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MASTER'S THESIS

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Abstract

Over the last few years the production process in the offshore Oil & Gas (O&G) industry has concentrated on innovative subsea solutions. This development has increased the need for advanced multi-purpose Offshore Support Vessels (OSV). Their role in oil field development has widened the intersection between the traditional petroleum and maritime sector, leaving the borderline between them somewhat diffused. This has increased the need for interfacing the two business sectors. As a response to the demand of innovative and efficient solutions, the O&G industry has implemented its novel operation scenario solution, termed Integrated Operations (IO). However, this study shows that the maritime sector is still oblivious to IO and its proven effect in the Norwegian Continental Shelf (NCF). The remarkable difference in the operational approach between the two sectors is a challenging situation as there is a need for a seamless interface between the two operational environments.

This study describes the opportunities and limitations of adapting the IO approach into Maritime Asset Management (MAM) and specifically in the OSV management companies. The study has a practical approach to actual maritime operations, using specific problems encountered during normal operations, critical maintenance operations and an environmental initiative project. By the use of three industrial case studies, supported by interviews, the frictional elements in the operational interface of the two sectors have been identified. This has enabled the outlining of a new organizational approach to MAM. However, in order to utilize the full potential of IO several identified obstacles needs to be acknowledged by the maritime industry and mitigated through a joint effort and an open and including process. The study outlines 13 recommended actions specified to the authority, the oil field operator and the OSV companies for facilitating full implementation of IO into the maritime sector.

Acknowledgement

The time has finally come to mark the completion of my Master of Science degree in Offshore Technology - Industrial Asset Management at the University of Stavanger. The study has given me knowledge and new insights into the offshore and maritime industry. Along the way this has inspired me to front necessary changes within the Norwegian Maritime Authority (NMA). I would like to thank the NMA for making it possible for me to study and for the support from the head of my department, Mr. Bjørn Pedersen.

Throughout my work with maritime accident investigations and offshore vessel management, I have seen too many examples of lives being lost due to poor communication, information complacency and system failures. These are some of the key elements in this study and hopefully the work will contribute to a safer and more efficient maritime asset management.

I would like to express my gratitude to Professor Jayantha P. Liyanage for outstanding lectures and guidance of the master's thesis. Your knowledge and ability to motivate has been important in developing this thesis. I would also like to thank Professor Tore Markeset for his excellent lectures and his inspiring words throughout the years of completing my education. It is also important for me to thank all the persons who contributed in the interviews and meetings. Your open mind, courage and willingness to share your experience were necessary in order to complete the thesis.

Finally, to my wife Julia, thank you for the years of patience and support. And to my lovely daughters Solveig (8) and Rine (3);
Yes! I will come out and play with you now…

Stavanger, 15th June, 2013

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Roar Aamodt

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Abbreviations

IO	Integrated Operations
IWP	Integrated Work Processes
IP	Integrated Planning
OSV	Offshore Support Vessels
PSV	Platform Support Vessels
AHTS	Anchor Handling and Tug Support
MPV	Multi-Purpose Vessels
NMA	Norwegian Maritime Authority
PSA	Petroleum Safety Authority
O&G	Oil and Gas
OC	Operation Center
KPI	Key Performance Indicators
NCW	Network Centered Warfare
ROV	Remote Operated Vehicle
MOU	Mobile Offshore Unit
MAM	Maritime Asset Management
NCS	Norwegian Continental Shelf
IMO	International Maritime Organization
ISM	International Safety Management
SMS	Safety Management System

PART ONE: INTRODUCTION

1 Introduction

1.1 BACKGROUND AND MOTIVATION

1.1.1 Background

At the end of the 1990s the Norwegian petroleum industry acknowledged the challenges they were facing. The increasing operational costs, declining rate of production due to field maturity and the safety focus required a re-engineering of the whole industry (OLF, 2003). There was a need for better coordination and closer cooperation between the different stakeholders in order to obtain the desired level of safety and efficiency. The effort resulted in an implementation of new technology, work processes and organizational structures, which later became known as Integrated Operations (IO). Almost twenty years later the principals have been widely implemented and several IO centers have been developed across Norway. However, despite of the development within the petroleum industry, it seems like the same challenges are unattended in the maritime industry. Initial research in preparing this master's thesis indicates that the OSV management companies are operating based on traditions rather than actual needs, and has not been a part of the IO development in the NCS. There is a need to research if this really is the situation and if adopting the IO approach could mitigate the problems they now are facing.

