simulation of virtual walkthroughs of facilities in offshore oil platform.

(http://www.pipelineandgasjournal.com/virtual-reality-3d-training-pipeline-employees?page=show)

2.3Visualization Products in the Market

There are many Industries that have been using Visualization technology for training, performance improvement, reducing risk and many other benefits. Aerospace, transport, Architecture & Design, Education & training, health & medical and other more nowadays have applied 3D Visualization application. Visualization helps design team and engineers share a comprehensive understanding of complex processes, data and mechanisms. Visualization simulator helps reduce risk, costs and time for discovery research methods. In the past, the industries that apply this technology are high risk enterprises which required many hours of personnel training and safety procedure method. However, due to the rapidly development of computer graphic which not only become cheaper but also have more efficient on visualizing the real image and environment context, many industries have future plan to implement this Visualization simulator into their processes.

2.3.1 Christie Digital Systems 3D Visualization Applications

Christie is a global visual technologies company that offers alternative solutions for business, entertainment and industry. The main products of Christie are high resolution projection display and 3D advance visualization simulation. The 3D virtual reality applications and computer modelling for markets that Christie provides are Aerospace, Design and architecture, Education and training, Energy, Government and infrastructure, Museums and entertainment, Sciences and biotechnology. With the 3D display solutions that have the power and flexibility to produce images of any size or resolution for the selection options of customized or standard, Christie become the leader in market of visualization technology. The advance technology that Christie first introduced is the Christie Mirage 4K, the first and only 4K (3840 x 2160 pixels) DLP® (Digital Light Processing) projector at 120Hz performance (Christie, 2014). This is a new revolution high resolution display of image processors with increase frame rate capabilities for new levels of visualization functionality. A Christie® CAVE™, Cave Automatic Virtual Environment solution, is a visualization room that allow all area of users to share experiences, discovery and decision making (Christie, 2014).

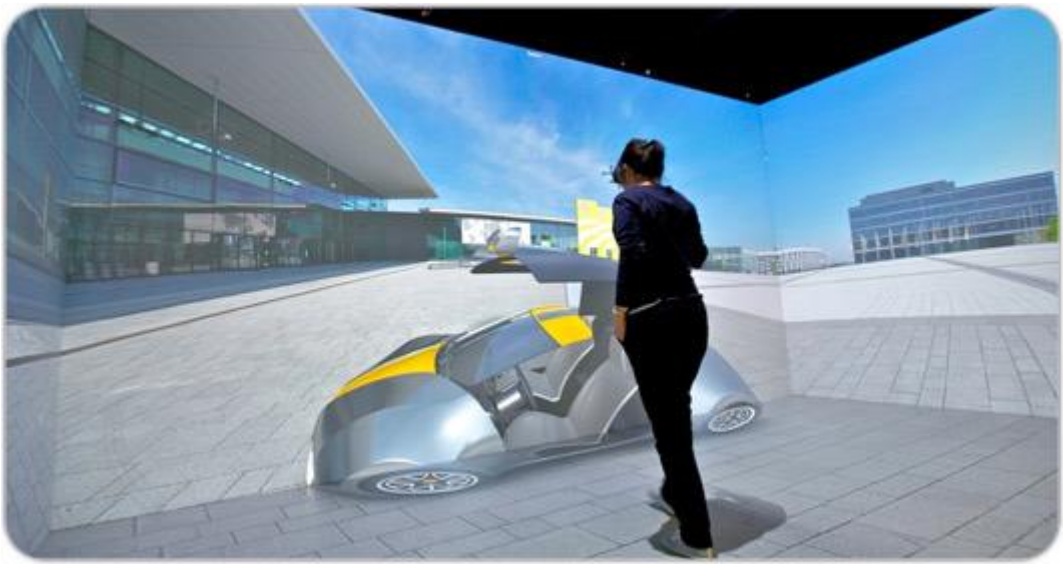
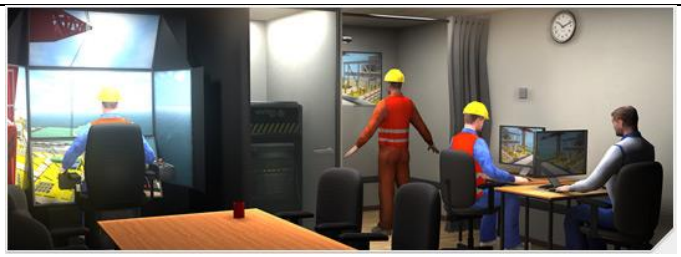


Figure 2.7 Christie CAVE™ (*Christie, 2014)*.

2.3.2 Vortex by CM labs Simulations

CM Labs Simulations Lnc. Has developed Vortex simulation platform software. Vortex software provides simulation capabilities for five different industrials, construction, defense, energy & offshore, ports and robotics. Vortex is capable of setting industry standard for interactive 3D dynamics and simulated equipment behavior (Vortex, 2014). In Energy and Offshore products, Vortex allows the industry to test, plan, and train operations with interactive, real-time simulations and visualizations. There are four type of products provided, Scalable Vortex Platforms, Offshore Equipment Training Modules, Team Training Station and Software for Simulation Engineers.

Table 1 Vortex by CM labs Simulations products and services

Scalable Vortex Platforms Vortex simulator platforms provide training equipment operators as in the pictures. The immersive scenarios are created for multiple worksite challenges to improve skills and preparation of user.	
Offshore Equipment Training Module There are four applications in offshore equipment training that Vortex has provided. Top left: Knuckle Boom pipe Handler Simulator. Top right: Luffing Boom Crane Simulator. Bottom left ROV simulator. Bottom right: Knuckle Boom Crane Simulator. All training scenarios prepare operators for extreme operational challenges.	   
Team Training Station Vortex team-based skill development training allows work crews to collaborate and communicate to get the task done safely and efficiently.	
Software for Simulation Engineers Vortex users have the tools, libraries, and powerful features they need to develop and integrate real-time, high-fidelity simulations	 

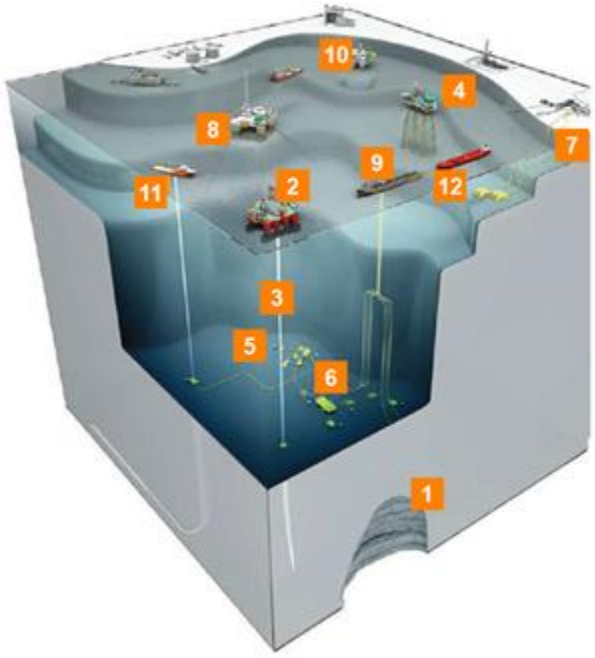
(Information and images from Vortex by CM Labs website: http://www.cm-labs.com/energy-offshore/products/all)

3. Industrial Case Overview

In this chapter, Aker Solutions, the company that this thesis is written about, is introduced. The company overview, main business areas and the innovative technologies are also reviewed. The present facts and technologies reviewed in this chapter come from the company website (AkerSolutions, 2014e).

3.1 Aker Solutions Company Overview

Aker Solutions is a global provider of products, systems and services to the oil and gas industry built on more than 170 years of industrial tradition. There are approximately 28,000 employees working for Aker Solutions more than 30 countries on all continents in the world. In year 2012, Aker Solutions reported an EBITDA of 4.7 billion NOK. Technical capabilities together with engineering, technologies and services range from field development, Development, Production and field life cycle services Figure. Aker Solutions has their own vision of being the third partner for solutions in the oil and gas industry through living on six values, which are HSE mindset, people and teams, open and direct dialog, hands-on management, and delivery quality results (AkerSolutions, 2014f).



1. Geology and geophysics
2. Deepwater drilling
3. Drilling risers
4. Surface trees
5. Subsea systems
6. Umbilicals and flowlines
7. Hydrate inhibition
8. Mooring equipment
9. Processing technology
10. Asset integrity management
11. Deepwater well intervention
12. Offshore loading systems

Figure 3.1 Aker Solution production and field life cycle services *(AkerSolutions, 2014f).*

3.2 Aker Solutions Business Areas

Aker Solutions has provided globally products, systems and services to the oil and gas industry through the life of a field as describe in figure below. There are six business areas of products and services that currently had been provided (AkerSolutions, 2014e).

1. **Drilling Technologies**

Aker Solutions provides deliveries of drilling equipment, systems and lifecycle services for application in offshore and onshore drilling units. There are two sub business areas, which are Drilling equipment and Drilling lifecycle services.

- Drilling equipment – Aker Solutions provides drilling rig packages and individual high performance equipment to many drilling service companies. The portfolio contains the full range of topside drilling equipment and systems.

- Drilling lifecycle services – Aker Solutions provides support of global drilling lifecycle service for customer worldwide. Services include spare parts, technical support, modification and professional rig training.

2. **Engineering**

Aker Solutions worldwide Engineering provides full field development understanding from concept selection to completion and covers all key products and technologies. They also provide services as a front-end engineering and design (FEED) provider and have strong track record from engineering and procurement (EP) deliveries and engineering, procurement and construction management assistance (EPcma) deliveries.

3. **Maintenance, Modifications and Operations**

Aker Solutions is significantly involved in increased oil recovery, tie ins, and other modification activities for example life extension of existing fields and facilities. Aker Solutions has been involved in design and construction of more than 85% of all platforms on Norwegian continental shelf. Together with maintenance, modification projects with development of technologies and engineering specialist teams, Aker Solutions provides efficiency solutions for Oil Company on effort of reducing price on operating cost and extent life of existing fields.

4. Subsea technologies and services

Aker Solutions provides comprehensive subsea products and operations to increase production, enhance feasibility and extend the boundaries of oil and gas recovery. Aker Solutions has 50 years of subsea design, manufacturing and installation experiences and also experience with innovative concept to produce cutting-edge design and services. Subsea technologies are the key to solving oil and gas challenges.

5. Subsurface and well services

Aker Solutions provides a wide range of subsurface and well services, including reservoir evaluation, access to subsea wells with intervention vessels and downhole well intervention services.

6. Wellstream processing

Aker Solutions supplies process equipment for the treatment of oil, gas, produced water and solids for the upstream oil and gas industry, offshore as well as onshore.

3.3 Visualization and 3D Simulation Products

Aker Solutions drilling technologies businesses have provided lifecycle services for all drilling equipment and systems, from top drives and drawworks to drilling riser and mud mixing systems. The services served customers in hubs around the world. The hubs are equipped with Aker Solutions drilling simulations, which offer onshore training opportunities to customers. This simulator technology based in Stavanger, Norway provides customers and clients with new opportunities for rig optimization through Aker Solutions performance technology center. Products and services are Visioneering simulators, Equipment training simulators, Single equipment simulators, Well simulators, Full operations simulators, Simulator operations and support, Drilling optimization.

3.3.1 Visioneering®

Visioneering defines as a work process that combines visualization technology, engeering and installation. The concept is to help understand reality across the collaboration between all parties involved in the production activity through the simulation technology in virtual world. Visioneering® principle combines visualization and engineering in new work method by involved 3D simulators in process of planning, organization and project execution for testing, training and quality assurance. If products and services are perceived to be equal, then it is not about the method of what to do but it is about how to do it. This principle focuses on the context of how to execute content of products and services. For example, in operation activity of oil and gas the content of engineering would be Rig specification, Physical construction and processes. The context of visioneering principle would be how to maximize equipment, performance and maximize process performance.

This principle also states that perception is reality. Human perceptions of any object or the way they understand the process are not the same. For example, lets person A and person B describe what is the color of apple would be, person A who grow up in the area that there are mostly red apple might say the color is red. However, person B who always eats only green apple might say the color is green. Therefore, both of them might talk about same object but totally different apparent depends on perception. This example often occurs in work process in every industry when there are misunderstandings in work process between work departments because of different perception. Visionneering technology allows people to share their perception in their mind by design and manage solutions through the knowledge of 3D simulator.

Xatrix™ is a 3D engine based on advanced gaming technology which is capable of handling large quantites of data at once, portraying these as highly detailed 3D scenarios and landscapes. There are five features of these software simulators according to iPort Magazine that Aker Solutions has published (Paulsen, 2010).

