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MASTER'S THESIS

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Abstract

In the beginning of the 21st century the Norwegian petroleum industry was faced with two possible future scenarios, the "disintegration" and the "long term" path. The "disintegration" path would involve a stagnation of the petroleum production in a 10-20 year perspective. The "long term" path would involve an increase in the petroleum production until 2050. In order to avoid the decline in production that was predicted in the "disintegration" path, the companies in the Norwegian petroleum industry started to rapidly implement Integrated Operations.

This Master's thesis is studying Integrated Operations and how this has been implemented in the petroleum industry on the Norwegian Continental Shelf. It studies how Integrated Operations have influenced the organisations that have implemented this work processes. In the research part operational results from two pilot projects have been analysed. The idea behind this research is to show whether or not the Integrated Operations have increase the efficiency and results described by different organisations.

The conclusion of this Master's thesis is that Integrated Operations have provided results that have increased the efficiency, reduced the operational costs and reduced the exposure time in hazardous areas on the platform for offshore personnel. However it has not been proved that the HSE performance has improved as a result of the implementation of Integrated Operations.

Preface

Since commencing my studies at the University of Stavanger in 2006, I have heard a lot about Integrated Operations and how these work processes are supposed to increase the revenues, efficiency, HSE results, and increase the oil production on the Norwegian Continental Shelf that have peaked and is declining. When I started working for Odfjell Well Management in 2009, the organisation was working according to the IO philosophy, so I quickly got involved with how the IO operations worked. Since I had not worked in an organisation that follows traditional or conventional organisational structure, I was curious on the effects that the IO concept made on the revenues, HSE performance and the overall efficiency of the work processes. Therefore when I started to prepare for my Master thesis I wanted to explore this further. My original approach was to focus on a risk management perspective, but this was broadened to include the performance of the different work processes due to the availability of data and the scale of the study. This scope made it much easier for me to find relevant data for the thesis. Some of the data that I have used is internal Odfjell Drilling documents, so I have decided to use depersonalized data in order to not have to make a confidential Master's thesis.

Acknowledgement

I would like to thank my employer, Odfjell Well Management, for the opportunity to study at the University of Stavanger while working in the company, and especially for their support during the work on my Master's thesis. Without this goodwill from my employer, this study would not have been possible.

I would like to thank my faculty supervisor at the University of Stavanger, Reidar Bratvold, giving me valuable and constructive feedback on my ideas and helped me define the scope of work.

I would also like to thank my external supervisor at Kongsberg Drilling Management Solutions, Erick Larson for his contribution to my Master's thesis. I have also received advice and guidance from other colleagues at OWM and Odfjell Drilling, and they all have my gratitude.

Most of all I would like to thank my pregnant fiancée, Lina Ryder for her patience and understanding during the two years of combining regular work with studies at the University of Stavanger. Without your patience and support I would have given up a long time ago.

Bergen, June 2011

Stian Tysnes Hauge

Abbreviations

DD	Directional Driller
GNI	Gross National Income
GPN	Gross National Product
HSE	Health, Safety and Environment
IO	Integrated Operations
KDMS	Kongsberg Drilling Management Solutions
KPI	Key Performance Indicators
NCS	Norwegian Continental Shelf
NPD	Norwegian Petroleum Directorate
OD	Odfjell Drilling
ODC	Onshore Drilling Centre
OLF	Oljeindustriens Landsforening
OSC	Onshore Support Centre
OWM	Odfjell Well Management

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1. Introduction and Background

In the beginning of the 21st century the Norwegian petroleum industry was faced with two possible future scenarios, the "disintegration" and the "long term" path. The "disintegration" path would involve a stagnation of the petroleum production in a 10-20 year perspective. The "long term" path would involve an increase in the petroleum production until 2050. In order to reach the long term goal of increasing production until 2050, the petroleum industry needed to produce the less accessible petroleum resources in a more efficient way. This was declared in a white paper from the Norwegian government in 2001-2002, "Stortingsmelding 38". This paper emphasized Integrated Operations as a key driver for achieving the goals of continuous growth in the production towards 2050. In order to avoid the decline in production that was predicted in the "disintegration" path, the companies in the Norwegian petroleum industry started to rapidly implement Integrated Operations.

1.1 Thesis Description

This master thesis is divided into two separate but connected parts. The first part has focus on the literature dealing with issues that is relevant for the integrated operations and its implementation in the petroleum industry on the NCS. In the second part I have done a case study and reviewed a case study in order to evaluate the results from the implementation of Integrated Operations.

I have used these two parts as the subject for my discussion and I have concluded on what I think is the results and the way forward of the implementation of Integrated Operations on the NCS.

I have chosen to address this problem in my Master's thesis, because I think it is important to not rush into deployment of new technology and use a lot of money on Integrated Operations, if it is not giving any results in terms of efficiency, HSE and improved production. Before starting to study this subject I personally thought that Integrated Operations and its benefits was hyped by technology and competence vendors that wanted to earn money on the fear from the operating companies that they was not going to be able to produce as much as they could do.

I think this is a very relevant problem for the petroleum industry, because it's important to analyse the results from the Integrated Operations in order to understand what benefits this approach is delivering. By studying how Integrated Operations is performing it is easier to make corrections/improvements in the approach in order to achieve even better results.

1.1 Problems and Challenges

Originally I wanted to study Integrated Operations and its impact on risk management. I wanted to find out if organisations that have implemented Integrated Operations were better on risk management than other organisations. After speaking with my faculty supervisor and external supervisor I decided to broaden my focus area to include the performance of the different work processes. I decided to conduct a case study where my employer, Odfjell Drilling, provided me with results from key performance indicators that they are using on their rigs. The data from the KPI's is confidential and I have depersonalized it in order to avoid writing a confidential Master's thesis.

I have had many challenges on the way especially with the combination of work, school and private life. I got promoted at work to Lead Drilling Engineer so my work load increased when I got responsible for the planning of an exploration well. I am also going to be a father soon so this has also demanded some of my time.

1.2 Scope and Objective

In the scope of work for this Master's thesis I want to answer the following problems

Describe Integrated Operations in the Norwegian petroleum industry.

I want to describe what Integrated Operations is and I will try to find out why this have become a topic in the petroleum industry on the Norwegian Continental Shelf.

The second objective with this Master's thesis is to perform:

A Study of performance indicators in organisations that have implemented IO and organisations that use more conventional organizational work processes and see if there is a difference in the performance with regards to economy, HSE and effectiveness.

Many technology and competence providers have claimed that by following the principals of Integrated Operations the organisations will have a huge benefit from this with regards to revenue, HSE etc. By comparing the results from "similar" rigs using two different organizational systems, this could give us a pointer to verify if the IO processes are more beneficial than the more conventional work process.

I have used several floating production, drilling and living quarter platforms on neighbouring production fields on the Norwegian Continental Shelf. One of the rigs "Platform A" started an IO pilot project in 2007.

In addition to this case study I have reviewed a SPE paper that summarized the result from an IO pilot project that ConocoPhillips conducted on the Ekofisk field. I have done this so that I would have a broader foundation to support my discussion and conclusion.

1.3 Methodology

Methodology deal with how you obtain the knowledge and develop theories, and further ensures that this knowledge and theories fulfil scientifically requirement and appear as relevant for the subject (Grønmo 2004). I want to describe the methodology and the methods I have used for collecting the literature about IO and the data from the IO processes in Odfjell Drilling. This literature and data will also be considered against the requirement about reliability and validity for the studies I am conducting.

1.3.1 Qualitative case study

To conduct a case study implies that you perform a thorough study of one or a few phenomena's (Andersen 1997). In this study I have examined the data from five similar offshore rigs that is contracted by Odfjell Drilling to see how the different rigs perform according to the same Key Performance Indicators.

The use of case is described by Yin (2003) that it can be used as an empirical study of a present time phenomenon in its natural context. It is important to understand that case study is not a data collection method in itself. A case study is a strategy on how to design a study, collection of data and the analysis of this data.

Yin also describes some criteria for when it is relevant to use the case study strategy. A case study is most suitable when you study a phenomenon in its present time that you cannot control, and when the studies have an explanatory purpose. This means that you search to give an answer to how and why, instead of having a describing focus, that will give you answers on who, what and when. The IO-process is happening in my present and I cannot control it as I would have the opportunity to do in a closed experiment. Also my goal is to explain the processes and try to see if it achieves the benefits that it is promising.