According to Liyanage (2008) the large scale re-engineering started in 2005 with an increased momentum towards 2010. He also describes how the learning process and knowledge development can be valuable for other industries. If this is the case, there might be an opportunity of a significant value creation by implementing IO into maritime asset management. The IO consultant, who was interviewed in this study, describes how the major oil field operators on the NCS require their suppliers to be IO compatible and hence force their partners to re-engineer as well. This requirement does still not apply for the maritime industry, but the operators are now indicating that this is a natural future step. According to Bai & Liyanage (2008) the current developments in industrial asset management is focusing towards the smart integration of complex operations, and particularly towards high risk and capital intensive assets. The theories within IO are also normally concerned with assets such as offshore production and drilling installations, but as this study will show it surely also apply for Offshore Support Vessels (OSV).

1.1.2 Motivation

If oil were blood, then production platforms would be the heart that pumps the blood through its veins (Liyanage, 2008). Following this analogy one can argue that the OSV are the muscles in the arms and legs. Lifting, dragging and moving equipment around, they have become an important part of the petroleum industry. At the very beginning of offshore production the best fit vessels were Norwegian fishing boats, developed through hundreds of years of experience with the harsh conditions in the North Sea. Lately they have become bigger and better, but also more complex. For a long time conventional Platform Supply Vessels (PSV) and Anchor Handling and Tug Support (AHTS) vessels were the only contribution by the maritime industry. However, as the demand for innovative solutions rose, the production process focused towards subsea installations. This has increased the need for versatile and advanced OSV in oil field developments and operations. This Multi-Purpose Vessel (MPV) has become an important tool in the advanced subsea operation environment.

Recent years these vessels have developed even further and have taken on more tasks, e.g. stimulation and well control. The concept has proven cost effective due to their mobility and efficient hull. The development has widened the intersection of maritime and petroleum activities and has left the border line between them diffuse. There really are no borders anymore, something which pose several challenges with respect to the operational development. As maritime asset management might be lagging with regards to novel operational scenarios, the situation seems to lead towards segregation, protectiveness of own operations and a disintegrated operational environment. This study addresses the issues of organizational effectiveness within a highly complex environment with tight couplings (Perrow, 1984). There seems to be a need for integrating the maritime management, their OSV and the oil field operators.

1.1.3 Integrated Operations – Introducing the term

During the last 10-15 years a significant amount of research and development has been undertaken to explore IO in different directions. Not all of them under the specific term IO. You might encounter descriptions such as eFields, Smart fields, e operations etc. Even if there are local differences they are all related movements towards smarter and more efficiently coordinated and controlled operations. OLF (2006) have concluded with the term Integrated Operations to describe the new collaboration, decision engineered and IT supported revolution in the NCS. The actual definition and meaning of the term has varied since the beginning of the 2000s. According to Statoil (2013) it can be understood as “employing real time data and new technology to remove barriers between disciplines, expert groups, and the company”. OLF (2006) defines the term to be “use of information technology to change work processes to achieve better decisions, remote control equipment and processes, and to move function and personnel onshore”. A common denominator in these two definitions and several others discovered through data acquisition in the subject seems to point towards new work processes, better decisions and a more efficient use of the organization by modern technology. This leaves room for many theoretical approaches to IO depending on the objective and the perspective to be studied.