1) **XfactorDES** (Drilling Equipment Simulator) generates identical 3D models of rigs, including their control systems. The simulations are so accurate and they can be used to test the actual equipment, train offshore crews, and plan entire projects while remaining onshore. The PDES (Portable DES) is in a transportable container so it can be moved to different locations without having to be reassembled.

2) **XfactorDPV** (Drilling Process Viewer) receives signals from the many sensors on and around the drilling equipment, which are converted into detailed images of drilling operation. This provides a clear picture of the health, progress and risk factors in the well, which would be portrayed as graphs and numbers.

3) **XfactorMOS** (Marine Operation Simulator) has identical control systems and physics to those of the ROVs (Remote Operation Vehicles) used for subsea operations, as well as a collision detection system including the data regarding subsea constructions and their surrounding environment. It also can be used for virtual subsea construction check-ups and maintenance, as well as subsea operation planning.

4) **XfactorLOS** (Lifting Operation Simulator) has identical control systems to the simulated crans space management technology, and collision detection. It can be used for pre-testing, planning, or to demonstrate lifting operations before there will be implemented with real cranes.

5) **XfactorRTM** (Real Time Monitor) has identical gathering information from offshore platforms and forward it to their simulated versions.

3.3.2 The iPort Centre

The iPort is an integrated operations center for offshore industry. It provides 3D simulators and other visualization technology in process of drilling, modification of topside, subsea and down-hole operations. The iPort Centre have five main areas, which equipped with different simulator setups. This simulators show virtual images of existing offshore constructions and real surrounding environments. Each virtual simulation copied and recreated a virtual asset of offshore together with the environment in virtual versions for real operation and installations for testing and training staff. There are five areas of iPort simulators, which are dome-shape training simulator, two Visioneering suite, A Mission Control Room, and an Online Rig Support room (Paulsen, 2010).

1) The dome simulator is the biggest simulator in the iPort. It is mainly be used for training of offshore personnel.

2) Two Visioneering Suites can be used for setting up planning, engineering and pre-commissioning to check the compatibility between pieces of machinery and to check the compatibility between existing software equipment and new software equipment to be installed.

3) Mission Control Room provides clients to bring their own crews and to have access to simulators to visualize drill floor activity (XfactorDES) and drilling process (XfactorDPV) from their own rigs. Other usages can be multi-discipline operational training, well construction and drilling management.

4) The Online Rig Support room contains personnel who provide 24 hours support for example troubleshooting and general support for day-to-day operations. The support personnel will have access to all rig documentation as well as a simulator. The purpose is to improve the communication between onshore and offshore personnel, facilitating rig operation and repair without having to send personnel to offshore.

4. Analysis of Product Usage Areas

Aker Solutions has applied the concept of visualization solutions into its business areas which covering the entire upstream value chain. This concept focuses on the ability to visualize a specific problem ahead of time and find out the way to solve the problem before it actually occurs. This visualization concept also provides the world class competitive advantages of innovative engineering, technologies, products and solutions in planning, fabrication and execution of capital projects for example, installation and removal platform, subsea system, and advanced drilling equipment. Not just provide the solutions but this concept also provides lifecycle operations, service and maintenance for offshore activities that contain high risk and costs. The Visioneering and iPort facility, located in Stavanger, Norway, have been used for training, planning and testing in drilling technologies, and maintenance, modifications and operations (MMO). The key benefits of this technology are to reduce risk, increase cost efficiencies and improve operational performance before the activity is started.

Figure 4.1 Visioneering and iPort centre in 3D simulator environment.

(http://akersolutions.com/Global/image_bank/Products_and_services/Drilling/Aker_Solutions_Drilling_simulator_in_a_dome_solution.jpg)

4.1 Drilling Technologies

Aker Solutions drilling technologies business area offers drilling lifecycle services to clients on equipment and systems ranging from top drives to drilling risers and mud mixing system (Aker). This global service presents expanded service availability and provided support throughout the lifetime of drilling equipment. While this drilling lifecycle services are being served to customers, the visualization and 3D simulation software also have developed to handle large quantities of data simultaneously and portray these as detailed 3D scenarios and landscapes with excellence visual quality. This technology helps understand reality for all involved parties (clients, operator and service provider) and also prevents misunderstanding and mistakes in operational activity. The main goal is to maintain long term relationship with customers and to deliver high quality services. The common usage areas of Visualization technology in Drilling lifecycle services are training, installation, drilling and design processes, condition based maintenance, and lifecycle engineering.

Remarks

Due to high complexity and technology advances of drilling equipment and operation, the services provided need to be delivered with high quality throughout the lifetime of equipment. To be able to accomplish this goal, there are needed to be excellence training and assessment services provided for clients to get to know more about the usage of advances drilling equipment and control systems. The services that often are provided in the market are spare part and equipment service, field operation service for solving technical challenges, overhaul and repairs service. The quality of services can be indicated by speed (time consumption) and product quality warranty that the company promise to the clients.

Strengths: Aker Solutions have provided all the requirements that the services providers have committed in the market. 3D visualization and simulator are the key components that provide competitive advantages in the market particularly in field service. The traditional field service is conducted by providing personnel who has OEM experience and resources to solve the technical challenge at the field operation, which located in Offshore. With simulation facility, this service could be done onshore without having risk and expense sending personnel offshore. Moreover, simulation facility can be used to monitor the drilling condition to help support decision-making. With simulation technique, the speed of execution operation can be improved and optimized by training with the real equipment and control system under virtual environment at the simulation facility onshore.

Opportunities: The future opportunity that drilling operational service area could provide, would be fully automated drilling control systems. At the moment, Aker Solutions has provided up to date advance drilling equipment, also control and monitoring systems that partly using robotic system and less personnel at work site. However, as the human error is the main component that causes the accident or incident and skills of human operator are depended on personnel competency, fully automated system would be the future solution in this case. Moreover, remote drilling services have been introduced in the drilling operational by using advanced visualization and analysis capabilities for real-time data for example, WellLink RT service of Baker Hughes (BakerHughes, 2014). This service allows operators to make accurate decisions within a collaborative environment of support expert and real-time monitoring system onshore. With this technology services combined with fully automatic control systems and simulator, there will be opportunity that drilling operation could be done offshore without operators execution offshore.

4.2 Maintenance, Modification and Operation

In the beginning Visioneering technologies applied mainly to the rig and drilling simulation sector however, Visioneering is now increasingly being applied to the Maintenance, Modifications and Operation sector (MMO) after a series of successful applications with operators proved its effectiveness (AkerSolutions, 2014d). Visioneering MMO can deliver advanced simulator technology and services based on PDMS model or laser scan of Aker solution MMO (Fadnes, 2013). The simulator can provide radio of 1 by 1 size with design and reality of actual platform. There is possibility to integrate software, control systems and databases from other sources depend on the demand of client needs. The typical area of Visioneering services with MMO business areas is optimization of execution process, risk and cost reduction and improvement in HSE and reliability. Layout and method limitations and possibilities can be visualized in the simulator so that the client and project coordinator can review and find out the optimal method and design of work instruction. Moreover, this visioneering services also provide the installation team with the opportunity to verify the design and method used by provide training course in virtual environment on the agreed installation method and design. Animation can display a sequence of images of 3D model positions to create a conclusion of movement when modification and operation are taken place. Animation is part of Simulation technique that shows the imitation of operation in a real-world process and system over time period to help understand the reality.

Remarks

Offshore maintenance, modification and operation are large engineering projects that divided into smaller interrelated sub-projects. Each of sub-projects is dealing with others. For example, during concurrent design phase in the project, changing the position of large and heavy parts or equipment in the oil platform could affect the stability of the production unit. MMO work task also contains high risk since the operational task is located at oil production platform, which small incident can cause significant deserter. Therefore, MMO activity should be done without compromising other production. Visualization and simulation are developed from interactive gaming technology for offshore operators to train the activity work task as much as possible in virtual simulation under realistic environment.

Strengths: The main strength of Aker Solutions visualization technology is to reduce risk and increase performance of operational. The simulation not only provides practical realistic environment training but also available to simulate unexpected or unfamiliar scenarios. This could provide less likely to make mistake that could lead to significant deserter for example, oil spill and emergency situation that never happen before. Moreover, the simulator with 1 by 1 ratio of reality platform provide very realistic operation task so that the operator can experience very real work task under environment simulated, which gives a lot advantages in the simulation application market.

Opportunities: Maintenance and Modification operations require good planning, scheduling and work processes. Visioneering technology has proved that training program in simulator help improve performance of operations. However, at the moment there is only few integrated simulator training, which is not enough for the worldwide offshore operations. This would be big opportunity for Aker Solutions to keep developing this technology and expand the simulation facility to all over the available offshore operation location. The other opportunity of this technology is to expand to all area of offshore engineering projects for example, decommissioning offshore facilities.

4.3 Subsea

Aker Solutions has introduced 3D simulation for subsea tree, crash point, subsea equipment, and surroundings subsea environment to inspect and identify solutions for module replacing (Thomas, 2013). 3D simulation helps customizing the tool for replacing subsea module in virtual simulation and it also carries out the modifications on the tool sequence recorded

before it was sent to the actual rig. The pictures and measurements of flame surrounding high-pressure riser cutting at the seabed and the pictures of operation underwater were sent to the simulation facility for verification. Then subsea operator at simulation facility who operates the testing of actual equipment sent this ongoing dialog to the operator at rig to ensure that all the modifications are successful to prevent rig downtime. The success project feedback came from DONG, which the 3D visualization technology had helped the company save 100 million Norwegian kroners by reducing the operation for subsea retrieval operation at Oselvar field from 14 days to less than 24 hours (AkerSolutions, 2014a).

Remarks

Subsea installation process in deep water usually requires Remotely Operated underwater Vehicle or ROV to do subsea operation by operator remote control on the surface. Due to the limited visual come the camera survey displays under sea surface. 3D visualization and simulation of subsea environment could provide practical training and improve safety, speed and efficiency of the operations.

Strengths: Subsea operation is the challenge process that contain high financial risks and significantly complex environmental. However, this challenge can be overcome by developed simulation with advance tools and procedures that make the operations safer and more effective without environmental and financial risk.

Opportunities: In the future, every subsea operation project will be verified and put in a simulator to analysis every operational step before the real equipment is built. Real time visualizations and subsea field challenges can be analyzed through the simulator, which will make operation safer and more efficiency. ROV control systems will be integrated in the simulator (Pontaza and Menon, 2010).

4.4 Future Development

Visualization and 3D simulator are useful application for every business areas within Aker Solutions for training, implement work processes, cost and risk reduction and many other purposes. Aker Solutions has vision of being the preferred partners for solutions in the oil and gas industry through three main components, Man, Technology and Organization. Man component is the most critical to improve because most of the incidents in oil and gas industry in the past came from human errors. Technologies of control system and advance equipment together with organization of work processes and assets management are the important components that are needed to keep implementing and developing.

Remarks

In the future, Visualization and 3D simulation will play the main roles of performance improvement in every operation procedure, which will expand from Drilling Technologies, MMO and Subsea to Well service, Engineering and Wellstream production. Drilling operation will develop and implement the operation to be automated to increase the performance of drilling and reduce human errors. This development can be done by new innovative advance equipment and control systems together with new work processes. Visualization technology is involved in technology and organization to verify and train before the actual implement process occurs.

5. Evaluation of Visioneering Process Implementation

This chapter illustrates how Visioneering Technology is implemented into work processes of two business areas of Aker Solutions, Maintenance, Modification and Operation (MMO) and Drilling Technologies Operation. Visioneering is a work process that combines visualization, engineering and installation together and presents in 3D simulation models which designed to solve specific assignment task from client introduced in study phase and further processed through all phases of the project lifecycle (Fadnes, 2014)

5.1 Visioneering MMO

Visualization of the MMO work process ensures common understanding through 3D animation of concurrent design, integrated operations and simulated training and installation method. Visualization technique also reduces time consumption in engineering and optimizes the execution time of offshore activity process. Visioneering has established the work processes without compromising the requirement of project execution model by utilizing existing facilities, systems and work processes. Therefore, the projects will have a dynamic development and adjustments will occur continuously and simultaneously for all aspects of the project. Time Consumption in engineering process will be reduced and execution time in offshore will be optimized.