The use of case study is not always the best way of research and has been criticised by some researchers. It is mentioned three weaknesses with the use of this method. The first one is that when using a case study one may not be thorough enough when selecting the data acquisition methods. This inaccuracy from the researcher can lead to ambiguous results. Also a dilution of the case study method that includes only one single case or a case that is promoting a cause or opinion. This has resulted in that some researchers think that this research method is unsuitable as a research strategy. I have tried to avoid this in my case study by including results from several rigs that is measured in exactly the same way. The only thing that is different is the age on the rig. This may affect the effectiveness of the rig. The second weakness mentioned is that the case study is too extensive, that it takes to long time to execute and that the amount of data gathered is to large and can be partly irrelevant. This Master’s thesis has its limitations on time and length, and I have

tried to focus on gathering only the key information that can help me to answer the problem I have addressed. My goal was to find key information sources where I also could extract the most relevant information. The third weakness of the case study strategy is the lack of ability to generalise statistics. It is correct that the case study method is not suitable if you like to generalise to a determined population. Instead of searching for this statistical generalisation the goal here is to make an analytic generalisation. This means that you try to generalise the theories instead of searching for frequencies in a population.

1.3.2 Document analysis

This form of data acquisition involves a systematic review of documents with a view to categorize the content and register data that is relevant for the problem that is being addressed (Grønmo 2004). The characteristics of this method are that you conduct the data acquisition and the data analysis at the same time. During the studies the researcher gradually increases its ability to select documents that is relevant for the studies as he gets more and more information about the problem that is addressed (ibid). The advantage with the use of these types of documents is that the researcher cannot influence the material. If the researcher is using for instance interview as a source of information, the researcher can use leading questions or in other ways enforce certain answers. This will not be the case when using already produced documents (Marshall and Rossman 2006).

In this study, I have used a variety of document material that is summarized in chapter 6 References. Some of the documents I have used are internal documents that are confidential but the documents can be placed under these general categories:

- Documents that state Odfjell Drilling's goal for implementation of IO on company level.
- Plans for implementing of IO in the different business units. This is more operational plans on how they want to use IO. New working structures, positions and working descriptions.
- Master thesis written in connection with the company's agreement with Handelshøyskolen BI. This is a cooperation where Odfjell Drilling employees can take a experience based Master degree. Several of these Master thesis has been written on different situations in the company, among them also some about the use of IO in Odfjell Drilling

In addition to this I have also had access to several presentations and notes. Some have been used as source for this thesis, while others have helped me to get a greater understanding of the company and the IO processes.

1.3.3 Processing and criticism of the data groundwork

After finishing the data acquisition it is very important to evaluate the quality of the data that is acquired. This is crucial in order to be able to give a relevant and credible answer on the research question that is the basis of this study (Grønmo 2004). Because of this, it is very important to evaluate the data against the methodological quality criteria. The most common and the ones I have used are reliability and validity.

Reliability is to evaluate if the data acquired is reliable and with using the exact same methods in the same way on the same phenomena, it will produce the same result (King et al. 1994). This means that by doing this study again it will produce the same results. According to Grønmo (2004) there are two factors that can weaken the reliability of the study. The phenomenon that is studied can be altered after the study has ended and therefore a new study with the same methods can end up with another result. Also the study methods used to conduct a qualitative study are often complex and flexible, so it is difficult to do the same data acquisition exactly the same way.

Validity is to evaluate to which extent the acquired data is relevant for the problem that is to be addressed in the study. The validity is high if the acquired data correspond to what is the intention of the researcher (Grønmo 2004). The validity of the data is ensured by selecting data collection methods that will give information that is relevant for the study and that you document and quality checks these methods.

I have given it my best effort to conduct the data acquisition and the interpretation of the data in a systematic and objective way, so that the results appear as valid and reliable. It should also be mentioned that my affiliation with Odfjell Drilling can potentially be problematic. I have worked in Odfjell Well Management since June 2009, and this can mean that it is in my self-interest to give a positive presentation of Odfjell Drilling, since I am a part of this organisation. Despite of this, I think that I have managed to keep an objective role during these studies.

It should also be stated that a closer affiliation with the company can have its positive sides. By being on the inside of the organisation, I have had a better overview and understanding of how the organisation works. I think that this has increased my ability to consider my presentation of the IO projects within Odfjell Drilling and that this has strengthened the empirical presentation in this Master's thesis.

2. Theory

In this chapter I will present the literature that is generating the framework for my studies. It is common to divide between descriptive and explanatory theory. The descriptive theory is explaining something on *how* things are, while the explanatory theory is trying to explain *why* something has happened (Troye og Grønnhaug 1989). In this chapter I have used both descriptive and explanatory theory in order to explain what Integrated Operations is and why it has been a topic in the petroleum industry on the NCS.

2.1 Integrated Operations

Integrated Operations (IO) is a term for the use of new technology and work processes in the organisations. The concept was being introduced in the beginning of year 2000 in the Norwegian petroleum industry. Today the most common way of defining IO is: "Integrated operations (IO) is about employing real time data and new technology to remove barriers between disiplines, expert groups and the company" (Statoil web page). Several names have been used for this technology: efield, smartfield, field of the future and ifield, but Oljeindustriens Landsforening (OLF) has been an initiator to use the term Integrated Operations (Bladet "Forskning" nr 4-2006). Common for all of the different organisation names is that they include much more into the concept of IO than just technology. This can best be described by the illustration bellow.

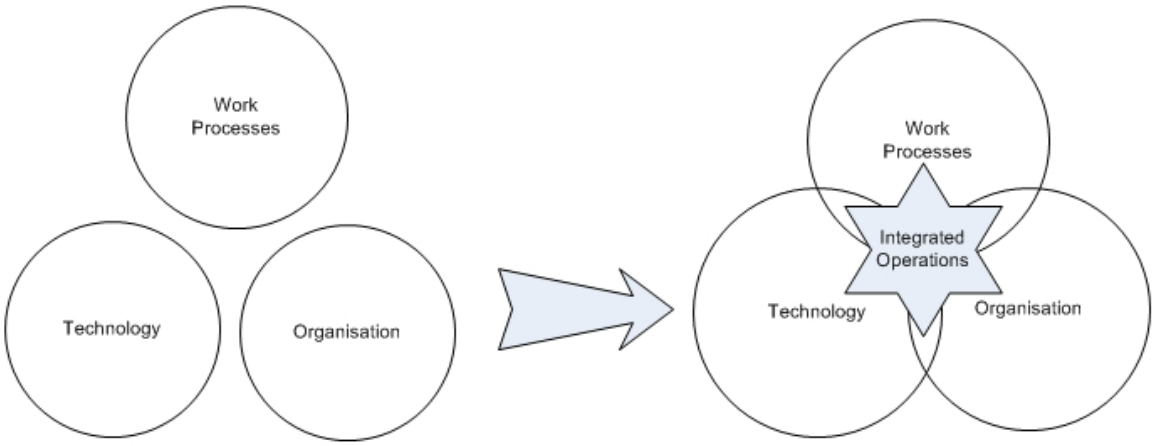

Figure 2-1 Illustration of Integrated Operations.

OLF was early enthusiastic to IO and in April 2006 they made an IO document (OLF 2006). Their definition of IO in this document is today sheared by other vendors in the industry and it is identical to the definition of IO in "Stortingsmelding nr. 38", "Use of information technology to change work processes to achieve better decisions, remote control equipment and processes, and to move functions and personnel onshore". This document is also the core for many companies initiative for introducing IO into their

organisations. In this report it concludes after conducting a survey in 11 of the biggest producing fields on the NCS, that by investing 25 billion NOK (NPV) in the period 2005-2015 into IO, it would provide a gain of up to 250 billion NOK (NPV) in the same period of time. The gain is considerably reduced if the investments are reduced or postponed. The value potential is specifically estimated for the 11 fields, in the form of increased recovery, accelerated and increased production and reduced operating expenses, and based on these results this information has been used to calculate for the entire NCS.

The estimates from this calculations is based on results from implementing IO projects on these 11 fields and comparable fields all over the NCS, together with conservative estimates of effects that still have not been tested. The 250 billion NOK gain is also based on an average oil price of 40- 45 USD/barrel. Because of the considerable gain the IO technologies potentially can provide, there is still some parts of the Norwegian oil business that don't believe in these results. But the last years after the major Operators has quantified their IO profits the confidence in the IO technology is increasing.

In 2007 OLF made an updated report with a potential of 300 billion NOK. Based on an oil price of 370 NOK/barrel to 2015, and a reduced oil price of 220 NOK/barrel the remaining years. This is equivalent to an oil price of 62 - 37 USD/barrel using exchange rate of 1 USD = 6 NOK. The increase of 50 billion NOK is partially because development of new technology and partially because the estimate of remaining production of the fields is used instead of stop in production in 2015 as in the first report.