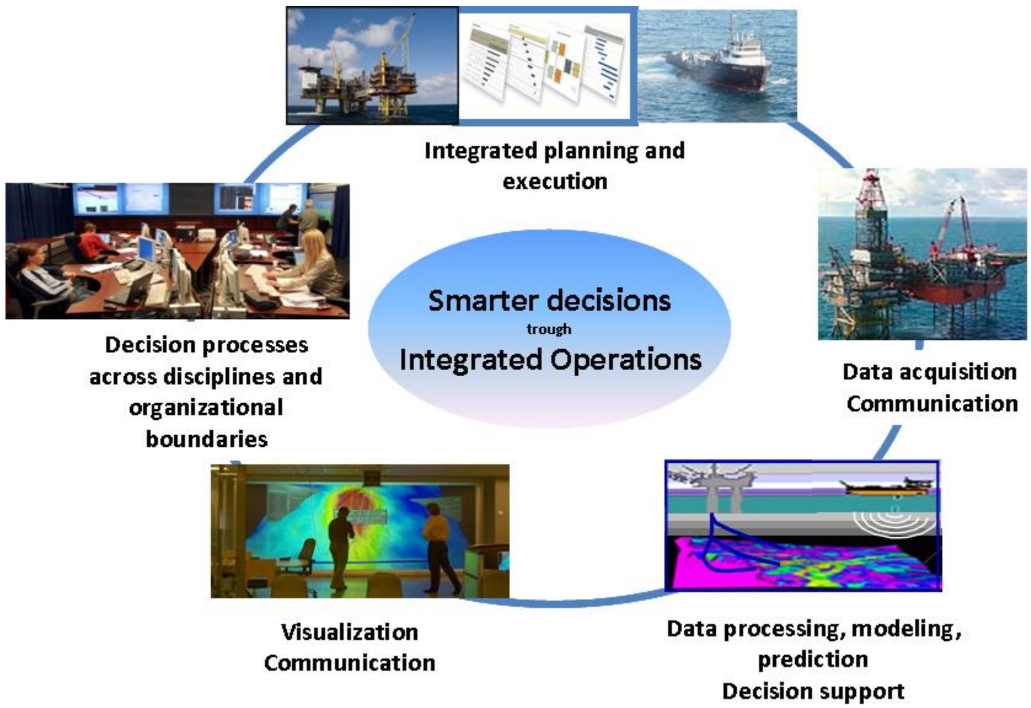

Figure 1: The IO loop (IO research center NTNU, 2013)

As figure 1 indicates there are many aspects to the IO loop and not all of them are expected to be relevant for the maritime industry at this stage. Even if the complexity might be comparable in some business areas, others might not be relevant. E.g. the visualization of the oil reservoir or precision drilling is hardly transferable to the maritime industry at the moment. However, there might be a need for the same technology or approach at a later stage. There are basically two approaches for this study, which not necessarily oppose each other. The first one being the implementation of the IO loop into maritime asset management as a self-sustaining operational philosophy. The second approach is obtaining a level of compatibility to other company's functioning IO loop. The latter might be the easiest and most realistic approach for the maritime industry in the short term perspective. However, in this study the self-sustaining approach will be chosen as this might give the highest value for the effort. It will probably also fulfill the compatibility requirements.

As the principles of IO are based on major theoretical subjects e.g. organizational theory, change management, logistics, maintenance and operation management, industrial services, decision engineering etc., it is more relevant to describe the theoretical framework in that context. I.e. it is not effective to elaborate on a specific IO theory of a business area, not easily comparable to maritime assets. However, if there is a need for an extensive description of the implementation status of IO in the petroleum sector in NCS, it is recommended seeing Hauge (2011).

1.2 OBJECTIVE AND SUB-OBJECTIVES

The main objective for this study is to describe the potential effects of implementing the Integrated Operations approach in the maritime industry, and in particular to the OSV industry. In order to accomplish this objective three sub-objectives have been identified. These are:

- Describe to what extent Integrated Operations is currently a part of the maritime operational management environment.
- Analyze the opportunities and limitations of implementing Integrated Operations to the OSV industry.
- Identify if there is a need for further study and research into the maritime perspective of Integrated Operations.

1.3 RESEARCH PROBLEM

1.3.1 Specific issues and problems

Based on the initial research in preparing the master's thesis and the description in the previous chapters, the specific problems can be summarized as:

- Despite of the focus on developing and implementing IO in the NCS, the maritime industry seems unfamiliar with the approach and its proven effect. This may lead to inefficient and unsafe operations particularly in the intersection of the petroleum and maritime industry.

- The largest oil companies are requiring their offshore suppliers to be IO compatible. However, they have not applied this requirement to their OSV and the maritime management companies. When this step will be taken, the OSV companies will face significant challenges. The ones best prepared may increase their attractiveness and competitiveness.

- It seems like the shipping companies function more as an appendix to the operations, and not fully integrated or conscious on their responsibility according to maritime law. This situation could explain the friction in maritime operational planning, recent accidents and the high level of maritime operational costs. There is a need to analyze the frictional elements of maritime operations in an organizational perspective.

Management of OSV under normal conditions and routine operations may not necessarily give the perception of needs to monitor, communicate and co-operate closer, but often the smallest change can generate major problems at high costs. Whether it is a break-down of a critical component, an unexpected lack of qualified personnel or a change to the operational environment, challenges can grow into costly obstacles. This will particularly be the case without the proper planning, communication and common understanding of the situation.