Figure 5.1 Crane lifting in Simulation Practice and actual

(http://www.akersolutions.com/en/Global-menu/Media/Image-library/Products-and-services/)

There are five features in this visualization method that Aker Solutions uses to establish the work process improvement in MMO (Fadnes, 2014).

a. **3D Animation** – The 3D model presentation of the project content is visualized in 3D animation, where both design and installation challenges are identified as display format that is easier to communicate. All the possible reviews related to safety, risk and installation method will be presented in this animation and these will provide better understanding to all parties involved in work process. However, risks are challenges to be identified and visualized through the project phases. The risky installation sequences can be simulated reality where all participants in the work process can be trained onshore at iPort Centre.

b. **Scanning** – the 3D model that used in the design software can be initiated and developed by scanning the platform to ensure that the latest changes to the installation offshore are updated in the 3D model. This is called "True View" which, can be established where the user can move through the model and evaluate the quality, sizes and distances of the design and installation method.

c. **Concurrent Design** – According to all phases of the project, participants will gather in the concurrent design rooms to review the design and methodology, together with, performing safety meeting as HAZOPs, SAFEOPs and SIMOPs. This meeting will involve both onshore and offshore personnel to discuss about the agenda whether identify the expect outcomes or what needs to be done. This process will reduce errors and rework which, mostly occur in the work process.

d. **iPort Visioneering and training** – In complex offshore installations or drilling operation, the whole operations can be simulated in the iPort Centre, where the existing platform model is installed and the structure to be handle modelled with weight and center of gravity. In iPort, the whole installation sequence can be display in same reality offshore environment which, crane winch operators, rope-men and flag men participate in the operations as reality work process at offshore. At iPort Centre, there are separate 180 degree dome for crane operator, and other operators where they can see and operate the installation as what they always experience at offshore. This is useful training that will provide a safe and efficient installation phase.

e. **Integrated Operations** – This is important process to involve offshore organization of all phases in the project. This process provides installation experience to those who will carry out the operations. By using video conference liked to the iPort centre, this enables the operating organization to be involved and offshore personnel to be utilized for video survey so that the quality of the model and scanning updates can be checked. All phases of the project are carried out using integrated operations to ensure that communication is controlled and installation is efficiency.

Remarks

The Maintenance, Modifications and Operations or MMO product is the project work that upgrade existing fully equipped and in operation offshore platform. Therefore, the installation processes are the main challenges that concerned high risk and interrupted productivity. To overcome this challenge, Aker Solutions has applied their technology of Visioneering into MMO work process for decision making and work management. Visioneering work process has designed in study phase and has carried on through the rest of project phases without compromising or interrupting the operational productivity. Visioneering also allow user to plan a schedule operational procedures and train operators under health and safety conditions by using integrated animated-3D environment with actual human/machine interfaced controller (iPort). Establish concurrent design by simulated work procedures in the virtual system, the critical problems can be identified by experts and engineers, then options and best practices of work processes can be selected by both parties (Onshore and Offshore personnel). After best practice is selected, project planner could test this operation virtually at iPort Centre where the operators are able to visual the actual work task and train on real handling equipment without interrupting routines work. This training facility not only provides training, but also retains the performance of workforce at high level of proficiency. The operators who has more practical training, trend to make less mistakes, recognize suspicious fault process and able to make better decision when any potentially harmful situations are occurred.

5.2 Visioneering Drilling Operation

Exploration and development drilling operations are frequently impaired by formation fluid influx (kicks), drilling fluid losses (hydraulic fractures), and wellbore instability due to shear failure (Purdy, 2011). These are the major problems of drilling operation that can cause the significant damages, accidents and loss of production. Formation Fluid influx or "Kick" is unexpected flow of formation fluid into the wellbore. It occurs when formation pressure is more than hydrostatic pressure in wellbore (Grace, 1994). One of the several cause of Kick is lack of personnel knowledge and experience or Human error because that personnel might not have well-trained of well control so they do not know how to react when this situation occur.

One of the solutions is to apply the visualization technology and 3D Simulator into work processes of Drilling Operation. To improve the performance of drilling, a real world mirror image 3D simulator of the entire drilling value is created to optimize operational process and procedures, equipment performance and drilling sequences. For example, if pipe is about to get stuck, it will be automatic reduction of reaming velocity. This visualization also educates, train and certify personnel off critical line in all activity of topside, subsea and downhole.

Drilling rig performance can be improved by optimize existing drilling equipment and control system by resolving non-conformance issues and utilizing the full potential of the drilling system and also by upgrade drilling equipment and control systems when needs to maintain high HSE and efficiency standards.

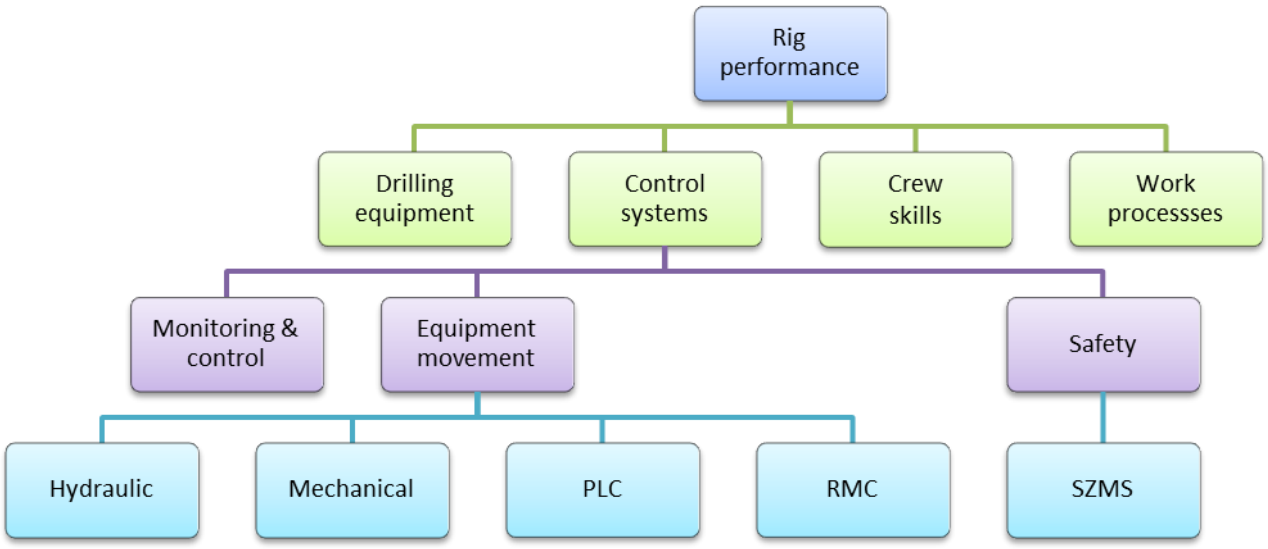


Figure 5.2 Process Chart of Rig Performance of Aker Solutions Drilling Technologies.

There are four main functions in rig performance that Drilling Technologies of Aker solutions provided as in the figure above, Drilling equipment, Control Systems, Work processes, Crew Skills. The key element on improvement of modern drilling rig is drilling control and monitoring systems.

5.2.1 Drilling Equipment

Aker Solutions provides the drilling equipment for the entire process of drilling operation. Hoisting systems, top drives, Drillfloor equipment, pipe handling equipment, drilling risers, handling tools, Drilling fluid equipment control rooms and cabins (AkerSolutions, 2014c). Most of the equipment is new advance technology and high performance that are delivered in package for the production platforms.

5.2.2 Drilling Control and Monitoring systems

Aker Solutions provides the modern control system for drilling rig supply for drilling control and monitoring system (AkerSolutions, 2014b). There are five main features systems;

- Local equipment controls/PLCs
- MH DrillView, data acquisition, presentation and control system
- MH configurable automatic drilling system (CADS)
- Computer Hardware
- Drilling control cabins (DCCs)

All drilling equipment can be monitored and controlled by drilling control cabins that designed according to industry standards related to HSE and human-machine interface. The MHDrillingView system can remote control of equipment and systems and synchronize various equipment with fully automatic mode of drilling operation sequences (CADS). CADS was developed to superior efficiency and safety control system. CADS includes predefined drilling operator sequences with operation standardization and safety improvement. Set-points, anti-collision, fully automated CCTV controls and other safety features were built into the software application (AkerSolutions, 2014b).

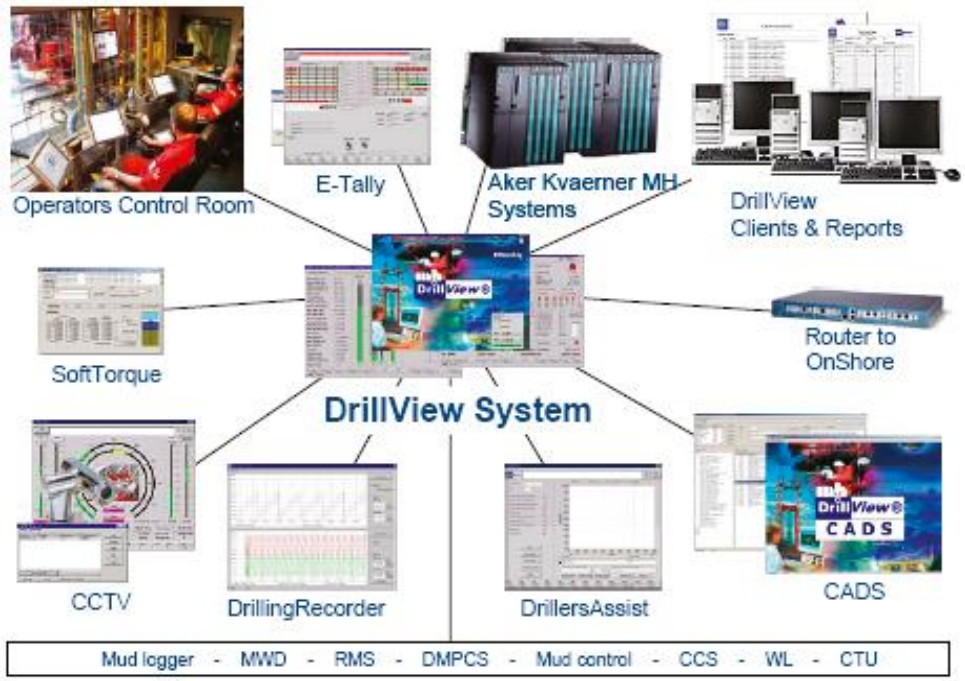


Figure 5.3 MH DrillView overview *(AkerSolutions, 2014c).*

According to the webpage of Aker Solutions, There are five components in control and monitoring system in drilling operation process.

Table 2. The key element features of drilling control and monitoring system.

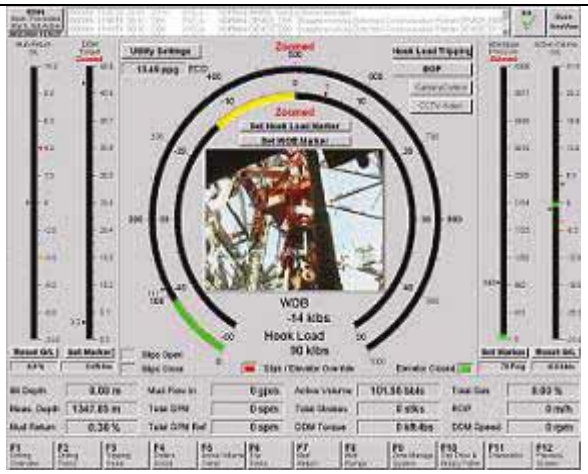
MH Operator Chair The operator chair is designed either for remote control single or multiple drill floor equipment. • No escape restrictions • Touch screen technology well-coordinated with low force/low dead band joystick control • Throttles and multifunction wheel for control of mud pumps and drilling derrick machine speed/torque • Full multi-user selection between different drilling operation modes and efficient/rapid installation due to "plug in" design • Robust, modular and maintenance friendly design • Designed for operation in non-hazardous area	

MH DrillView

The MH DrillView system provides a user friendly interface for

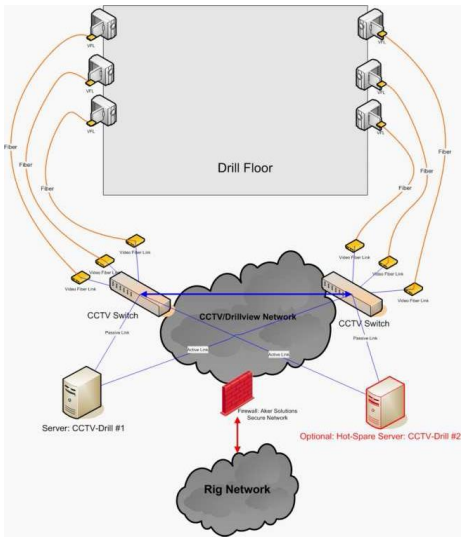
- Acquisition
- Logging
- Storage
- distribution
- display of drilling data
- set-up and remote control of drilling equipment

MH DrillView integrates drilling systems into one common control and monitoring center. Real time drilling data can be shared between the driller, rig offices, shorebase or other locations accessible by telecommunications



MH CCTV

- A modern system developed and integrated internally in Aker Solutions
- Delivered to the market since 2006 to more than 20 different rig projects
- Over 600 cameras deployed into service
- Based on open standards
- Modularized for each upgrades
- Designed for the needs of the offshore drilling market
- Utilize the newest technologies to give the best performance, quality and security
- Tightly integrated with the MH DrillView software package



MH robotic motion control Robotic motion control (RMC) has ability to move large machines safety and efficiently by using a joystick handling. It moves the machines along paths of six axes that define the position and orientation of the load. This robotic technology ensures that no motors are moved in such a manner that load can be dropped.	
MH E-tally The electronic tally book system keeps track of all items passing through the V-door. The system uses the length measuring capabilitis of the tubular feeding machine.	