2.1.1 Difference between IO and Conventional management systems

When an organisation decides to implement IO work processes there are several changes that needs to be performed in the organisation. They need to change their work processes and implement use of new technology like video conference systems or real time data programs. In order for this process to be successful the organisation needs to be flexible and willing to change their work habits to fit the new work processes that are being implemented. It can be challenging for the organisation to change the workers attitude towards the new organisational structure, especially if it’s not clear to the employees why and how the organisation want to implement the new organisational structure, and how this will benefit the employees, the company, owners and customers.

The main differences between the conventional work processes and the IO work processes can better be illustrated by fig. 2-2

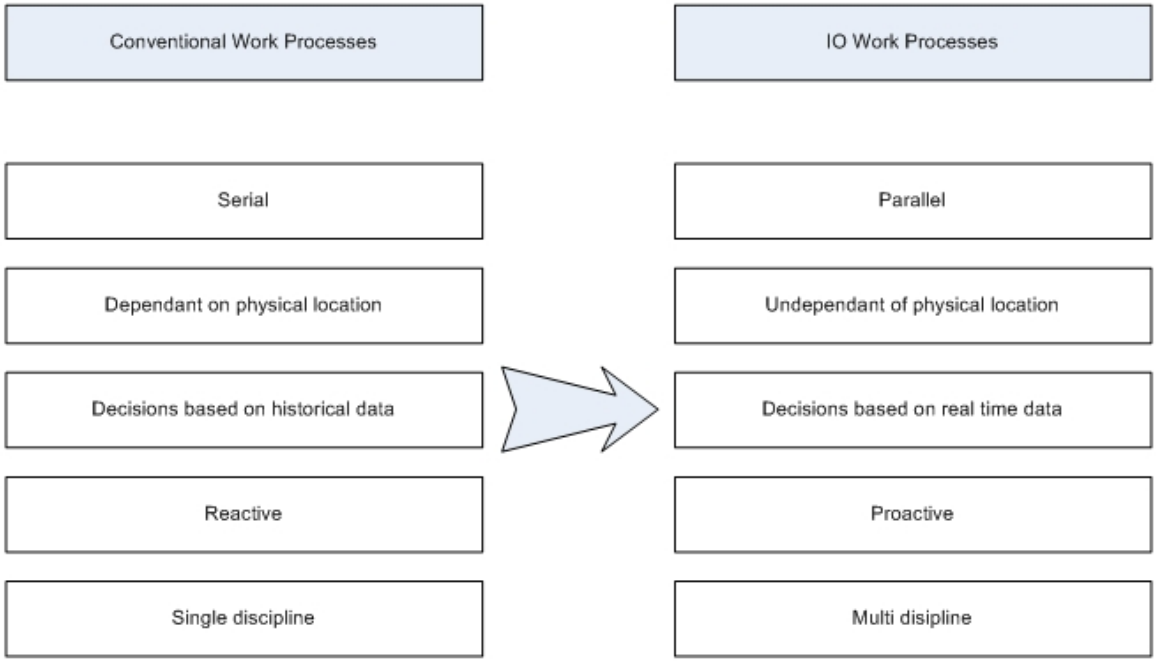

Fig. 2-2 Conventional work processes versus IO work processes.

2.1.2 Why is Integrated Operations on the agenda

In order to understand why companies in the Norwegian Oil business implement IO, it is appropriate to understand how this idea has developed in the Norwegian petroleum business. I would therefore like to describe the development of IO in Norway. I want to explain two of the underlying causes that have been important for the development of the IO concept. The first reason is the increased focus on improving the efficiency of the operations and the second is the installation of optical fibre cable on the NCS. The focus on the improvement of the efficiency resulted in the search for better ways to organize parts of the production, and the IO concept was an answer to this problem. The new optical fibre cables made this new IO concept possible.

2.1.3 Increased focus on efficiency

The Norwegian petroleum industry has a major impact on the Norwegian society. Ever since the petroleum production started on the NCS in the start of the 1970 it has grown to be the biggest industry in the Norway. In 2008 the Norwegian petroleum industry was responsible for 26 percent of the GPN, 50 percent of the Norwegian export and stood for 34 percent of the GNI (Nordvik et al. 2009). As these results indicate, the Norwegian petroleum industry has a major impact on the Norwegian economy, both the direct contribution but also the contributions through transfers to the Norwegian State. This is emphasizing the contribution to the growth and wealth of the Norwegian society.

At the end of the 90's and in the beginning of the 21 century people started to worry about how the Norwegian petroleum industry should maintain the size of the industry and its contributions to the society. In 2002 the Ministry of Petroleum and Energy outlined two possible future development paths. The "disintegration" path implied that the production on the producing fields continued with the same speed and technology as used today. This path resulted in a petroleum production that would stagnate in a 10-20 year perspective. Alternatively the Ministry thought that the "long term" path would imply that the production continued to after 2050. It was described as very challenging to reach the "long term" path. In order to be able to reach this "long term" path it involved to produce less accessible resources in a much more efficient way. Norway also needed to develop and start production on new fields, and old existing fields needed to increase the oil recovery percentage (Stortingsmelding 38, 2001-2002, Al-Kasim 2006). The Petroleum business also sheared the concerns from the State, and the OLF stated that the NCS is a mature oil and gas province with a decreasing activity and attractiveness level (OLF- rapport 2003).

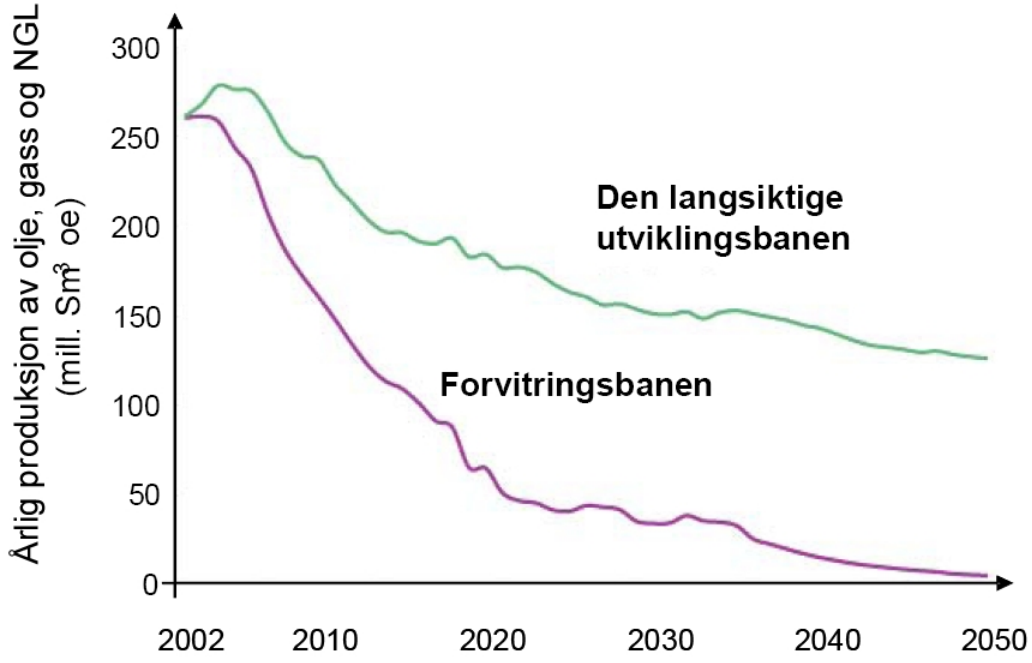

Fig. 2-3 "Long term" and "disintegration" path. (OLF 2003)

This future potential made the Norwegian petroleum industry looking for ways to slow down the decline and increase the possibilities of reaching towards the "long term" path described by the Ministry of Petroleum and Energy. In addition to exploration for new fields and start production on them, increased oil recovery on mature fields, a cost reduction in the industry, more efficient use of infrastructure and greater efforts on research and new technology was key actions that was used in order to avoid the "disintegration" path (Stortingsmelding 38, 2003-2004). IO was described as one of these actions to avoid the "disintegration" path. In other words IO was regarded as a considerable contribution to ensure that the industry should reach the "long term" path (ibid: 37). The increased focus on efficiency can therefore be viewed as a major driver for the IO concept.

2.1.4 Fibre cables in the North Sea

One of the core components for the IO concept is video communication between offshore and onshore personnel together with considerably amounts of data sheared between these locations. This demands a communication infrastructure with large capacity. Already at the start of the 1990's people started to discuss whether they should install optical fibre cables between onshore and the offshore installations. Earlier mid- and short wave radio telephony and satellite transmission was used for communication (Paulsen 2005).