During the preparation of this study, several of these issues had already been identified. The most apparent observation was the seemingly normality of ad hoc task forcing. It seemed like the chaotic and critical work tasks attracted a certain kind of managers. The difficult and pressing emergencies required clear and firm actions, a problem solving attitude and ingenuity. The following statement was given in the first meeting with the vessel management team: “Every day is different, you never know what to expect, but it is interesting and challenging work”. The purpose of this study is not to make the work day more boring for the vessel managers, but maybe the study can show that reducing the level of unexpected and sudden work orders might actually benefit them. The hypothesis is actually that an integrated operational approach could benefit all stakeholders an increase value across the business areas.

1.3.2 Research questions

There is a need to answer the following research questions:

1. To what extent is IO a part of the OSV maritime operational and managerial environment?
2. What are the opportunities and limitations of implementing the IO approach in the maritime asset management?

1.4 Scope and Delimitations

1.4.1 Scope and structure

The study will begin by briefly describing the need for and the general understanding of IO in the petroleum industry. Thereafter follows a clarification of the perspective and focus of IO under this study. In order to place IO and the thesis into a theoretical framework, a literature review will be focused towards the areas relevant for developing the answers. This will include scientific works in Integrated Planning, Industrial services, decision engineering and performance management and military theory.

The field work consists of analyzing three industrial cases, supported by interviews of involved personnel. The first case is an extensive planned maintenance and modification project of a well stimulation vessel. Case 2 will look at a company’s environmental initiative and identify any organizational difficulties in the process, and case 3 consists of an unscheduled critical maintenance task leading to millions in losses. Through these cases and the interviews the aim is to describe and exemplify the need for IO in the maritime industry and what opportunities and limiting realities exist. Learning from the problems identified in the case studies a novel operational scenario of maritime asset management will be developed. At the very end follows a short description of the necessary further research and recommended actions to the authority, maritime and petroleum industry.

1.4.2 Delimitations

A fundamental part of IO is the integration of all activities and resources in order to extract the synergetic effects. It is therefore a challenge to limit the study as everything is connected to everything. However, in this study IO will be reviewed in the frame of maritime operations, decision engineering and organizational effectiveness. The study is expected to be relevant for the maritime and the petroleum industry as a whole. However, the assets to be analyzed will be limited to advanced offshore support vessels. The operational perspective will be limited to the three cases. The study will not focus towards information technology, sensor-to-decision theory, but rather on work processes, organizational efficiency, collaboration and communication across disciplines. The results will not be quantifiable in the monetary sense. It has been necessary to limit the analysis to the qualitative description of removing the identified frictional elements. The study only follows one specific OSV company, something which might raise the level of uncertainty in the results. However, the uncertainty is mitigated through a verification process further described in part three; the results and analyses.

1.4.3 The significance of the research

The study will describe an area of IO theory, where little or no scientific work has previously been undertaken. The study might serve as a step stone towards further research into the field of advanced maritime operations. Through the activities and final report the study might help to close the gap between operational collaboration and set the issue on the shipping company's agenda. The study hopes to highlight the significance of incorporating the OSV managers in IO and at the same time indicate the obstacles that have to be overcome on the way. One could expect the recommended actions to reduce costs, increase safety and obtain the same benefits as seen in the petroleum industry.

PART TWO: THEORETICAL FRAMEWORK AND SCIENTIFIC APPROACH

In this section relevant theory for the study is presented. Delimitations have been made according to the previous stated perspective and focus areas. Even though some of the theoretical works presented in this chapter are not traditionally combined in IO, it is expected to help form the future operating solutions for the maritime industry. In chapter 2 some of the theoretical constellations are extracted and based on the undersigned's previous submitted materials in the class of Industrial Services and in the class of Decision Engineering and Performance Management (DE&PM) at the University of Stavanger (UIS). The prior work is highly relevant with regards to implementing the IO approach to the maritime industry and is therefore adapted to describe parts of the theoretical framework of this study. The scientific methods for obtaining the necessary knowledge are described in the latter part of this section.

2 Theoretical Framework

2.1 INTEGRATED WORK PROCESSES AND PLANNING

2.1.1 Integrated work processes

According to Bai & Liyanage (2007) Integrated Work Processes (IWP) "involves a series of technical and managerial measures for integration and streamlining of decision loops and activity flow across disciplines". They also highlight that information has to be available to all decision stakeholders near real time. This creates a need for establishing new teams and organizational structures. The new teams should have decision making authorities, access to real time filtered information and tools for live collaboration between vendors, operators and management. It is important to highlight that new technology and smart tools will not alone facilitate the leap towards IO in the NCS, there is also a need for novel work processes and organizational optimization (Bai & Liyanage, 2007). One of several identified concerns of non-integrated planning and work management tools are conflicts, misunderstandings and unnecessary use of time and resources (Bai & Liyanage, 2007). According to OLF (2005) the streamlining and integration of work processes across different disciplines are vital for the IO success.