Reference from (AkerSolutions, 2014b)

Equipment Operation Interface

It is important to understand how a rig can be controlled through the equipment operation Interface by operator user interface. A typical rig has equipped with Driller's cabin on drill floor that control the entire drilling process from inside. In Driller's cabin, there are two Intelligent Operator Chairs which Driller is on the left chair and assistant driller is on the right chair. The operator chairs are used to remote control machines and drilling operations by the two joysticks, two touch panels and two large DrillView screens. There are three key interfaces in drilling control and monitoring between operators and drilling equipment machine, Intelligent Operator Chair, DrillView and CCTV.

DrillView is the software program designed for independent high resolution graphic display system for distributed monitoring and control real time and stored drilling data. DrillView is easy to use because it consists of operator machine interfaces with separate screen pictures for separate rig operators. It also consists of alarm system and displays the graphical and animated on screen objects. The functions include setting and adjustment of parameters, limits, trends, reports, alarms, configurations, setting or reset of parameter, start/stop of motors, managing the large database of drilling data, playing back old wells and offline analysis. Moreover, logged data from DrillView can be used as a documentation of every meter of the drilled well.

5.2.3 Crews Skills

The performance of crew's skills depends on the experience and competence on handling the drilling equipment and control system of that crew. To improve the performance of crew skills, Aker Solutions has provided Training courses of handling equipment and control system. The four steps of training courses are consisted of e-learning, classroom training, simulator training and practical training. eLearning is the first step of training that based on the multimedia online course that can conduct over the Internet with regular computer. The objective of this course is to adjust the basic background knowledge level and fulfill the needs of individual crew. Classroom training is instructed by the experience person together with the use of modern technology and material. The technical and theoretical understanding will be discussed between trainers and instructors. The competitive advantage training that Aker Solutions lead in this industry is simulator training at fully equipped of whole drilling control system at the facilities. Simulator training contribute to more effective rig operation, and also help drilling crew to understand more reality and process the operation faster. This results less stops due to errors and increase more performance of drilling operators. The last training course is onboard training after the crew has done those three steps of training, the last step will be to train with real drilling equipment with real environment.

5.2.4 Work processes

Drilling work processes are the procedures of drilling operation that operators/crews handle the drilling equipment using drilling control system. The performance of work processes is resulted in time consumed when drilling operation was processing. The less time consumed to finish the drilling process, the higher performance of drilling rig will gain. The advance way to optimized rig performance is to reduce non-productive time by visualized all the actual processes and operation patterns, identified and modified unnecessary process and created new efficiently work processes.

Remarks

In traditional improvement way, key tool is to analysis method of key drilling sequences for document user value of improvement opportunities for example, operational analysis, cause-effect analysis and cost-benefit analysis. However, the new innovation tool to improve the rig performance is Simulator verification. Simulator technology can reveal all aspect of identifies problems to fully understand complexity and direct/indirect causes like cause-effect analysis and can reveal document actual effect and user value of possible solutions like cost-benefit analysis. The simulator tool also performs pre-commissioning to minimize potential non-conformance during rig implementation.

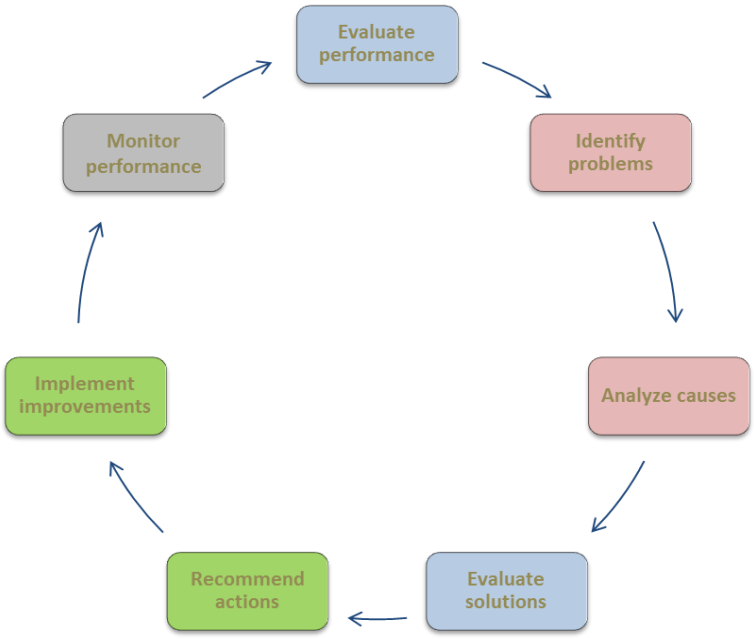


Figure 5.4 Improvement process chart of Drilling Rig Operation.

The improvement process starts from monitoring activity of actual operation rig to analyze and optimize the operational. Risk, critical activities, bottlenecks, limitations, dependencies and parallel activities can be analyzed in virtual rig using the data monitoring from actual rig. The operational analysis is often described as Gantt chart that illustrates work breakdown process against the time consumed so that it can be easily seen which activity and path are critical. After Operational analysis, work processes and control system can be identified. Work processes can be selected by the best practice of operational procedures and establish the training session in virtual rig to perform before apply to actual rig. If the work processes still are not the best practice after perform in virtual world, the operation analysis has to be done again to identify what goes wrong. Control systems are being analyzed and optimized

the equipment control and safety systems in virtual rig after operational analysis. Mechanical, hydraulic and electrical systems of drilling equipment are being analyzed and optimized together with control systems. Then technical improvements in control systems and drilling equipment are verified in simulator upfront rig installation in pre-commissioning to make sure the concept of doing right at the first time before actual rig commissioning is taken place.

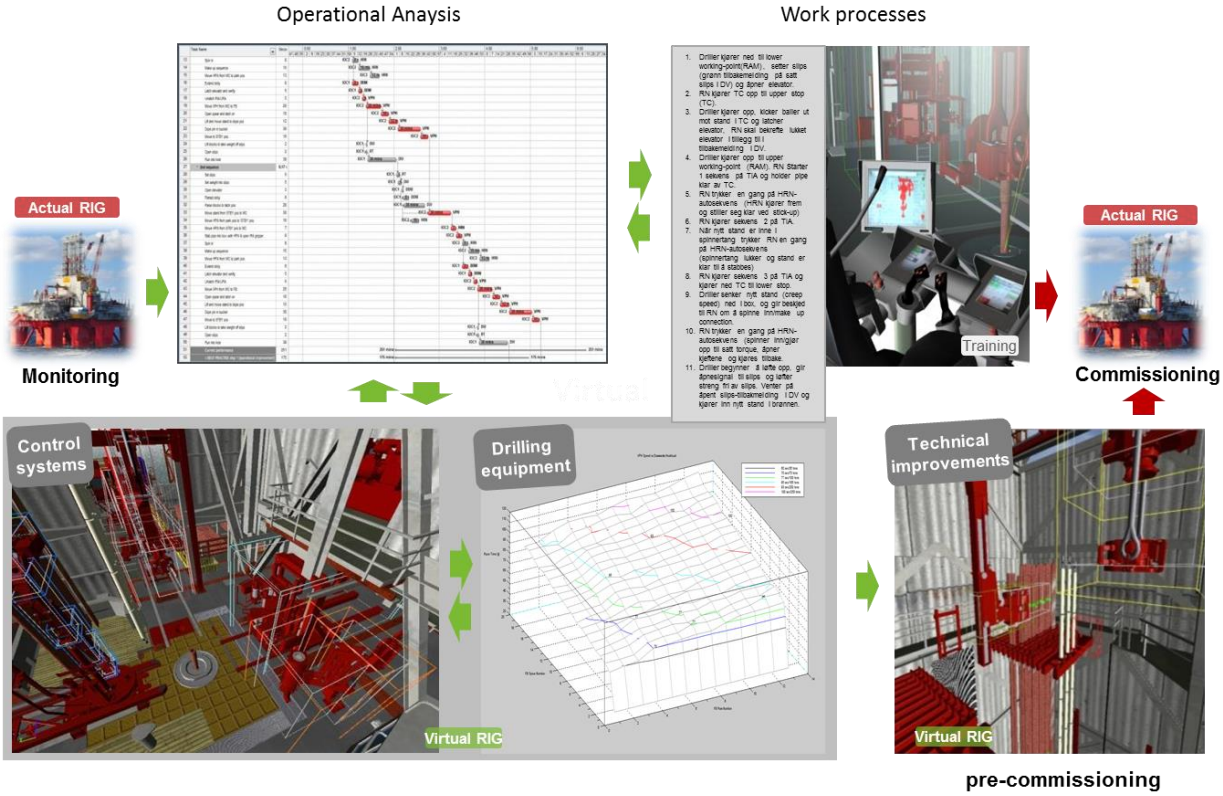


Figure 5.5 Image flow chart of Visualization improvement process of Drilling Rig Operation.

Modified from Images Ref. (Larsen, 2012)

6. Evaluation of Project Operational Improvement

This chapter illustrates the operational performance management of Aker Solutions' project lifecycle services by using Visioneering Technology in Drilling lifecycle services and Maintenance, Modification and Operations business areas. Visioneering has supported project lifecycle phases of the products and services that Aker Solutions has delivered to customers to maintain and optimize operational performance. Man (operator skills), Technology (Visioneering and advance equipment) and Organization (work processes) are three main components of performance improvement.

6.1Drilling Rig Performance Optimization Projects

To be able to improve the performance of the rig operation, Aker Performance Technology has established the concept that describes the processes that use a virtual mirror model of the actual rig to design, test, train, support and also optimize the operational procedures and processes of equipment performance and drilling sequences in non-critical line (figure). There are five steps of typical execution of rig performance optimization projects.

6.1.1 Create a Visioneering simulator identical with actual rig.

There are three identical that need to be created in Visioneering simulator. However, all of this identical need to be kept updated and synchronized with actual rig

a. 3D models of rig and drilling equipment – the actual 3D models are established by Plant Design Management System (PDMS) known as 3D design software that delivers productivity and capability on offshore rig plant (figure1). This software develops from using 2D CAD drawings convert to 3D model and also develops from 3D laser scanning of both drilling floor and drilling equipment.

Figure 6.1 3D models of rig and drilling equipment

(http://www.akersolutions.com/Global/image_bank/Products_and_services/Drilling/Aker_Solutions_Drilling_CatD.jpg)

b. Drilling equipment movement patterns – the movement patterns or signal list can be retrieved from suppliers (operators) by record signal flow in existing systems on actual rig operational. Then the next is to analyze and define movement patterns based on model.

c. Drilling equipment control systems – First, access to Programmable logic controller (PLC) and control systems and then upload code from PLC system. After getting data from PLC and control system, the artificial control systems will be established into the model to perform the drilling process in virtual world.

6.1.2 Create a training simulator

The training simulator is created according to the actual activity of drilling rig that need to be improved. The training can be customized depends on the operators. Training facilities for example, Driller chairs with full control systems, display solution and loudspeakers and communication system will be provided for the operators to come and train in the virtual drilling process activity before they execute the real task. iPort centre in Stavanger provides the training facilities. XfactorDES (3.3.1) is the software application that Aker Solutions use to visualize actual offshore installations in 3D real-time for drilling process.

Figure 6.2 iPort centre the dome simulator.

(http://www.akersolutions.com/Global/image_bank/Products_and_services/Drilling/Aker_Solutions_Drilling_simulator_in_a_dome_solution.jpg)

6.1.3 Establish KPIs and Monitor Performance

There are eight phases of rig lifecycle management, conceptual, design, engineering, fabrication, installation, commissioning, operation and decommissioning. The rig performance could be monitored from the installation phase through operation phase until decommissioning phase. It is important to set up key performance indicators (KPI) monitoring during the actual drilling operation to review work processes, control systems and drilling equipment performance. Riglogger, Aker Solutions' product, is high performance data collector from drilling equipment offshore consolidated onshore used for condition monitoring and measure rig performance shown as KPI (Bjerke, 2012). myDrilling is an interactive web based customer and collaboration portal that shows both operational and administrative information for drilling operation from riglogger in real time. It also provides online 3D remote diagnostic functions and play back the recorded data.