When Statoil developed the Troll A - platform, installation of fibre cables was made topical. The intention was to remotely operate certain operations from onshore and needed therefore new technology to realise this goal. Troll A started the production in 1995 and was the first platform on the NCS that used optical fibre cables for communication with the onshore organisation. This was followed up with a lot of fibre cable installations in the end of the 1990's. This installation was done together with operating companies and technology vendors. On the vendor side Telia Norge and Enitel was the largest suppliers. Their goal was not primarily to help the petroleum activities, but to install a cable between Norway and Great Britain. In order to do this, they needed checkpoints in the North Sea that could amplify the signals on their way across the North Sea. Statoil, British Petroleum, Phillips and Amoco were partners in this joint venture, and the cables were installed via Draupner, Ekofisk, Vallhall and Ula (ibid). At the same time operators on the NCS installed shorter cables on their own. At the millennium most of the field on the NCS was connected to shore and it continued in the next decade. The communication infrastructure had taken a big technological leap, and this new technological infrastructure arranged for a broader implementation of IO.

2.1.5 The growth of Integrated Operations on the NCS

It is difficult to say exactly when the IO concept started in the Norwegian petroleum industry, but it's clear that in the period between 2002 and 2005 it started to be a common consensus that the technological interaction possibilities that was being developed was going to have an effect on the efficiency improvement that was needed on the NCS. This is very clear when comparing the "Stortingsmelding" about the petroleum industry that was presented in 2001-2002 and in 2003-2004. In the first one it is emphasizing that the industry needs to pursue new technology, improve the efficiency of the work processes and perhaps move workers onshore. It is not mentioned which technological solutions that is needed and how they are supposed to be used except from stating that "the government want to realise efficiency improving measures within exploration and production" (Stortingsmelding 38, 2001-2002:15). In the "Stortingsmelding" from 2003-2004 they have developed an overall strategy on how the government shall contribute to the implementation of IO in the petroleum industry. They emphasize that an initiative for IO could contribute to increased production, increased lifetime and maintain the jobs in the petroleum industry. The government emphasizes that they want to "contribute so that the potential value creation through use of e-management" (Stortingsmelding 38, 2003-2004:37). The Ministry of Oil and Energy also asks the Norwegian Petroleum Directorate to initiate in cooperation with the petroleum industry in order to contribute to the implementation of IO. This is concreted the fall of 2004 when "E-driftsforum" is being established. This forum is consisting of representatives from the operating companies, vendors, labour union, research institution and the authorities. Their main task was to realise the government's policy to contribute to increase the use of IO-solutions in the Norwegian petroleum industry (Oljedirektoratet 2006).

The NPD was not the first organisation to contribute to the increased focus on cooperation around IO in the petroleum industry. OLF established a project group in 2002 that was supposed to approach to the problem as the "E-driftsforum". They also emphasized on the preparation for the introduction of IO. Their goal was to develop a future scenario that showed how the IO implementation would look like in the future. The project group presented their first report in 2003 and updated this in 2005.

In these years between 2002 and 2005 the different companies in the Norwegian petroleum industry started to invest in video conference rooms where onshore organisation could shear data with the offshore organisation. In the 2005 report OLF stated "Some companies are still running pilots, whilst others are well into the implementation stage" (OLF 2005:12). In this period there was installed several new technical solutions that made it possible to monitor several aspects of the production on the platform and control some processes from onshore. The companies that were leading on the implementation of IO solutions could show positive results from the implementation. In some cases the implementation of production monitoring had resulted in up to 10% increase in the

production. They also experienced changes in the manning on the offshore installations. The offshore personnel could be reduced and in some cases one third of the personnel were moved onshore (Wahlen et al. 2005). This caused some concerns for the labour unions because they feared that the traditional offshore positions would disappear and that the safety for the personnel that stayed would deteriorate. Also the increase in use of cameras and continuous control from onshore was not positively received by the workers. All of this monitoring could potentially be used for keeping the workers under surveillance and therefore impact the psychosocial work environment (SAFE 2005, Furre 2006).

In addition to these problems the implementation of IO solutions had some other challenges as well. The organizational adjustments that need to be done in order to function as an integrated organisation were not easy. Many employees was sceptic to the changes and afraid that this would impact their work situation in a negative way. There was also a problem with standardization of the technologies. In order to experience the full benefits from the IO concept, there was a need for technological equipment that was compatible with each other within the company but also with external companies like the service providers. There were several differences between the operator companies and the service providers on this matter. The service providers feared that the standardisation would reduce the company's abilities to make unique and distinctive products. In Wahlen (2005:12) it was concluded that "The conflict of interest has made the work towards standardization go slowly".

In this period it was also drawn attention to how the development within IO should be in the future. The industry had great expectations to the IO concept and they believed in a broad and rapid implementation of this technology in the following years. In 2003 in the report made by OLF it was concluded that "eManagement would reduce the level of cost, accelerate the production, increase the degree of production and make a significantly improvement to the HSE results" (OLF rapport 2003:8). In 2005 the OLF presented a time plan showing how they thought that the petroleum industry needed to move forward in order to take full advantages of the possibilities that new technologies introduced. They divided the development into two generations, 1 and 2. They thought that in 2005 they stood at the borderline between traditional production support and the first generation of IO. They thought that this generation would last until the end of the decade and that the generation 2 would go from 2010 to 2015, see fig. 2-4

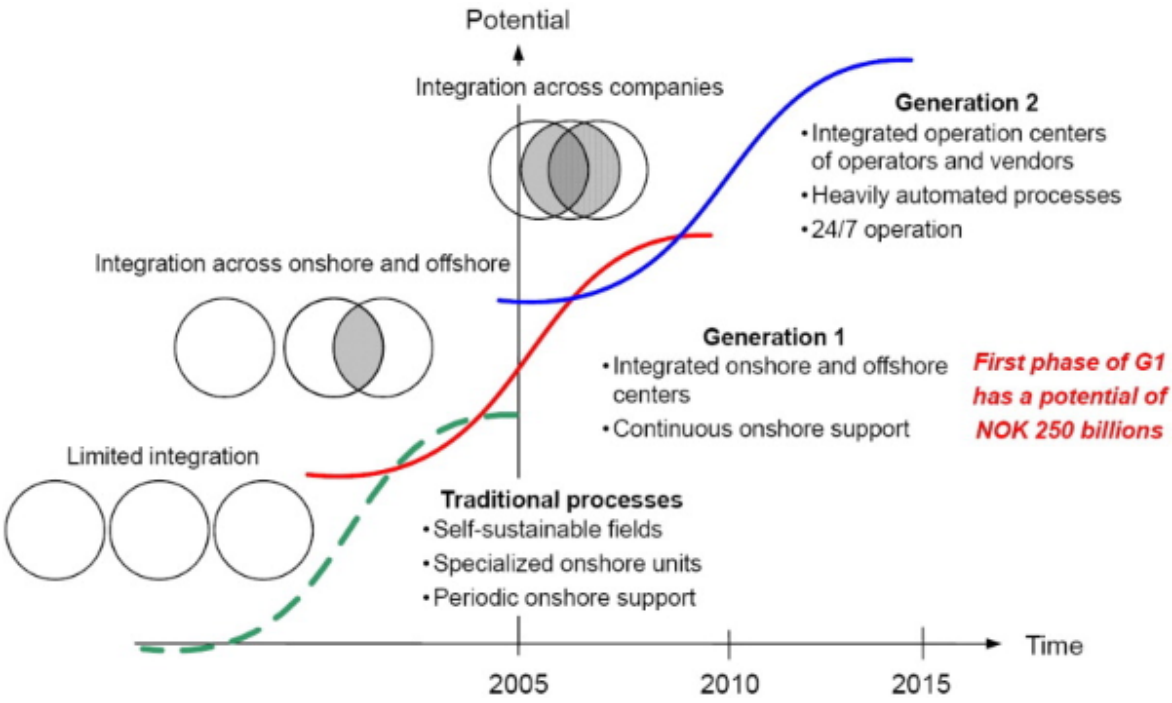

Fig. 2-4 Integrated work process development. Presented by OLF (see reference under chapter 6.4 Internet)

In the 1st generation the industry should start to use video conference/interaction rooms that should be used for communication, monitoring and shearing of real time data between on- and offshore organisations. Personnel from different departments should meet and work together in these interaction rooms instead of working in separate offices. Both production and maintenance would be planned from onshore personnel together with experts in these interaction rooms. As an addition to the video conference systems the industry would use sensors that are sending real time data onshore, in the wells and on important equipment. This real time data would help the production modelling and therefore give a much more efficient planning on how to produce the different reservoirs (OLF-rapport 2005).