Traditionally the monitoring and decision making has been done offshore. The operators on board were cut off from the experts on shore and their line management. If there were any advice or communications in the decision making process, it was made by phone, mail or similar single line dialogue. This often resulted in a different understanding of the reality, as different information was given to the involved personnel. Planning and execution were not very flexible or adaptable. The following paragraph was developed and submitted by the undersigned during the spring of 2012, in the subject of DE&PM at the UIS. It became the start of the idea of developing the IO approach for maritime asset management.

Frankel (2008) describe how the new role of technology in decision making enables new work processes and a more efficient working environment. Due to the increased availability of live data one can alter directions, adapt to the situation both on shore and off shore. Hence, time is reduced between decision steps in the organization. He also describes the need for abandoning the traditional rituals of regular meetings at defined times with a fixed agenda. These rituals are ineffective as new communication forms are available. The internet and information exchange capacity has changed how we interact with each other. Mail, chat rooms, video streaming and satellite phones have facilitated new ways of communicating and working together. The technology is making room for new work processes and more effective ways of how an organization can function. According to OLF (2005) a vital requirement in this setting is sharing of the information.

Bai & Liyanage (2007) describes that traditionally in the O&G industry, information was kept close and within the respective disciplines and the functions in the organization. The focus was on their local process and segregated planning of the same identical operations. There was limited interaction across disciplines and the experts and workers were only familiar with their own specific role. According to Bai & Liyanage (2008) there is a need to install an effective planning process, rearranging all activities within or between disciplines in order to fully realize IWP. These are issues on the agenda of the petroleum industry, but as the preliminary studies for this thesis indicates, the maritime industry are oblivious to this knowledge, including the petroleum operators' initiatives in mitigating the traditional challenges.

2.1.2 Integrated planning

Integrated Planning (IP) is about coordinating, scheduling and executing the work tasks more efficiently (Bai & Liyanage, 2008). One should strive to extract a synergetic effect by sharing plans, reduce duplication of work and reduce last minute changes due to misunderstandings and poor communication. According to Payne (2008) IP enables the alignment of key elements in the planning processes in order to provide a common understanding across work plans. The common understanding and overview is an important feature that will be further described in the context of modern military theory in the following chapter.

Bai & Liyanage (2008) have identified three operational requirements of IP. These are:

- Planning the future work with horizontal periodic plans with constraints factors.
- Creating commitment to reaching work process milestones and template for continuous integrity in planning.
- Enhancing the IT environment to better suit the users.

According to Bai & Liyanage (2008) IP involves a short, medium and long term perspective in planning and the constraints can be identified using these perspectives. The short term plan typically includes the operational details and is made on a weekly basis. The plan requires measureable objectives in order to ensure business success. Medium term plans looks a bit further and contain information of the future work tasks in relation to obtaining production continuity. The plans could typically be on a monthly basis. Multi-discipline work teams can help identify and reduce conflicts and constraints that are limiting the production capacity. The long term plan reflects the company's strategy and includes constraints such as costs, time and risk on a yearly basis (Bai & Liyanage, 2008).

Due to different constraints IP is implemented to a varied degree in the O&G business environment. Bai & Liyanage (2008) has classified the degree of IP into four levels, whereas level 1 is limited and level 4 is high.

- Level 1: At the first level the different disciplines plan their activities for themselves and come up with a list of work. Through a multi-discipline work shop the different disciplines agree upon a priority list, taking different constraints under consideration.
- Level 2: The different disciplines enter their data into an independent database. An integrated planning process has been implemented to prioritize the work according to the short, medium and long term objectives and according to a

standard input list of criteria. The other important part of level 2 is the key performance indicators (KPIs) in order to evaluate the planning process.

- Level 3: The major part of stepping into this level is the integration of planning to Onshore Centers (OC). By the use of high quality communication technology multi-disciplines can connect to evaluate real time feedback.
- Level 4: Focus to improve and expand the cooperation between external vendors and partners.

The levels described above will be used to assess to what extent the traditional maritime operations within the offshore segment have implemented IP and IO.