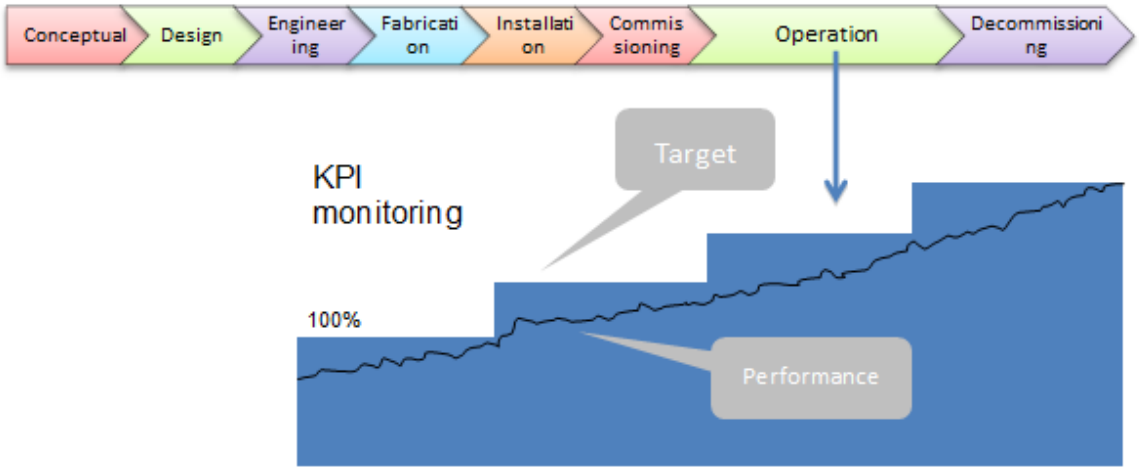


Figure 6.3 Project lifecycle phases and KPI monitoring.

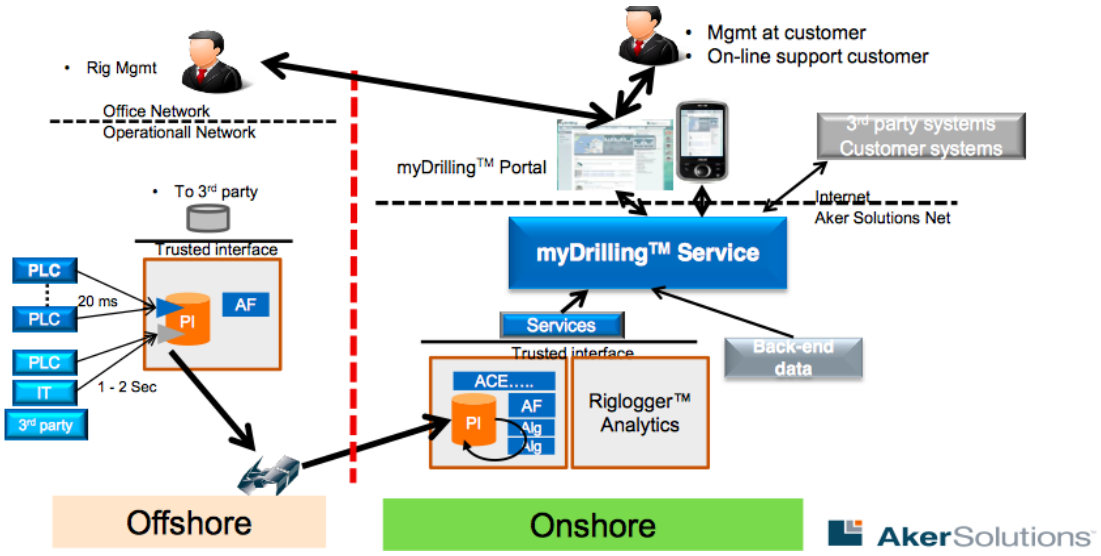


Figure 6.4 High-level architecture of myDrilling and Riglogger.

(Bjerke, 2012)

6.1.4 Optimize work process, control system and drilling equipment

Figure 6.5 Rig Project Lifecycle Management.

After analyze the KPIs and monitor performance in Operation phase, there will be improvement plan to optimize work process, control system and drilling equipment in the project execution. Visioneering Technology is used through phases of rig lifecycle management from Conceptual phase to Decommissioning phase. Figure has explained the improvement process when applying the simulation virtual rig concept into work processes, control system and drilling equipment.

1) The optimization of work process starts from monitor drilling operators handling of drilling equipment against procedures. In simulator training, all drilling equipment such as operator chair and control system monitor were the same as the actual equipment in real offshore rig. Therefore, the improvements of procedures after monitoring the operator's performance can be implemented to get best practice procedure (example). Then the best practice procedure can be tested by real operator interact with real drill equipment at iPort centre as operation simulator training to make sure that the action and procedures are right before apply in actual operation. New training program will be established to improve the performance of both operational process and the drilling operators.

Figure 6.6 Flow process chart of work process optimizations.

2) Visioneering together with iPort centre have provided the virtual copy equipment of actual control systems of drilling equipment at the facilities onshore for training simulation and also solution identifying.

The optimizations of control systems start from optimize equipment anti-collision system. In drilling wells process, there is high emphasis on avoiding collision with offset welbores. Many wells are drilled close to each other, which make an anti-collision system highly important. The visualization of 3D well will be used to display better picture of offset wells.

The configurable Automatic drilling system (CADS) creates safety and efficiency of user configurable system for drilling contractor's personnel on site. This system includes drilling operator sequences and equipment priority system. However, this automatic drilling system had to be verified and re-configured when there are changes on work processes. Visioneering technology will be applied on the implementation phase of this control system to simulate the system through the virtual world.

Aker Solutions provide the robotic motion control to move large machines along paths safely and efficiently by using a joystick handle. The control system in motion control can be optimized by simulated the actual drilling activity to review the motion and position of the machine. After this simulation, the correct positioning and safety control can be adjusted for the best control practice that will be applied in actual rig.

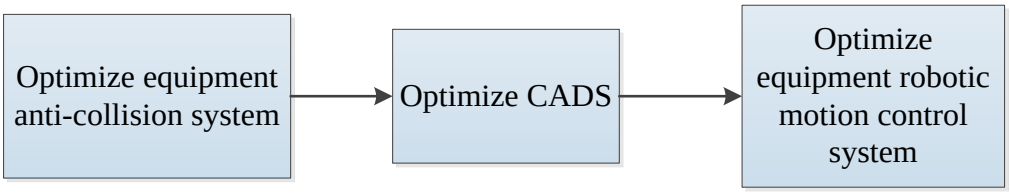


Figure 6.7 Flow process chart of control system optimizations.

3) The optimization of Drilling equipment

The performance of drilling equipment during operation can be seen in myDrilling (step3). The first step of drilling equipment optimization is to identify the equipment that not performing well and optimal. Then, analyze the options of improvement whether to modify, replace or overhaul that drilling equipment. The improvement options can be simulated in

virtual world by Visioneering technology to select the best options for the equipment optimization.

Figure 6.8 Flow process chart of Drilling equipment optimizations.

6.1.5 Execution in 3D Simulator prior to drilling rig installation

The table below shows the summary of using visualization technology and 3D simulator to optimize the drilling rig installation in project lifecycle phase. The visoneering process start from Conceptual phase to check and verify the identical problem defined in design phase. Then the operational risk will be reduced when the drilling equipment and control system are installed by using 3D simulator. This will make sure that the process will be executed right at the first time. During pre-commissioning phase, the drilling control system can be verified at the simulation facility (iPort center). Operator will have practical training on control system and understanding of drilling equipment usage. Then this will result in reduced operational downtime in commissioning phase and less offshore operator crew in installation phase. In start-up phase, equipment expert support can review and monitor drilling rig in virtual world at the visioneeering facility onshore.

Table 3. The summary of 3D simulator in Project lifecycle execution

Conceptual/ Design/ Engineering	- Early verification to identify design errors - Reduce operational risk during installation and start-up
Pre-commissioning	- Verify control system and anti-system upfront installation on rig
Installation	- Improved preparations and utilization of key operator results in reduced downtime and less offshore crew
Commissioning	- Reduced commissioning period or operational down time
Start-up	- Smoother start-up by onshore equipment expert support

Remarks

The performacne of drilling rig needs to be continuously improved. Improvement opportunities are defined through a systematic approach in a virtual environment. Simulator verification and training are requried when there are new implemented control systems, drilling equipment and workprocesses. The flow chart below illustrates the process of continuous improvement of drilling rig perfromance and safety.

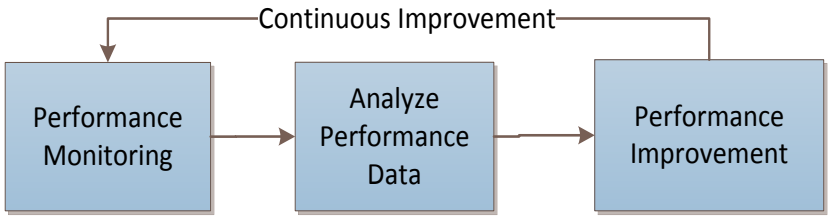


Figure 6.9 Flow process chart of performance continuous improvement.

1. The first process is performance monitoring. The performance of productivity in drilling activity can be monitored by review KPI reports from the operation. The reports can identify the key variable that is critical in the performance monitoring system. The equipment and machine performance can be monitored by condition monitoring system reports.
2. The second process is performance data analysis. This process analyze performance data by identified improvement potential sequences based on safety factor and non productive time. The drilling sequences are control systems, drilling equipment and personnel training. Then define the best practice of work preparation and corrective actions for drilling sequences and use simulator tools to verify and adjust sequences in virtual environment.
3. Performance improvement process can be done by optimized work processes, control system and drilling equipment (see in charter 6.1.4). After the performance improvement of all three sequences are optimized and updated, then they will be carried on to perform in training simulation facility (iPort).

The continuous improvement processes can be performed in the simulator over and over again until the best optimization practice in commissioning phase is established.

6.2 MMO Project Execution

By using Visioneering and iPort, Aker Solutions MMO can simulate methods, layout and work processes which enables MMO to reduce risk, ensure reliability, reduce cost, and operational downtime. This will help us deliver value to our customer and achieve a competitive advantage.

There are four step of Visioneering start from:

1. Start-up of the Visioneering phase
2. Visioneering in practice
3. Presentation of Visioneering result
4. Engineering presentation

Visioneering and iPort MMO has been established within an organization to provide the visualization activities in both existing MMO project and MMO concept study. The development of simulation tools will be used as method, layout and installation personnel that move objects around and test possibilities and limitations to optimize design and method in MMO activities. This development also provides the installation team the possibility to train on the final best method after operational analysis. Both relevant project manager and customer representatives are needed to go through, optimize and agree when method has selected by using Visioneering simulator tools.

The useful simulation tools that are used in MMO operations are (AkerSolutions, 2014d):

- Installation and critical lifting operations
- Hook ups
- Shutdown logistics
- Material handling
- Layout challenges
- Removal and Decommissioning operations

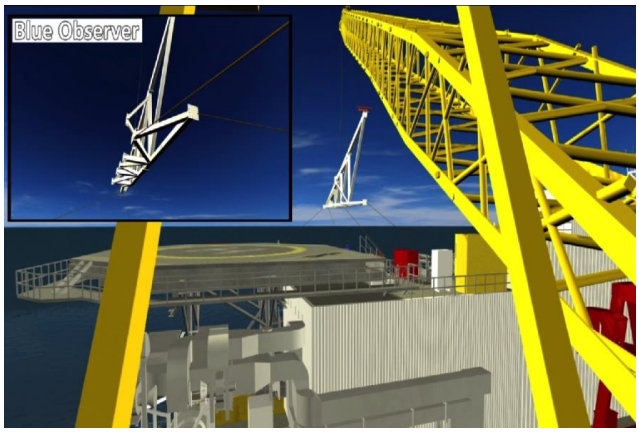


Figure 6.10 3D simulation of installation and lifting operations

(http://www.cm-labs.com/market/energy-offshore/news/aker-solutions-in-norway-selects-vortex-for-crane-simulation)

Figure 6.11 Actual installation and lifting operations

(http://www.ktf.no/fileadmin/Dokumenter/Kursdokumenter/2013/1320100/Day_1/16.30_Terje_Fadnes_130423_Kranseminar.pdf)

Simulation of optimized design is a product of conducted simulations, which it is possible to change viewpoint, move around and change design in the computer software display. The simulation animation can present these activities (AkerSolutions, 2014d):

- Hazid (Hazard Identification Study)
- Layout and HSE review
- Safety operation
- Visual part of work package
- Safe Job Analysis review on work station
- Method and design review with drift organisation
- Study reports and presentation
- Tenders and method reviews

The differentiator can be established by combining visualization and simulation tools together with engineering capabilities. This process of Visioneering enables the advantage competitive service in the market todays. Visioneering also enables the next level of concurrent design to be used for complex method development. In the figure below shows the actual concurrent design consisted of Man, Work Process and Technology Tools. To improve the performance of the operation, these three key components need to be optimized. In process of concurrent design, there are multidiscipline review of solutions that supported by distribution of information to other onsite location. Visioneering process develops this method by using real-time simulation together with engineering method in iPort facility to explore the process solutions. In technology tools of concurrent design, Plant Design Management System (PDMS) is 3D CAD engineer controlled design software that show the structure of offshore platform, which is used together with PowerPoint slides to present the structure design for the operational task work. Visioneering is using simulation software instead of PowerPoint slides that has ability to integrate and combine large amount of data and software tools of PDMS. Then the operation, Human will have better understanding of reality process and actual environment by using 3D simulator for training.