In the 2nd generation from 2010 to 2015 these tools would be developed further. The interaction groups would include more people from different organisations and companies. The operating companies would also increase their cooperation and interaction with the service providers. Also the onshore support and monitoring would be on a 24 hours basis. The amount of real time data would increase and a greater part of this data would be processed by computers without human supervision. A lot of decisions would therefore be automated.

If this two generation plan was to be followed the rate of change needed to be increased. The cooperation between the parties needed to be improved, the technology

standardization needed to be prioritized and the research and development of new technology was important. This figure of the two generations was often used to show where the industry had come and where they were supposed to be.

2.2 Successful implementation of Integrated Operations

In order for an organization to see benefits from the implementation of IO, it is important to ensure that the implementation is done properly. There are two types of organizational structures, the mechanical and the organic organizational structure. This was first described by Burns and Stalker (1961). The mechanical organization was rigid, hierarchic with specialization of the different subjects with a vertical communication. This can be compared to the typical bureaucracy. The organic organization is characterized by informal and more contact between the workers on different levels, less specialized and division of power in the organization. Based on studies in British industrial companies Burns and Stalker discover that the mechanical structured organizations is mainly used in organizations with stable and predictable environments. The organic organization structure was often found in organizations with altering and unstable environments. With this information Burns and Stalker concluded that organic organizations where more innovative than the mechanical organizations. This is studied further and it is concluded that the organic organizations promote innovation in the design phase and that the mechanical organization promotes the innovation in the implementation phase (Zaltman et al. 1973). The reason for this difference can be that the less formalized conditions promotes creativity and innovation which is important in the design phase, while the hierarchic conditions in the mechanical organizations makes it easier and more effective in the implementation phase.

This is important knowledge for organizations that want to implement IO into their work processes. To understanding how the different types of organizations is reacting to change is important when designing and implementing the new work structure.

2.3 Odfjell Drilling and Kongsberg Drilling Management Solution

Odfjell Drilling is an international offshore company located in Norway, UK, Angola, Tanzania and the Middle East. Odfjell Drillings vision is to be a recognised leader within oil drilling and oil related services in the North Sea and other chosen geographical regions (OD webpage). The company saw the potential in IO early and in 2001 they started to evaluate cost effectiveness profits of implementing video conference equipment to connect on- and offshore. Integrated operations were still unknown and terms like e-field drilling and e-field management was just at the starting line. Together with a major Operator on the NCS Odfjell Drilling invested in videoconference systems both offshore and in dedicated meeting rooms onshore. The so called morning call that conventionally was held on telephone conference was now held on videoconference systems. This was brand new

for all involved parties and it took a long time before positive effects from the technology could be demonstrated. However the snowball had started to role together with a the oil business experienced a boom in the activity which lead to a bigger pressure on the resources available.

The management in Odfjell Drilling saw a need for intensification of the work with IO processes and in 2005 IO was included in the overall strategies of the company. Odfjell Drilling started a division in Odfjell Drilling Technology called Odfjell IO-consulting. Odfjell IO-consulting provides services in integrated rig and operations management technologies and consulting. The products provide upstream operators and service companies with management support and tools towards optimized and integrated operations, including development and implementation. In 2010 this division was sold to the Kongsberg group and started up a new business called Kongsberg Drilling Management Solutions (KDMS).

Kongsberg Drilling Management Solutions

Kongsberg Drilling Management Solutions (KDMS) is a Norwegian-based management consulting- and software company delivering management - and technology services to the international oil & gas industry. The company has built a unique competence through strategic roles in milestone projects for major companies on the Norwegian Continental Shelf, which are in turn some of the largest global operators. KDMS provides market leading management consulting, and rig management software products - tailored for Integrated Operations. Expertise in change management and organizational development combines with our technology experience to ensure effective implementation and integration of new solutions (KDMS home page, see internet ref.).

3. Research

In this chapter I will present the research I have done in my Master's thesis. I will present the case study that has been performed together with Odfjell Drilling and the results from a similar pilot project conducted by ConocoPhillips. I have also tried to highlight some of the important issues that need to be taken into consideration for a successful implementation of an IO work process.

3.1 Case study of IO pilot in Odfjell Drilling

In this case study I have use data that I have received from Odfjell Drilling on the KPI of similar floating drilling, production and living quarters platform on five neighbouring production fields on the NCS. I have depersonalized the data in order to avoid delivering a confidential Master's thesis. I have also received some Odfjell Drilling internal data on how the IO pilot project has been conducted.

3.1.1 Introduction to the IO pilot project

In 2006 Odfjell Drilling started an IO work group together with the Operator Company on "Platform A". This group contained drilling personnel, leading personnel and IO expert personnel from both of the companies. They started off to make a plan on how to successfully implement IO work tools and methodology. The main changes from the conventional to IO methodology can be summarized as followed:

- Improve interaction between all parts in the organisation
- Increased detailing level in the planning phase
- Parallel activity planning, so called " concurrent planning"

When the work on the implementation model was done, Odfjell Drilling and the Operator agreed on some Key Performance Indicators (KPI) that should be used in the evaluation of the project. After 6 months of operation with the new IO model the KPI was evaluated together with the experience gained.

3.1.2 The conventional management methodology

The conventional management methodology is a standard way for the drilling contractor to operate. Similar ways of working was being used by the drilling contractors on the NCS when this pilot project started. The oil business has a reputation of being very conservative. The oil business has in general not tried to evaluate experience from other businesses with regards to technology, work processes and competence skills. The usual attitude is "to do it like we always has done it".

The conventional management methodology can be summarized by:

- Hierarchic structure on the onshore organisation
- Focus on the daily management and follow up

When following this management methodology the drilling contractor has not been much involved in the planning of the drilling operation. The most important driver for the drilling contractor has been to have an up and running available rig for the customer (Operator). Because of this the drilling contractor has not been troubled by the time the different operations takes as long as the rig is working. The rig usually gets paid by up time, not on how fast and safe the drilling operations are performed. The organisation of the drilling contractor can therefore be perceived as reactive and less proactive.

There are a lot of real time data available from the rig but this is not being utilised in this management methodology. There has also been installed a lot of new technological equipment, but this is not utilised because of low knowledge on how to operate them.

The conventional model also needs extra personnel offshore, in order to do some of the administrative work that is required from the leading personnel on the rig, so that they can focus on the operations. Because of this need for extra personnel the contractor loses money (wages of extra personnel) and bed spaces on board. Bed spaces are often tight on offshore installations especially on the floating rigs.

3.1.3 IO management methodology

The IO management methodology was implemented to the organisation early 2007. When implementing the new IO tools in the organisation, the organisation model also changed with implementing the three focus areas that was identified in the pre study:

- Improve interaction between all parts in the organisation
- Increased detailing level in the planning phase
- Parallel activity planning, so called " concurrent planning"

The new IO organisation wanted to increase the interaction between all of the parts in the organisation from the Contractor side and the Operator side. One of the things done to improve this was video conference meetings with all involved parties. Video conference equipment was installed in the onshore support centre and also offshore in the meeting room. They had two daily meetings between the offshore and onshore organisation where they sheared documents and evaluated real time data from the drilling operation.

The onshore support centre also got more involved in the detailed planning that earlier had been done by offshore personnel. This reduced the need for personnel on the rig and also increased the onshore organisations influence on the detailed planning and execution of the operations. The offshore organisation also started to use a new daily reporting system which had an activity planning module that was used for so called "concurrent planning". This module imports the time planner from the upcoming operations and allows the rig crew to plan maintenance on the rig so that the downtime for maintenance and repairs can be reduced. If something on the drill floor needs maintenance then instead of stopping the drilling operation, the rig crew can perform this maintenance when they are doing an operation that is not performed on the drill floor i.e. while waiting on the casing cement to set up.

The last improvement in this pilot was to evaluate all the administrative routines on board the rig with a goal to move as much of the administrative work as possible over to the onshore support centre. This was also to reduce the meeting activity on board the rig and use this extra time on the ongoing operations.

3.1.4 Results from the IO pilot project

6 months into the pilot project Odfjell Drilling and the Operator evaluated the project and saw for improvement on the pre defined KPI's. The conclusion from the pilot project was that the team all over was more informed of the ongoing operations. The interaction between the various parts in the organisation was improved, which was confirmed by the survey performed by the end of the pilot project. From the survey it was also concluded that the cooperation between the Contractor and the Operator has increased from 59% to 75% as a result of the IO pilot.

The "concurrent planning" function in the rig reporting system was a big success in terms of reducing the numbers of overdue maintenance of the rig and drilling equipment. By using the time planner for the upcoming operations and the schedule for the planned maintenance, the rig could plan the rig maintenance according to the operations and avoid that the maintenance was overdue. The IO management concept was introduced in the middle of March and after the installation period and the time to get used to the new systems, clear results can be seen from July and to the end of the year.