2.1.3 Systems engineering and overview

This chapter is based on a previous submitted constellation of theories by the undersigned, in the subject of DE&PM at UIS during the spring of 2012. The description is important in understanding the larger picture of the needs in a new maritime asset management system. When viewing the organization as a system one obtains a richer picture (Jackson, 2000). The different subsystem's interactions and interrelations are revealed and can be evaluated against the organizational goal and objectives. If the perspective is too limited and narrow one risk measuring and managing the wrong things (Frankel, 2008). Parnell et al. (2011) describe systems thinking as looking into a more complex world were single changes effects other parts of the system. A holistic approach is needed to uncover hidden critical changes and non-conformities. Frankel (2008) describe the need of an effective decision-based management as a result of the rapid changes and development within technology and market requirements. He also describes the need to integrate the structure of an organization with the available information. This has become even more relevant in recent years and seems to increase exponentially.

The meaning of overview should be interpreted as a “detailed understanding of decisions that would allow an organization to perform effectively and efficiently (Liyanage 2012). Frankel (2008) states that in order for decisions to be efficient and effective they need to be taken at the appropriate level in the organization at the right time. One needs to enable near real time flow of operational information, filter and amplify it for tactical and strategic use (Frankel, 2008). Operational, tactical and strategic decisions presented by Frankel (2008) and their impact on business over a short, medium or long term are an important part of the role of obtaining an “overview”. Having the proper overview enables that correct and sufficient information is presented to the right decision maker and that they are taken in accordance with the stated goals. In order to achieve this, the impact and interdependence of each decision has to be analyzed with respect to the complete risk involved (Frankel, 2008). In order to remove barriers of optimal decisions and information flow one need to integrate the information, organizational structural systems and the operational partnership.

2.1.4 Value creation and knowledge as an asset

Within the field of industrial services there are relevant information, that should be utilized when describing and implementing IO in the maritime industry. Between an operator and a service provider, e.g. an OSV company, you have many of the elements of the traditional seller-customer relationship. In the class of Industrial Services at UIS, during the autumn of 2011, the undersigned submitted a perspective of value creation that is further developed in the context of IO. The customers all want value creations, and if you want to become competitive you should focus towards how your customers can create values (Grønroos, 2000). In order to truly understand the common goal one needs to accept that knowledge has become an important asset and a commodity. According to Windrum and Tomlinson (1999) Knowledge Intensive Services (KIS) is an external businesses’ primary source of knowledge information and form key inputs in their performance processes. In their paper they state that knowledge has overtaken the material inputs as the key source of value creation. Strambach (1997) argue that the products of KIS are” Specialized experts knowledge, research and development ability, and problem-solving know-how”. He also describes the effects of this knowledge to be early recognition of problems and a more rapid adjustment to current economic and structural change. Understanding and acknowledging these statements could help the different stakeholders in maritime operations to open up their information channels and share experience and challenges early enough to minimize friction and ineffective operations. There seems to be a need for the traditional maritime industry to adapt the novel approach in the theory of industrial services. Combining integrated work process and planning with industrial service and the process of benchmarking one might be able to open up enough for integrating the operations as well.

2.2 BENCHMARKING

During the course of this study it became apparent that mitigating the challenges and obstacles of IO may be related to the theory of benchmarking. This will be further elaborated when analyzing the results from the field studies. However, there is a need to describe the concept and some critical challenges of benchmarking. The following text is based on a previous submitted report in DE&PM at UIS during the spring of 2012. Benchmarking has been widely implemented by both small and larger businesses, but the definition and understanding of the term is varying (Kyrö, 2003). According to Christopher and Thor (1993), benchmarking is the process of comparing a company’s practices and techniques to other companies in order to improve their performance. It could also be seen as an approach for stating the company’s operating and productivity goals. Benchmarking is a process with several important steps. They involve the collection of data, analysis and comparison, goal setting and implementation of action plans and monitoring of progression (Liyanage, 2012). Five critical challenges in connection with the benchmarking process have been developed and all of these are likely obstacles to be faced during the implementation process of IO. They are:

Collaboration between competitors: How do you get competitors to exchange information of the sensitive areas where they may have supreme performance? The answer lies in acknowledging the nature of benchmarking, that you are never the best in all business areas. If you give in some parts you will gain in others. This is the concept that raises the overall quality of your business and the performance of an entire industry as a whole.

Management involvement: According to St. Clair (1993) there is a challenge of obtaining management involvement. The necessary time and resources are often traded off to other more short-term actions and it can be difficult to keep up the momentum in order to implement the necessary changes.