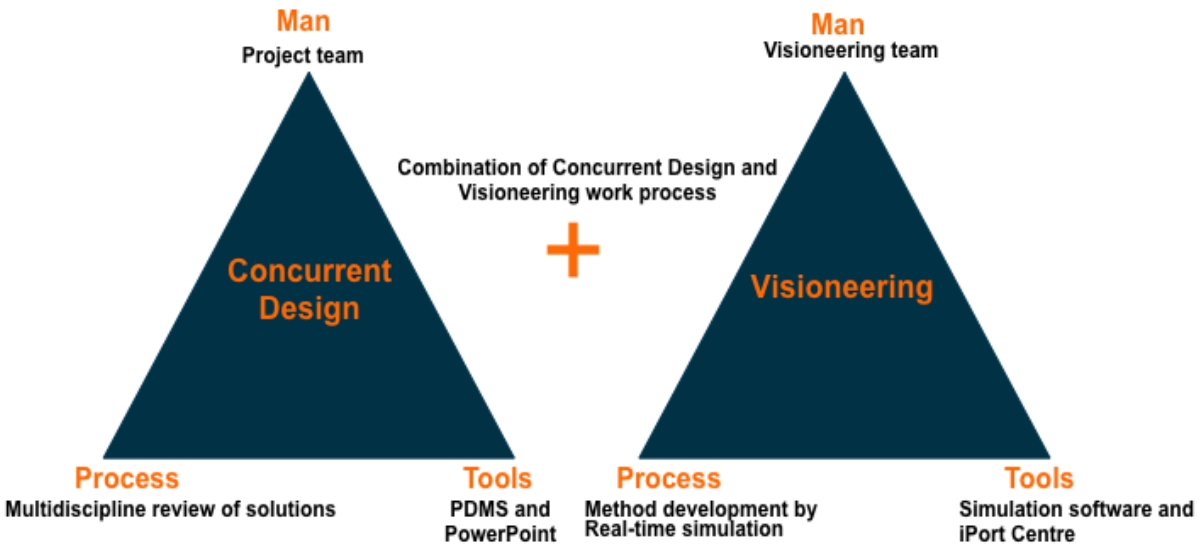


Figure 6.12 Combination of Concurrent Design and Visioneering Work process

Remarks

Visioneering has created Value added in MMO project. Visioneering has delivered added values and advantage competitive result that optimize the performance of project operational. Visioneering has improved ability to keep and attract the most competent people and operator. It also created a technology differentiator, which can help achieve a competitive advantage in the oil and gas sector. Visioneering provided facilitates innovation and next generation services and work processes that improved ability to align towards projects with higher risk and margins. In term of projects execution, layout and method solutions will be optimized to reduce quality cost, HSE and risk that often occur during the operational process. Training facility in virtual environment helps reduced Engineering, installation time and workforce in term of man-hours. These value added had also been delivered to the customer in term of increased revenues through reduced shutdown time and reduced operator on board at the offshore platform.

7. Benefits of Visualization Technology and 3D Simulation

There are many benefits of applying Visualization Technology and 3D Simulation into the oilfield development project for example optimize the operational performance, reduce operational time at offshore, reduce quality cost, reduce operational risks, increase HSE values, accurate decision-making, provide better collaboration and explore new operation opportunity. These benefits can be qualified through the use of simplified virtual platform that integrates visualization and simulation in to the process planning, capital project management and product lifecycle management. The benefits from previous projects that Aker Solutions has implemented are analyzed and qualified in this chapter as an industrial case study.

7.1 Project Valhall IP of BP

Valhall is a large oilfield located southern Norwegian North Sea, BP Norge AS is the operator in this oil field (Oljemuseum, 2012). Currently Valhall activities are day to day production, injection and maintenance operations on eight offshore platform hosting over 90 production and injection wells. Drilling activities are currently produced by IP platform rig of BP and Maersk Reacher HDJU (BP, 2014). The water Injection Platform (IP) was installed in 2003. It has integrated topsides with water injection facilities, seawater treatment facilities and platform-based drilling rig (BP, 2014). Valhall IP drilling platform was delivered by Aker Solutions in 2003, which fully automated drilling facility of control systems, anti-collision and Computer Aided Drilling Systems (CADS). In 2006, BP has established performance improvement plan to reduce time spent for non-routine tasks for example, rigging operations, change of operation and building bottom hole assembly, and save drilling cost by letting Aker Solutions implemented offline test and commissioning environment to upgrade the Smart Zone management System (SZMS) and drilling equipment. In 2010, Aker Solutions successfully implemented Visioneering Technology into the project performance improvement as described in chapter 6. The following benefits information was shown according to the previous report result (Eide, 2010) after project performance has improved:

- All deliveries on time and according to budget
- Offshore commissioning time for Tubular Feeding Machine reduced with up to 70%
- Each day in simulator equals to one day saved Non-Productive time (NPT) rig time
- ROI for simulator within the first 6 months of operation
- First well drilled after upgrade is the fastest ever drilled at Valhall IP

- All future changes are to be tested and verified in simulator prior to installation
- The simulator has been a major contribution to Rig NPT decrease from 8%-2%
- Increased tripping speed from 12 to 30 stands per Hour

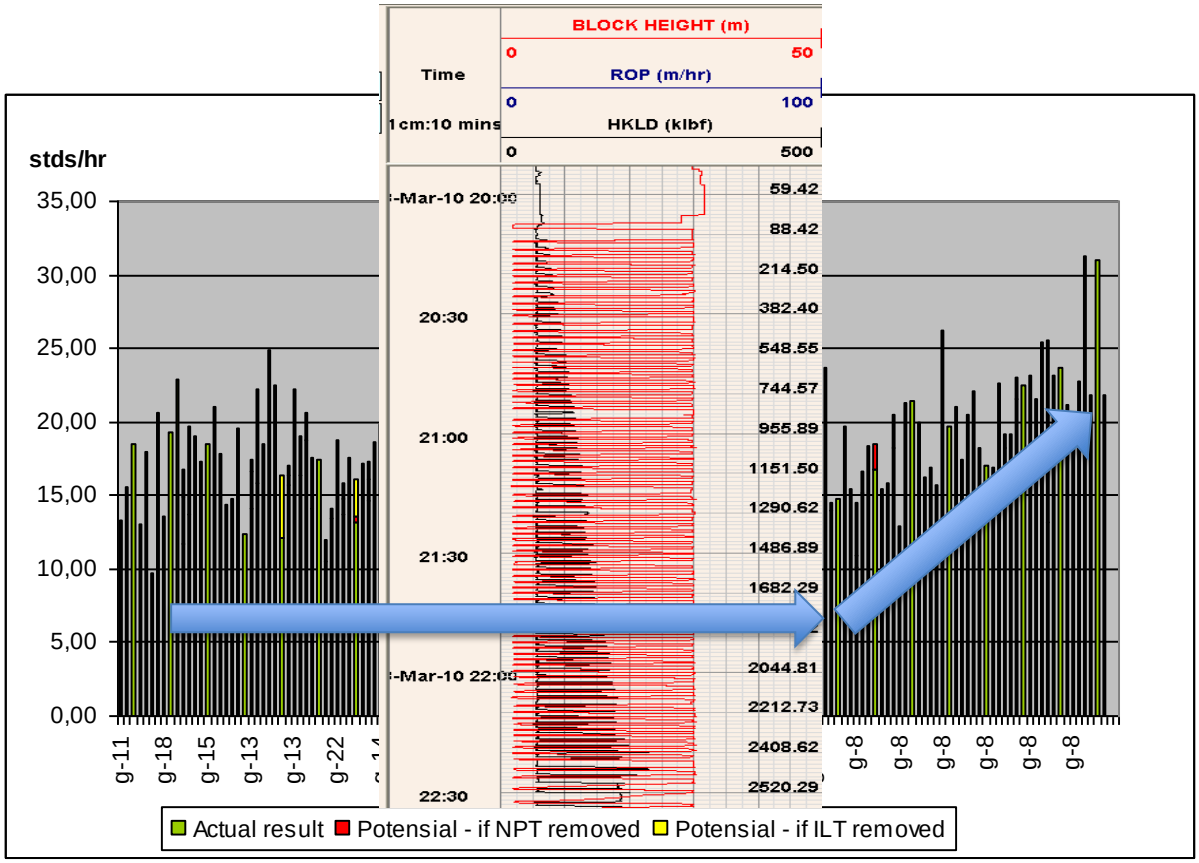


Figure 7.1 The result of increasing tripping speed.
(https://akersolutions.com/Documents/Media/Features/TechDay2010/VisualisationandSimulation_seeagenda09501045.pdf)

Benefits Remarks

Drilling expenses has increased significantly in recent years. The productivity of drilling operations (drilled per day) sharply affects exploration costs. Due to the high rig rates on Norwegian Continental Shelf (NCS), rig rate has increased from 75,000 dollar per day in 2003 to around 500,000 dollar per day today, which is about 6 times increased (Osmundsen and Tveteras, 2010). This is the reason why the operator company wants to improve the operation on drilling speed. Another interest fact is "Drilling oil wells takes double amount of time for the same job as it did in the 1990s" said by Grethe Moen Director of Petoro (Skarsaune, 2014). This fact means that there are more process tasks that required more execution time. Moen also mentioned that "The industry managed to execute standard tasks in drilling operations twice as fast before, through simplification, technology" (Moen, 2014).

Good intention of increasing safety and reducing chance of high risk can create inefficiencies process over the time. The big and easy accessible reservoirs are developed. Developing smaller and deeper reservoirs requires more complex wells than before. Visualization Technology system provides the improvement of work method, establishes training with 3D simulator and gives the technical solutions by real time simulation.

7.2 Project Dong Oselvar

The Oselvar oil and gas field is located southern Norwegian North Sea near British/Norwegian demarcation. Oselvar is subsea solution connected to the Ula field via a pipeline with water depth of approximately 70 meters. The production in this field started April 2012 (DongEnergy, 2014). In 2010, Aker Solution Subsea has taken the project of Hazop Experience from Dong E&P Norway by using 3D models/Animations. The objective of the Hazops was to define operational risks on subsea Drilling and completion operations planned on Oselvar fields before production start.

The normal standard Hazop requires average 15 to 20 key workers and it takes one to two workdays to process, which the meeting is planned and organized within one to two week by external Hazop facilitating companies with limited detailed knowledge and background about the Hazop tasks. It is normally faced lack of communication between the customer and the hazop facilitator, which might lead to limited information about important tasks (Herland, 2010). 3D models and animations (XfactorMOS) from Aker Solution has developed to facilitate efficient accessibility checks. XfactorMOS also has reduced the time it takes to perform accessibility checks by between 500 and 1000 hours per project and the time it takes to prepare for accessibility checks also reduced from weeks to hours.