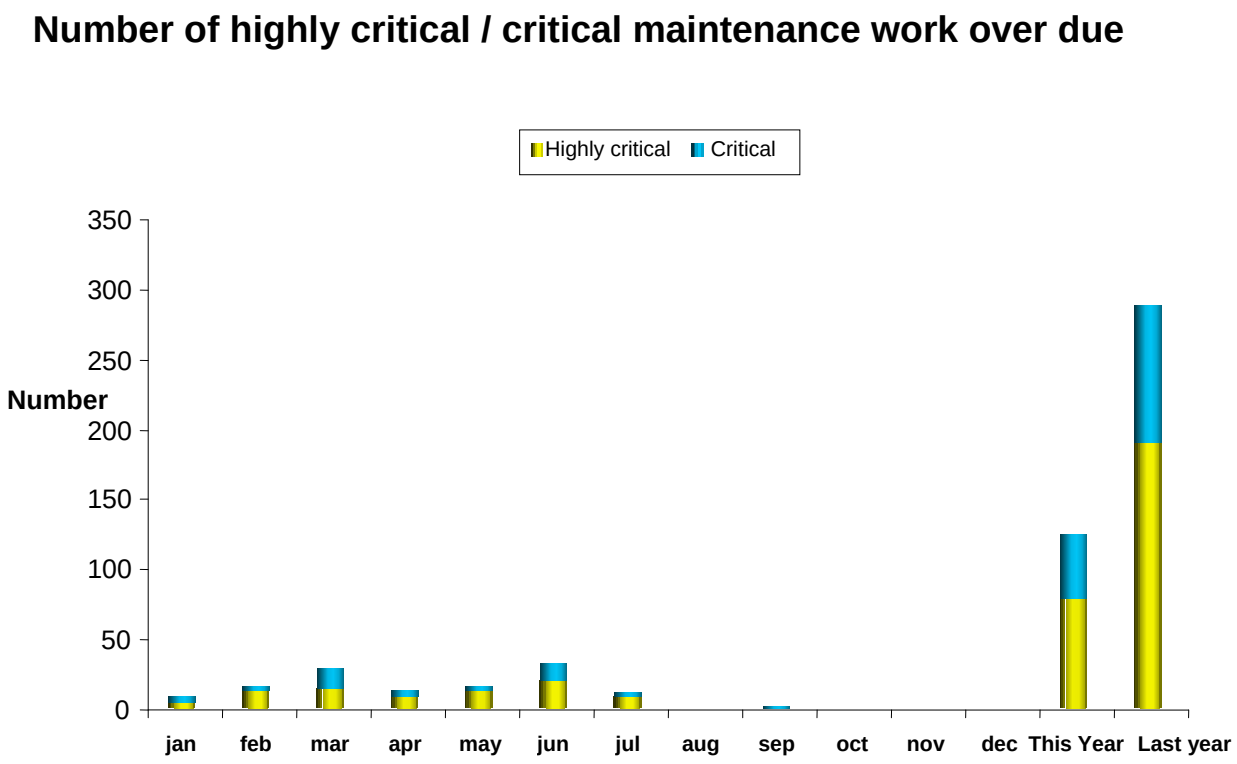

Fig. 3-1 Overdue maintenance.

The same trends can be seen on the rig down time. From the installation period in March to June the downtime due to the technical equipment increased. This has probably to do with the implementation of new equipment and that the new work processes need to get fully implemented into the different crews. But after this period the down time due to technical equipment has been reduced.

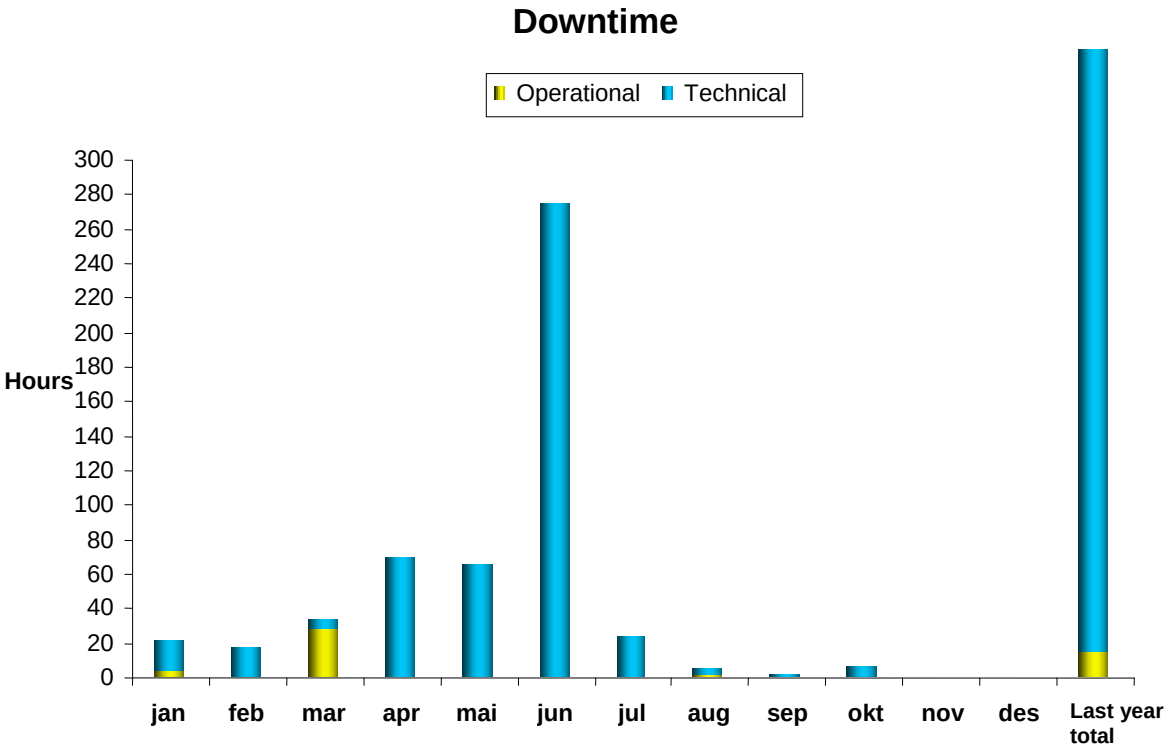

Fig. 3-2 Operational downtime.

Although the project was successful in terms of reduced down time due to good and detailed operational planning and good maintenance planning, the results from the implementation could have been better and more effective if the implementation phase had been smoother. Next time the plan on how to implement and how to implement into the different work processes needs to be better discussed and evaluated before the processes gets implemented into the organisation.

On the personnel issue the pilot project experienced positive results from moving some administrative tasks onshore. They was not able to reduce the personnel offshore, but they were able to move some off the administrative workload onshore, so that the offshore personnel could focus more on the operational problems. Even if they did not reduce the offshore personnel on the pilot project, they experienced that there is a potential for further improvement in this area.

After this pilot project Odfjell Drilling continued this IO project on the rig and also have expanded this philosophy to other rigs. The following figures presents to graphs that compare tripping speed and weight to weight on a few non IO platforms and some that have implemented IO processes. The rig from the pilot project is called platform A.