Obtaining accurate information: St. Clair (1993) also describes the challenge of obtaining correct, relevant and enough information in order to compare businesses and companies. The performance data varies as the companies are different in how and what they are recording and storing. Difficulties in comparing the valuable data could then occur. If the different companies commit to a high quality standard of the information, it could reduce this challenge significantly.

Isolating mechanisms: Freiling and Huth (2005) describe how isolating mechanisms makes it difficult to make effectively use of benchmarking. The mechanism is explained as a lack of transparency between structures and activity networks, making it very difficult to identify the true cause-effect of the identified gaps.

Balancing innovation and imitation: There is a continuous challenge in keeping up the important innovative and future driven perspective in a company. As benchmarking could be interpreted as a sort of imitation process that saves resources compared to an innovation process, it may represent a pitfall (Freiling and Huth, 2005). Watson (1993) emphasize that benchmarking is not about copying others, but rather adopting the best practices to your own business, strategy and philosophy.

These theories and the similarities to IO will be revisited in later chapters when attempting to develop a new maritime asset management and battle the inherent obstacles.

2.3 MILITARY THEORY

2.3.1 Unified understanding

According to Cramton (2002) common understanding is the knowledge that the different stakeholders share deliberately. All parties should have the common situational understanding (Reitan and Pålhaugen, 2004). In the Norwegian Naval Academy, leadership and organizational effectiveness is highlighted through education and training. An important principal is called “mission centered leadership”. The principal is based on a unified understanding of the goal and the leader’s intentions. In order for a highly complex and dynamic military operation to be effective, one has to abandon the traditional detailed plans and highly hierarchical organizations. One needs to communicate the intentions and the common goal, and leave it to the local leaders to act and change based on the dynamic variables. However, there should be an acceptance that the operations are managed with regards to the medium to long term perspective in a centralized, well informed multi discipline team. In the setting of IO there are some apparent parallels to this principal. The different stakeholders of a maritime operation, even if they have different roles and business areas needs to understand and serve the common goal and value creation for all. Emphasis should be put on understanding and accepting the intentions of the operation and how each individual can help to create value for each other. In order to utilize this concept one needs to trust each other, rely on the level of competence and sound judgment (FMU, 2003).

2.3.2 Network centered warfare

Network Centered Warfare (NCW) has no short or simple definition. It is in many ways the Norwegian army's parallel to IO and as such has a broad and diversified understanding. Reitan and Pålhaugen (2004) have distinguished the principal into six categories which is very similar to the approach to IO. The categories are briefly described below, but are more extensively elaborated in the analyses part of this report. The categories are:

<u>Network organization:</u> Flexible and optimal use of resources and robust organizations.
<u>Decentralization:</u> Effective change management to dynamic operations, local decisions based on local live information without detailed governance under normal situations.
<u>Centralization:</u> Coordinated decisions and information overview.
<u>Common situational awareness:</u> Enhanced effectiveness and quality decisions.
<u>Common intent:</u> Speedy decision process and synergetic effects.
<u>Geographical independence:</u> Increased flexibility and robustness of organization.