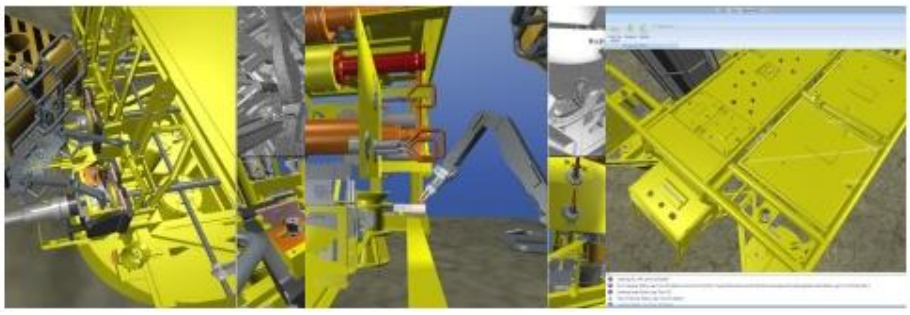


Figure 7.2 3D Workflow in XfactorMOS application.
(http://first-interactive.com/en/Menu/Products/XfactorMOS/)

During subsea installation, there was a requirement to retrieve the Subsea control module (SCM) after high-pressure riser is connected. Nevertheless, there was proved that it is impossible to get access to control module without removing the high-pressure riser first after crash point investigation. This operation, involving plugging the well and pulling out the High-pressure riser, was caused high cost and lots of time consumed with possible HSE challenges. In these challenges, Aker Solutions had solved the problem by visualizing all subsea installations from the Oselvar field in 3D simulation of the subsea tree, the crash point, equipment and surrounding environment. The follow results of implementing visualization and simulation in this project (AkerSolutions, 2014a).

- A damaged subsea control module (SCM) on a Christmas tree had to be removed, with a high pressure riser connected
- A crash point made it impossible to remove the SCM without removing the HP riser
- Cost of operation estimated to NOK 100 million, with a narrow weather window
- Aker Solutions used 3D simulation tool to investigate and find a solution for removing the SCM in cooperation with Ågotnes and the rig crew
- Replacing the SCM was done in 23 hours, without down time on rig

Benefits Remarks

Due to the complexity of subsea operations, especially in deep water, there are many benefits of using 3D visualization and simulation or Visioneering tools to improve the performance of operations. Not only providing better visualized prospection but able to generated real time data of subsea worksite to the operators control room, these benefits would effect on speed, safety and efficiency to be increased. Moreover, cost of subsea operations are very high due to the usage of remotely operated vehicles and time summing. The simulation system of XfactorMOS has developed for accessibility checks to be executed faster operation. By using 3D simulation to investigate and identify the solution of replacing the subsea module, it resulted to be no rig downtime occurred in this operation.

7.3 Grane Living Quarters Installation

Kvaerner has awarded Edvard Grieg platform topside Engineering, procurement and construction (EPC) contract from Lundin Norway AS in May 2012. The topside consists of main topside module, a combined living quarter, a process module and a flare tower. It has total weight of 21,000 tones (Kvaerner, 2014). Kvaerner has also delivered the steel jacket, weights 14,500 tones, for the Edvard Grieg platform. Aker Solutions has performed design engineering and technical procurement for fabrication and assembly of the process module. Apply Leirvik AS is the sub-contracted for the living quarter module. The final delivery of EPC contract is set to be April 2015. Aker Solutions engineering team has applied Visioneering Technology for the installation simulation through the project lifecycle phase of Project Execution Model, which start from feasibility & concept through the system complement. The figure below has explained how the simulation and animation have effective on each phase. After simulated through the process, it shows that Visioneering helps reduce offshore, engineering hours and also save the quality cost of incidents that could have been avoided.

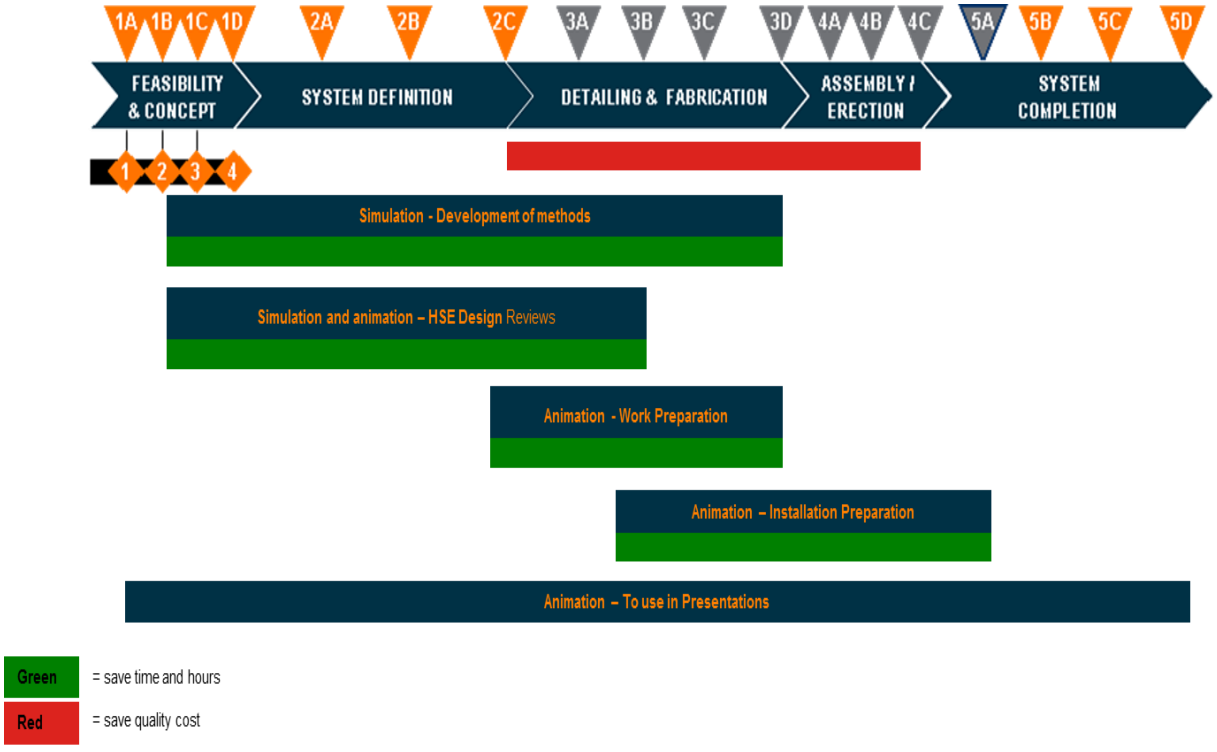


Figure 7.3 Visioneering tools helps optimize design, methods and installation processes in early phase of the Grane living quarters installation project *(Fadnes, 2012)*.

These are the results after using Visioneering tools in the Grane LQ installation project in Front-end engineering design or FEED (Fadnes, 2012).

- Reduced delivery time with 5 of 14 weeks and total engineering man-hours with 2000 of 3800 hours
- EPC engineering could have reduced delivery time with 6 of 26 weeks and total man-hours by 8033 of 48,081 hours.
- EPC offshore work could have reduced delivery time with 3 of 30 weeks and total man-hours by 840 of 36,497 hours.
- Reduction in work preparations and quality cost not included in estimate above.

Benefits Remarks

The top part of platform and the jack up steel are constructed from the different contract companies. The project has to be executed with the best procedure project management, engineering, assembly and fabrication to be able to avoid high cost of installation and operation risk. Visioneering has implemented during the concept design by creating the simulation of procedure method and the animation of HSE reviews. With the simulation system, operator and machines interaction on the job site can be simulated to predict the possible outcomes. Scenarios work methods can be conducted for the selection of best practice process and these scenarios can also review the possible incidents that could avoid operation offshore-site from the losses of platform installations. In fabrication and assembly phases, Visioneering tools could be fully implemented together with the animation scenarios of work and installation preparation for the operators or crews to have real training with actual equipment under virtual simulated environment. The concept of doing right at first time by review various scenarios animation has capability to lowers the incidents and risks of mistakes, delays, and rework and also increase overall performance for operations procedures. The results showed the significantly reduction of man-hours in both onshore and offshore and also reduction of processing times, which are the main factor of key performance indicator. Moreover, the quality cost of avoiding possible incidents in MMO could cost around 500 – 100 million NOK per MMO project (Bradbury, 2013). Therefore, if the incidents could have been prevented by Visioneering tools in the early phase of fabrication and assembly, the quality cost and risks would be reduced in actual installation process.

8. Map the future Solutions

This chapter illustrates how the visualization technology can be used and developed to optimize the operational performance in the oilfield production and operation. The future solutions are mapped by analyzed previous industrial case evaluations in previous chapters against the Man, Technology and Organization (MTO) performance analysis to make recommendations for future trend of visualization technology.

Oilfield operations are the complex work systems that involved many directional interactions between three variables of Man, Technology and Organization. To improve the performance and reliability of the operations, these three variables are the key drivers to be investigated and optimized. However, in the historical performance and incidents reports showed that the detailed analyzes of accidents and near-miss reveal human errors as the main cause of poor performance evaluation (Bridger, 1995). Therefore, the solutions of improving performance of the operation are based on the concept of design job tasks to suit with characteristics of workers. Then these three components are identified as:

Man: In an oilfield operation, man or operator is working with machine or equipment under offshore environment which considered as high risk enterprise. Therefore, offshore personnel are required not only technical knowledge and skills but also the ability to solve and react under the safety discipline and corrective action when unexpected situation is occurred. The man-machine interfaces also have effects on the performance of operation before offshore plant is one of the most complex facilities that operated nonstop under extreme conditions particularly in high risk operations such as high-pressure leaks and emergency incidents.

Technology: Technologies have designed to help man-machine interfaces run smoother. The machine and equipment control system, such as display, sensor, processing system, material handling and communication system, are developed to operate more efficiency and better understand for workers to use. Hybrid and fully automated machines and equipment become the goal of technology improvement to prevent human errors. There are also many challenges appeared in operation for example, upgrade, modification and maintenance projects could involve hundreds of workers who have to be well-trained and need to shut down the production. The advantage of technology system can develop to overcome these challenges.

Organization: Oil and gas industry companies have intense pressure from growing demand of fossils field resources. Particularly in oilfield located at sea side; there are increasingly safety and sticky environmental regulations. To overcome the challenges of growing demand, the organization has to explore more resources and produce more petroleum. However, exploration process have taken long time and lots of investments. Therefore, the organization has to focus on optimization of oilfield project lifecycle management. The main goal is to spend less money on oilfield development with less processing time and high performance efficiency under the safety criteria. Work processes in conceptual, design, installation, operation and commissioning phases are the main key to optimize the performance of oilfield projects.

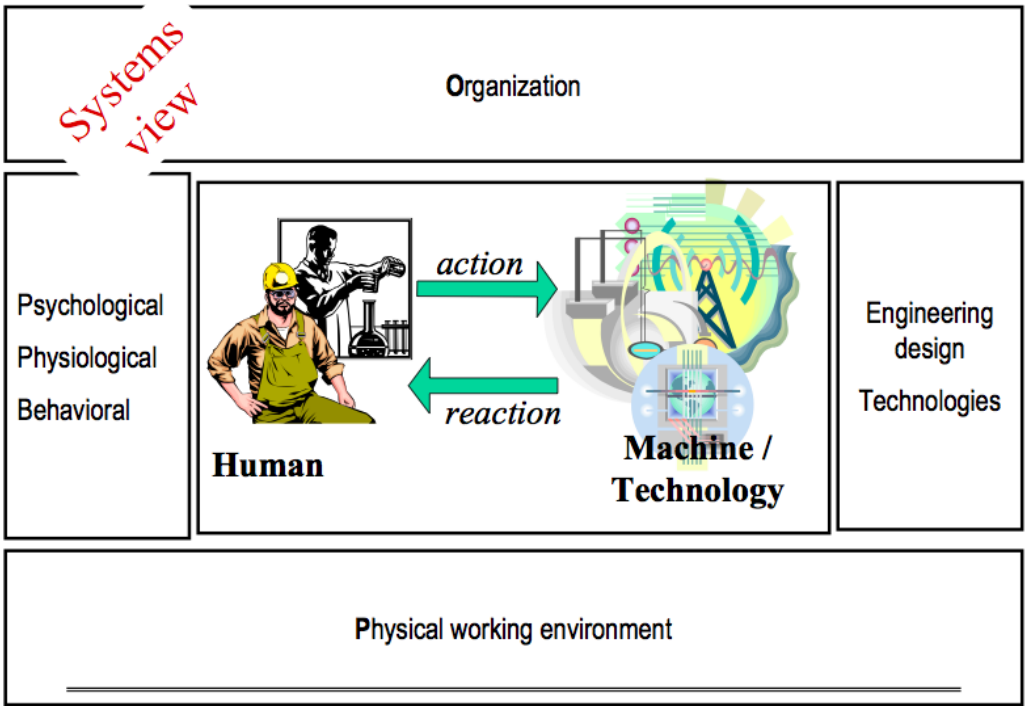


Figure 8.1 Performance systems view of Human-Machine interfaces *(Liyanage, 2013)*.

The future solution not only focuses on optimized performance but also establish high reliability organizations with no single failure caused disaster. There are five processes of mapping future solutions on the product services of visualization technology and 3D simulation. The flow process chart below illustrates the steps of processes.