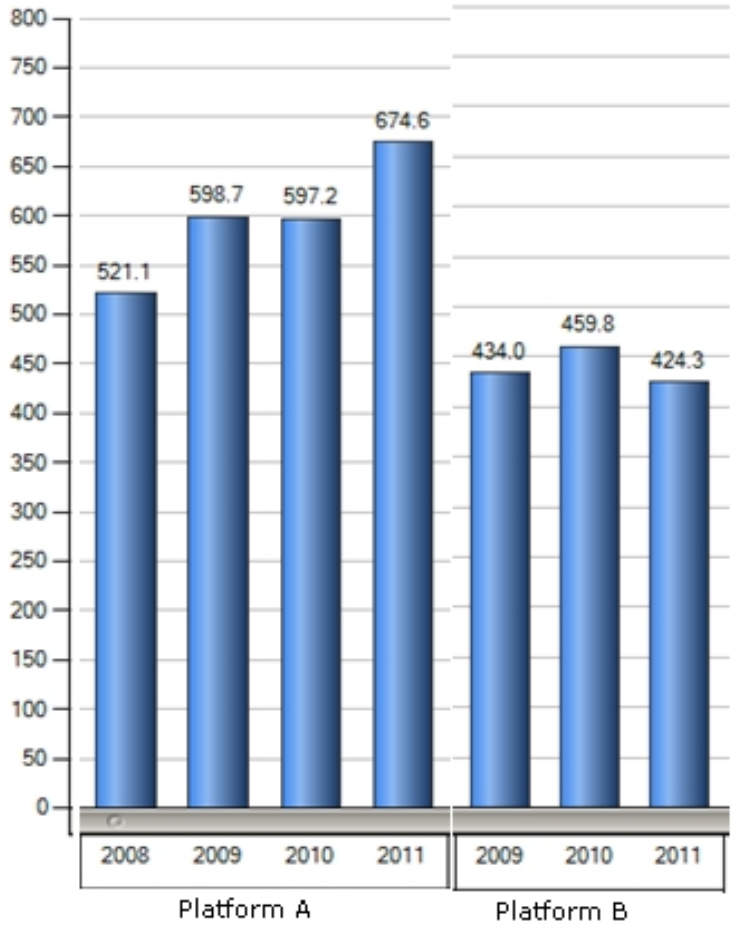

Fig. 3-3 Tripping Speed. Comparison of the tripping speed of two platforms

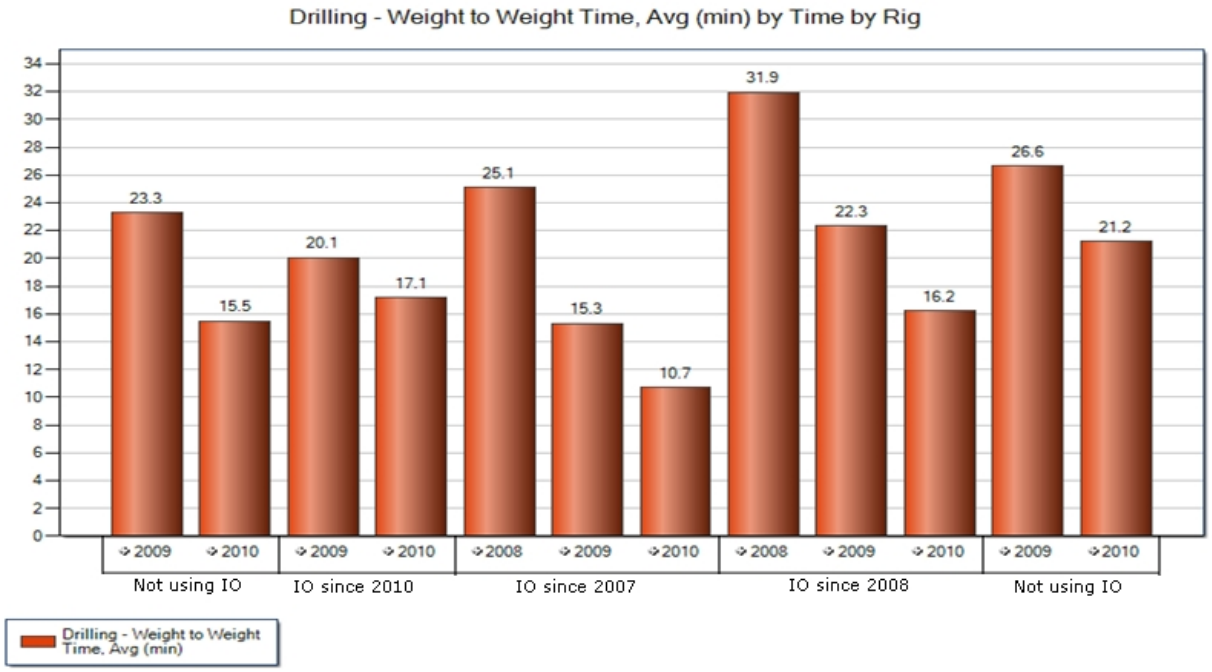

Fig. 3-4 Weight to weight.

From the tripping speed figure we can draw the conclusion that the IO platform (Platform A) has better performance on the tripping speed than the non IO platform (Platform B). We can see that Platform A have an increasing trend whilst Platform B has a more stable performance. From the weight to weight figure all off the rigs have a decline on the average time. However the two platforms that have used IO the longest tends to have a more rapid decline of the average time. On Platform A they have also initiated a new work process where they monitor the different crews and use the data to monitor which crew that is the most efficient on the different operations. After this monitoring they choose the crew with the best performance on for instance the tripping and evaluate what they do better than the others and use this information to make a best practice video that is distributed to all of the different crews. This helps the overall performance on the rig if all of the crews do the operations the same safe and efficient ways.

3.1.5 Success criteria's for the implementation of Integrated Operations

After the pilot project was finished the project group evaluated the project and defined the key success criteria that needed to be in place in order to ensure a successful implementation of the IO into the organisation. The key success criterion that was defined was:

- Communication and involvement
- Ownership and loyalty
- Open to change
- The right IO tools
- Resources and continuous training

3.2 ConocoPhillips implementation of IO

In order to have a broader data basis to do my discussion and conclusion I have found some information regarding ConocoPhillips contribution to the IO implementation, the Onshore Drilling Centre in Stavanger (SPE 111372). The SPE paper from 2008 presents the experiences gained the last 5 years from the ODC project at ConocoPhillips offices in Stavanger. ConocoPhillips established an ODC in their offices where they cooperated together with the contractors and service providers. The ODC has large operation rooms with big screens where they displayed real time drilling data, such as depth, weight on bit, string torque, mud weight in/out and gas levels. They also had a high resolution microscope offshore that the onshore geologist could use in critical parts of the well as setting a casing in a specific formation. The onshore organization also had access to live video streaming and portable cameras that could be used all around the rig if expert help was needed from the onshore organization. In Fig. 3-5 the design of the ODC is presented.

The room was equipped with off the shelf equipment, in order to avoid downtime by using prototype technology. At the time when this SPE paper was written the ODC had experienced zero downtime due to fault on this system.

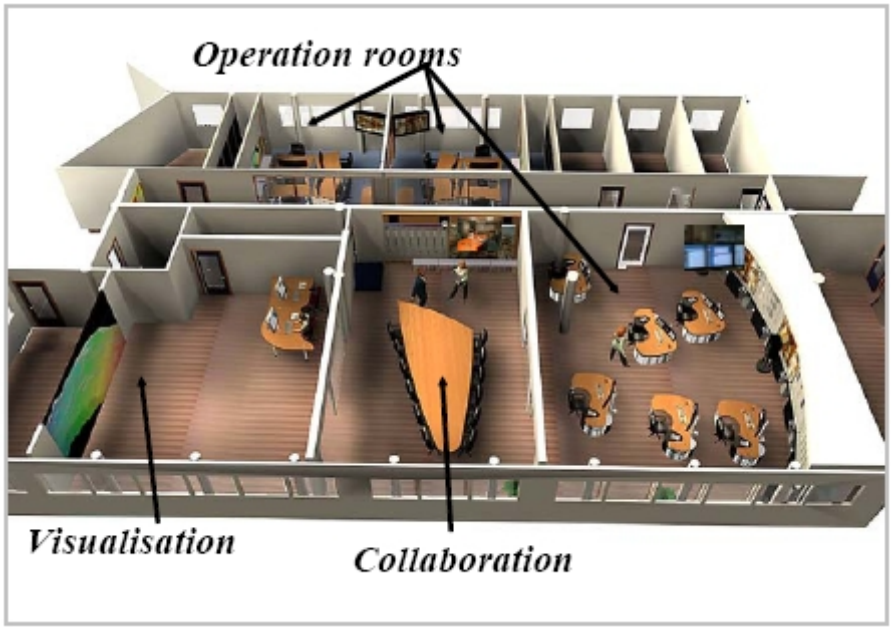

Fig.3-5 ConocoPhillips Onshore Drilling Centre.

3.2.1 The results from the IO implementations

The price for setting up the ODC and systems offshore to support the drilling and well operations was 4 million USD. The documented savings from the use of the ODC compared to the conventional operating cost showed that in the startup of the project the monthly savings was over 1 million USD. The benefits from the ODC increased to 1.5 million dollars saved each month. These monthly savings does not include the benefits of increased oil production as a result of the use of visualization room while drilling. Over 900 helicopter seats have been saved and the number of offshore days has been reduced by over 9000 days since the start of the project. They have also seen improvement on the HSE without going thoroughly into the results. By reducing the offshore days with over 9000 days, the personnel exposure is decreased and thereby creating better HSE results. Also remote operation of certain operations reduces the exposure of the personnel i.e. using a remotely operated iron roughneck instead of three roughnecks making up drill pipe with manual tongs. By utilizing all of these technologies in the ODC together with suppliers they have taken the integrated work processes over into the 2nd generation according to the work process development plan presented by the OLF (see figure 2-4).

4. Discussion

In this Master's thesis I have tried to explain how and why integrated operations have become a subject in the petroleum industry on the NCS. I have also done a case study on the pilot project in Odfjell Drilling and some key performance indicators from different rigs to evaluate the benefits gained from the implementation of Integrated Operations. In this chapter I will try to reflect upon the results from my studies and in the next chapter make a conclusion from this research.

First, I would like to start with a recap of what expected benefits from integrated operations are. In the OLF report from 2006 it is stated that by investing 25 billion NOK into IO projects it will generate an income of 250 billion NOK in the period 2005 - 2015. This was going to be achieved by better decisions, remote controlled equipment and by moving functions and personnel onshore. Today in 2011, some of these goals have been reached. Several production platforms have started to use onshore support centers that can monitor and remote control the production offshore. Examples of this are the Odfjell OSC and the ConocoPhillips ODC. The ConocoPhillips pilot project can already show a monthly cost reduction of 1.5 million USD.

One thing I have experienced while writing this Master's thesis is that it is difficult to define what IO is. Some call it a technology, some a work process while others call it a concept. I think that some of the challenge with IO is that it can be hard for people to understand what it actually is without going into the philosophy behind it. I think it would be much easier for people to accept it and embrace the implementation of it, if the idea of IO is expressed more clearly. I define it as: an approach to work more efficient by utilizing new technology and work processes suited for the different operations and tasks.

I have not found any documents that states how long the integration of IO has come as of 2011, but my researches indicates that some of the earliest IO projects have moved over to the 2nd generation by expanding the integration between the companies in the oil business. Some project has also started to utilize 24/7 operation rooms that are constantly staffed to follow the ongoing drilling operations and production.

One of the key drivers for the implementation of IO on the NCS is the improvement in HSE performance as a consequence of remotely operated operations. I have not been able to obtain data that can be used to conclude if the HSE effects promised actually are achieved. A common result has been that the personnel that are measuring the effects of the IO implementation state that the HSE results are positive. This is mainly connected with reduced man hours offshore and more remotely operated systems. The reduced man hour's offshore and remote operations will at least reduce the exposure time to hazardous work areas, but the increased use of complex systems can perhaps lead to other types of accidents or that the damage potential can be much greater if something is actually

happening. However a Master's thesis from NTNU (Solem, 2007) indicates that the implementation of IO on the Statfjord platforms did not show any improvement in the HSE performance. The implementation of IO did not contribute to any reduction in the number of reported personnel injuries or other incidents with high potential. But it is also stated that improved HSE was not one of the focus points when implementing IO. They focused on reduction in offshore manning and reduced operational costs. This low focus on HSE may be the reason why the HSE performance was not improved.

The effectiveness of the operations has also had a great focus from the authorities. It is getting more expensive to search and produce hydrocarbons, so to increase the effectiveness of the operations could have a large potential for cost and time savings. The case study that is performed in this Master's thesis, together with the SPE paper from ConocoPhillips, shows that the efficiency is increased in operations where IO has been implemented. I have also been showed results that is showing that rigs following the IO concept is a significantly amount of days ahead of the time budged of the drilling program. The reason for this positive result can be the increased focus on efficiency in operations that have implemented the IO concept. Also on the Odfjell pilot project they have tried to standardize the operations on the different rigs, so that the different crews have an even performance on the various operations. This standardization is also promoted by the technology used in the IO.

On the ConocoPhillips case and in the Master's thesis from Statfjord (SPE 111372 and Solem, 2007) one of the key drivers from the IO implementation have been to reduce the personnel offshore because of limited sleeping accommodations and reduced costs of having the people working onshore instead of offshore. In the ConocoPhillips project this was achieved by reducing the offshore days with over 9000 days while the project was running. This was also a result from the Odfjell pilot where the administration offshore could be reduced due to support from the Onshore Support Centre. A further improvement to reduce offshore personnel is to cross train the offshore personnel. In my day to day work in drilling operations, we encourage our suppliers to provide personnel that are cross trained and can be used in several operations. A good example of this is that we have used directional drillers that are cross trained to handle and drill for cores. The DD who normally has nothing to do while the rig is coring, is now leading the coring operation and the extra core hands offshore is not needed. This reduce booth the personnel offshore and the need for extra helicopter flights for transport of the core hands.

Another thing that has not been discussed in this Master's thesis is the need for experienced personnel on remote locations in Norway. Earlier nearly all of the oil industry was located in Stavanger with only minor offices in other towns like Bergen, Oslo and Trondheim. Today this has changed and companies is moving to new locations all over Norway. Since the drilling started in the Barents Sea and with the resent Skrugard discovery the office locations in Stavanger is no longer suited as the main office for these

operations. Therefore the oil companies needs to build new offices closer to the area where they are doing their drilling operations. In order to be able to have all the expertise needed in these remote locations Integrated Operations can be a good solution to mitigate this problem. Personnel working i.e. in Alta could work together with specialists working in Stavanger by utilizing video conference systems and collaboration rooms. This can help mitigate the need for experienced personnel on all locations, reduce traveling activity and reduce cost of having people traveling and moving around between different offices in Norway. This can also be transferred to the offshore organizations where every rig has drilling/test engineers onboard on different operational phases. Instead of traveling offshore, drilling/test engineers can be onshore and serve several rigs at the same time by utilizing video conference systems and collaboration rooms.

5. Conclusions

I started my Master's thesis with following problem that I wanted to study more into detail:

Describe Integrated Operations in the Norwegian petroleum industry.

In chapter 2 I described what Integrated Operations is and how it has become a topic in the petroleum industry on the NCS. I think that the key drivers for the implementation on the NCS are the possibility of increased production (therefore increased earnings) and that the technology and infrastructure is available and much easier to utilize today compared to 10-15 years ago. I also feel that the IO work processes are easier to comprehend today when people see what the ideas behind is and that it basically is to optimize how we do our day to day operations by utilizing new technology and work processes.

The Second problem was:

A Study of performance indicators in organisations that have implemented IO and organisations that use more conventional organizational work processes and see if there is a difference in the performance with regards to economy, HSE and effectiveness.

In chapter 3 I described the case study I have conducted together with a SPE paper that was written on the experiences from ConocoPhillips of the implementation of IO.

From the results presented in chapter 3 I can conclude that Integrated Operations already have made a big impact on the results from the organisations that have implemented the IO concept. The results back up that they have increased the economy in the projects by reducing the costs and increased the effectiveness of the operations. With regards to the HSE perspective I am more uncertain if IO is giving the positive results that it is supposed to. The case study and SPE paper indicates that the HSE is improved without giving any results to back up this statement. However the Master's thesis conducted at NTNU is concluding that the implementation of IO has not improved the HSE. But I think it is safe to conclude that IO minimizes the exposure time in hazardous areas for offshore personnel. This is a result of the increased use of remote operations instead of manual operations of for example the drill floor.

Although the results from this study imply that there are a lot of benefits with implementation of Integrated Operations, it could be that the data would be altered after the IO concept has been used over a long period of time. Maybe the results are a bit optimistic because the people working with the implementation want to see these positive results.

I am convinced that Integrated Operations is the way forward for the Norwegian petroleum industry. I think that by using cutting edge technology and in projects where several different divisions work together towards a common goal is positive. By involving the people into the project they get a stronger feeling that they own the projects and therefore want positive results. I think that this is much easier in a group than when people from the different divisions work on their own and only minds their part of the work. The activity on the NCS is also very high at the moment and there is a high need for experienced personnel. By using Integrated Operations I think that the personnel can be used in a more efficient way with the video conference systems and the collaboration rooms.

I feel that the most negative thing with Integrated Operations is that it can be a bit hard to understand what it actually is and what it does. Offshore personnel are afraid that they can lose their jobs if their function is filled from shore. Therefore is it important to have a clear definition of Integrated Operations and to say that it is just a way of working together more effective. Also, when implementing Integrated Operations into an organisation it is important to commit to the project and train the personnel on how to use the new technology. I have seen many times that workers are afraid of using i.e. video conferencing system because they don't know how it works and they are afraid to not be perceived as a professional.

Final word is that I feel that Integrated Operations are a positive work methodology, but it still needs to evolve and be made more accessible for the users so that it's not frightening for the employees to use the new technology that follows with the implementation of IO.

6. Further Studies

During my studies I saw some areas of interest that I would have liked to study further. The limited time and lack of sources that could provide relevant data made me unable to evaluate this any further.

In order to evaluate the impact of Integrated Operations on the NCS the studies should be conducted with KPI's from several companies that have implemented IO. I recommend that this study is emphasizing on the HSE results, and see if there are clear trends on the HSE performance on IO platforms and non IO platforms. This would be a valuable research in terms of evaluating what should be done in the future to increase the HSE performance and live up to the Zero fault philosophy that the industry is working towards.

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