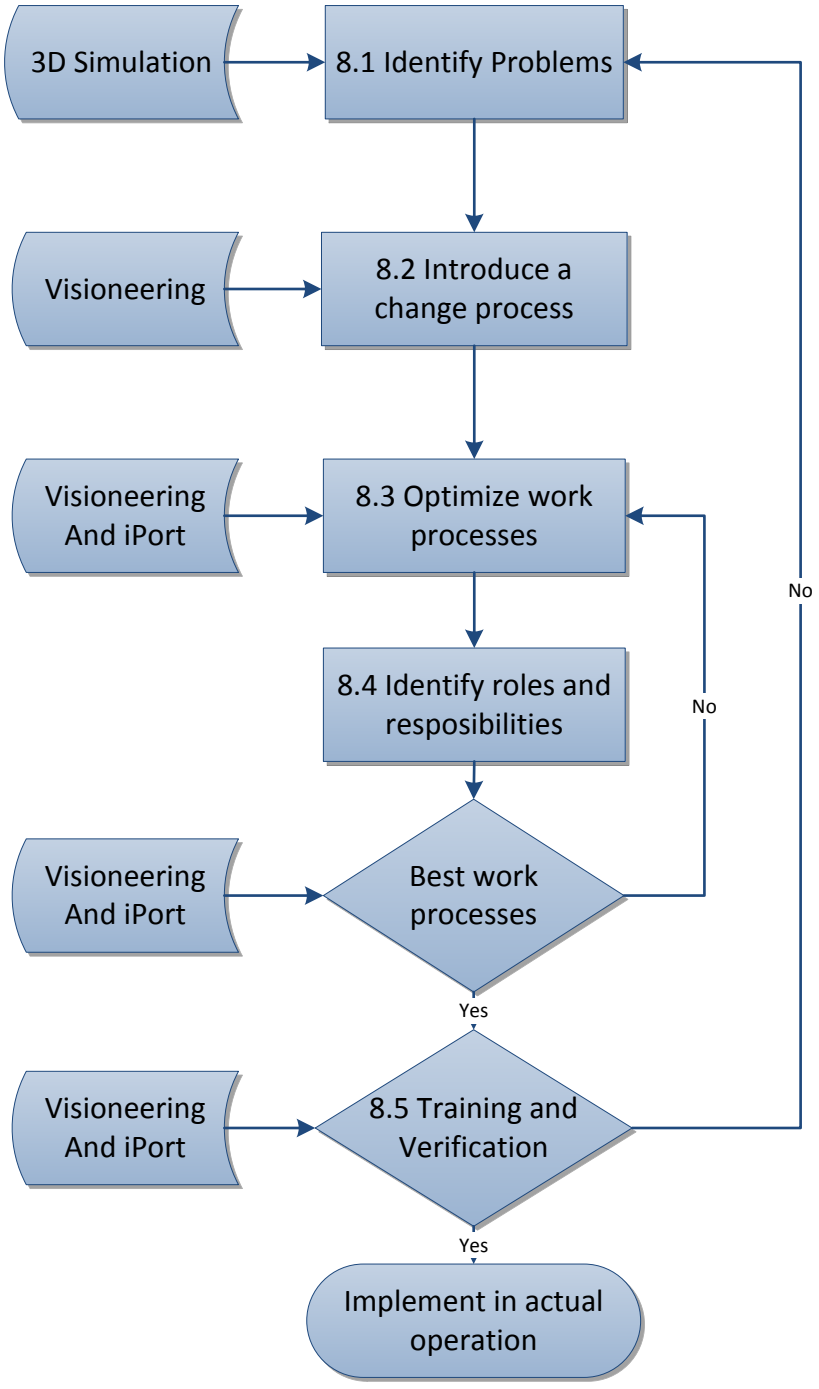


Figure 8.2 Flow process chart of mapping the future solutions of Visualization Technology.

8.1 Identify the problem in operational work processes

One of the critical problems of the work processes in the oilfield operational is collaboration between different functionalities. In oil and gas industry, the integrated operation has provided connection of different parties between offshore platforms and onshore offices. Every personnel has own specific duty task, which is related in the operation process. There are different ways that process parameters or information data are collected, interpreted and being used in the project execution of offshore operation. It often occurs that decision making in the high risk operation process is made by insufficient observations basis. There is lack of sharing overview of operation process between contractors and operators. For example, operators might observe this process as critical improvement from onshore office but contractors may seem this process as normal. Therefore, the common picture of operation process is urgently needed to create and share perception of the situation.

Another problem that often occurs at offshore operations is the operational faults that could have caused by many factors, human errors, machine faults, maintenance delay, accidents and incidents, and man/machine interfaces. When operation is taken place at oil production offshore in extreme climates environmental awareness located 200-300 kilometers away from landsite together, personnel, operators and equipment are being concerned on the performance and safety awareness. Training, equipment verification and planning become the key performance indicators for work processes improvement.

8.2 Introduce a change process by using Visualization technology

After problems are identified in the first step, visualization technology will be implemented into the process. According to previous chapters, the Visioneering process implementation is being applied in specific usages of operational process (Drilling, and MMO). However, every operation process improvement mainly focuses on operator skills, operational equipment and collaboration. The future solutions of change process are looking forward to establish more automatic control system and intelligence collaboration. Human performance can be very varied depends on experience and skills therefore with more automation system in oil production, the performance would result to be more accuracy. However, in this change process, 3D simulated-based system will be used to for testing over and over until the best process is being selected. 3D visualization and videoconference tools help collaborate cross discipline cooperation. 3D visualization shares the common picture between parties for

example, geologist collects visualization picture of geological models and send over to drilling engineers who visualize the wellbore in real-time. As one unified teamwork, integrated operation could run more efficiently.

8.3 Optimize work processes

Three performance-drives based on MTO analysis after implementation of Visualization Technology in the organization new work processes.

1. More comprehensive operator skills and fewer workforces needed at offshore.

The combination of field operators training and advance equipment control system with reality virtual environmental conditions is integrated as visualization tools of simulation training facility (Concept of iPort centre). These tools can help improve man/machine interactions, prevent unexpected incidents, and operate onsite without damage to the environment and possible personnel injury.

2. More efficient operation processes.

The operation process performance is indicated by productivity against time consumed. Achieving productivity target with less time consumed and safety procedure is the main goal for optimizing efficient operation. Visualization concept has involved in the project lifecycle phase from the conceptual design to establish better work preparation and HSE reviews and also verify the process in pre-commissioning phase before the actual operation have been carried out.

3. High quality in decisions making through collaboration.

During the operational phase, visualization tools of real time monitoring can be used to support decisions making. By having experts monitored the process in virtual system in the same time as when actual operation is executing, this creates high quality of decisions making. Onsite operators can directly communicate with other supporters onshore around the world via the smart collaboration system such as videoconference, when the decision is being decided on the operation.

8.4 Identify changes of organizational roles & responsibilities

The usages of visualization tools have consequences on the organization roles. The benefits of accessing real-time data together with a mind-sharing perception have an effect on basic change of some positions in organizations, both onsite offshore and onshore office. There are changes in roles of specific workers.

- **Offshore Operators**: The operators have more ability to train on handling real equipment with control system in simulator application secarios and to review the operations planning and processing through 3D simulation tools before the actual work tasks are performed. The training simulator also provides opportunities for operator to train and verify the future process during their weeks off before the new shift starts.
- **Suppliers/Contractors**: Suppliers and contractors are usually located in separate work rooms at offshore, reviewing different data and having diffient perception of the operation work tasks. However, the visualization and simulation tools could establish the operation tasks in virtual application that involved all personnel related to the project execution and shared as display of overall picture. Together with better integrated access to the resources, the visualization tools allow both parties to share their perceptions and it will be possible in the future to do these jobs from onshore.
- **Engineers**: Engineers will have more access to the operations by validating the project execution on simulator tools. Experts will no longer be send to offshore platform to solve and review the problems. Conceptual and designing phases of the project lifecycle could be verified and simulated through the visualization tools. For example, when there is an improvement process in ongoing project, engineers could verify the improvement process in the off critical line simulator before the plan is carried out to the actual operation.
- **Monitoring and control staffs**: The visualization application tools could provide better support, with less personnel, on offshore opration through the real time monitoring and control system. These benefits allow onshore staffs to support offshore crews on condition monitoring and operational assisting with collaborative systems. The staffs have to be actived 24 hours 7 days a week to monitor and control the performance and possible incidents by using remote diagnostic and application tools from onshore office.

- **Integrated visualization tools and simulator supporters**: These are the new roles and responsibilities that are established to support both work tasks of real-time operation monitoring and performance optimization process. These roles support the oilfield operations and maintenance by using integrated operation simulator (Visioneering and iPort) and responsible for system validation of real-time data and monitoring performance of the operators. The supporters also work together with experts and engineers to establish modeling and scenario diagnosis on the simulation tools.

8.5 Visualized Simulation Training and Verification

Training and verification process is a decision step that considers new optimized work preparation whether it should be carry on to the actual implementation of the operation or not. This process will make sure that the optimization of work processes are the best practice for the actual operation by using the simulator training and simulator verification. The training facility that equipped with simulation tools for example, iPort centre, can provide full operation work task in virtual world for the users to either train or verify any implemented operation project. The future solution that are recommended is to use the benefit of visualization technology and 3D simulator to verify and optimize the performance of key variables of workers, machines and operation processes and keep continue improve until there are the best results before the actual operation is taken.

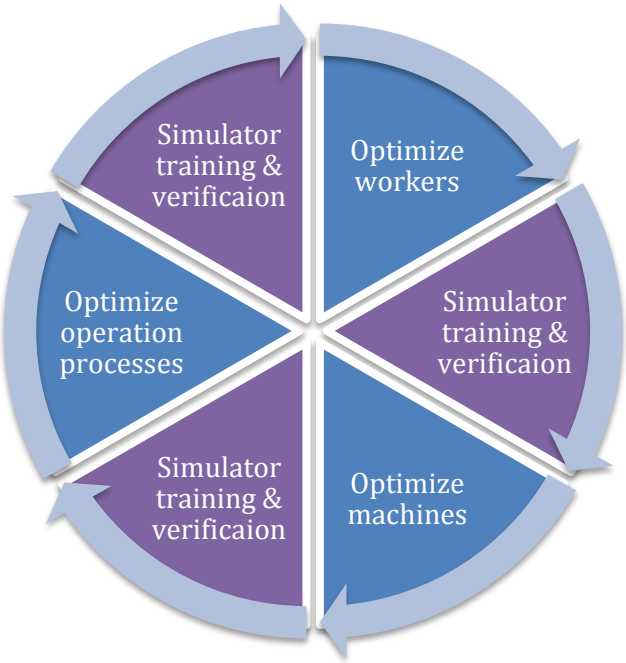


Figure 8.3 Continous Improvement flow process of future solutions.

9. Discussion

3D Visualization and simulation are new innovative technology that many industrials have interested to implement in their work process. Aker Solutions has established this innovative product of Visioneering to be the future solutions for Oil and Gas industry sector. It has been a great opportunity to experience these power future solutions and to explore the usages and benefits to others. There are many challenges of getting information and exploring this technology. Since the concept of visualization has just been introduced in the oil and gas industry past decade, the results of implemented project study still have not been provided many in the literature database. The analysis and evaluation are based on previous implemented development project from Aker Solutions. However, in the future, all industries trend to explore more about this technology to adapt to their work processes because training and testing processes are the most important improvement processes for the performance optimization. Therefore, this thesis can be carried out in the future to explore more new challenge solutions and new opportunity to increase productivity with lower costs and higher safety procedure not only in oil and gas industry but also any other industries.

10. Conclusion

Visualization and 3D simulator product of Aker Solutions were developed to optimize the oilfield development projects particularly in offshore operations. The technology of Visioneering and iPort simulation facility has been integrated into work processes of offshore operation to improve and optimize performance. In the status reviews of the product shows that Aker Solutions is the leader in this technology solution by provided the service of simulation training and visualized verification in three of theirs business areas, drilling technologies, MMO and subsea. There are many benefits were qualified in this thesis, which show that this product has high potential to expand to other usage areas of well services and well stream processing. The strengths of these product services are to simplify the daily operation job tasks in the simulation tools and display results in virtual simulated environment to improve the visualize of all parties related in the operation to see the same picture and to create better collaborative scenario sessions to accomplish the work tasks. The future opportunity of this product is to expand the usage beneficial to all functionality of oilfield operation.

In the future, I believe that many other organizations within oil and gas industry and other complex enterprises will start to use this visualization technology to implement their work processes in decision making and work management, which will become a future solution to increase their business performance and reduce risks. I hope that this thesis work will help illustrate the usages and benefits and demonstrate the future solutions of Visualization Technology and 3D simulator services.

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