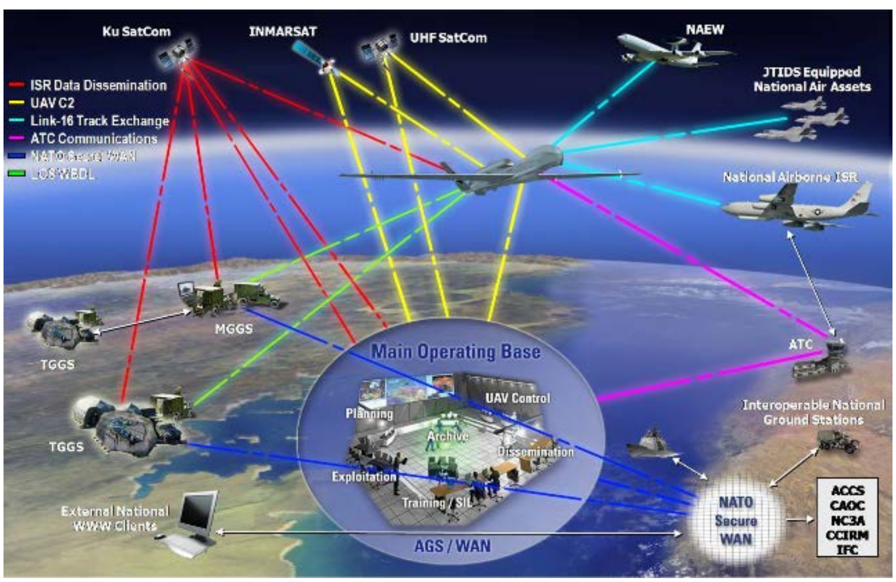

Figure 2: The modern theater of war – Network centered warfare

2.4 OSV TECHNOLOGY AND THE OPERATIONAL ENVIRONMENT

As the main assets in this study are advanced OSV and the subject is maritime operations, there is a need for presenting some brief outlines of the situation. In the 1960s -1990s vessels were highly special purpose built and operated. E.g. a traditional fishing vessel was built for one kind of fishing, another for fabrication and one for transport over vast distances. Today a modern fishing vessel are able to utilize many kinds of fishing methods, they can process the fish onboard, freeze it and pack it ready for transportation by trailers or airplanes. This development is the result from the required level of efficiency and cost effective solutions. One can also identify the same multipurpose development in the OSV fleet. They started out as traditional fishing vessels and were converted to carry casings and pipes. Then they were modified to carry liquids in bulk, operate large cranes and winches, Remote Operated Vehicles (ROV) by the use of dynamic positioning systems etc. The vessels have developed over the years to include many areas of utilization in order to minimize down time and to replace some of the Mobile Offshore Units (MOU). The development has made the vessels highly complex and has put new requirements of knowledge and training for the crew and onshore managers. The maritime management companies have undertaken the same kind of development. The largest OSV companies in Norway origins from the fishing industry and has adapted to the market and available resources. Often the senior managers are former fishing vessel captains within their own company and has limited or no knowledge of the petroleum industry, offshore technology or organizational theory.

Prior to the era of the OSV market, maritime industry was mainly concerned with carry passengers and cargo over vast distances. Due to the lack of communications technology the vessel was left for themselves for weeks at a time. The complex tasks that the modern OSV fleet undertakes today require a different approach to maritime management and maritime law. The vessels are no longer just a hull and simple machinery, but have developed to be advanced precision tools for complex jobs in the subsea market.

Figure 3: Offshore Support Vessels

The literature research in this study has not identified any in-depth research of the effectiveness of maritime management within the petroleum industry. There seems to be little or no research concerning the opportunities and limitations of implementing IO in the maritime context. However, the developments of the last years have created the need for documenting the OSV operational environment and describe a path for optimization.

3 Scientific Methods

3.1 METHODOLOGY

Ringdal (2001) defines scientific methodology as “plans and techniques used to give answers to research questions”. The first step of obtaining the answers in this study was an initial literature review into the field of integrated maritime operations. The perspective was cooperation and collaboration between the vessel, the operator and the onshore management. After an extensive search period it was discovered that there was almost no specific research on the topic. Due to this fact it was decided to take an exploratory research approach. According to Brown and Suter (2012) exploratory research is used to understand an unclear situation, where one strives to connect different factors in order to get insight and ideas. Some typical types of exploratory (or qualitative) research methods are case studies, depth interviews and literature search. In this particular study all of these methods will be utilized to reach the objective. The methods are further described in the following chapters.

In order to facilitate the study of maritime assets and operations a cooperation agreement with a modern OSV company was made. Both vessels, its crew and on-shore management team were available for observation and interviews. Full access was given to operational procedures and their safety management system. A cooperation agreement with an IO consultant company served as the knowledge hub of implementing IO. There was also an agreement with an operator in order to bring their perspective into consideration of the study.

3.1.1 Literature search

Literature research is a cost and time effective method in obtaining a theoretical overview and a current situational understanding of the subject to be studied (Brown & Suter, 2012). In order to reduce the level of uncertainty and increase the quality a standard have been set. The literatures to be reviewed are scientific papers at the research library of

Universities and from the relevant companies and their partners. Google Scholar will also be used to locate relevant information. Throughout the study, care will be taken to distinguish the serious literature from the not so serious.

3.1.2 Interview

According to Ringdal (2001) the objective of the interview is to gather information and knowledge about the research questions and one way to do this is the so called flexible approach. The qualitative depth interviews are not pre fixed in structure, but can change direction and focus based on the answer and information obtained during the process. The persons interviewed were selected based on their work tasks, level of experience and the company they belong to. The interviews were made by phone or a physical meeting. Figure 4 lists all the persons interviewed.

Business sector	**Position / Title**	**Phone**	**Meeting**
IO consultant	Owner		X
Research center	Business developer		X
OSVcompany	Fleet Manager		X
OSVcompany	Vessel Manager		X
OSVcompany	Project Manager	X	
OSVcompany	Captain	X	
OSV company	All crew members in one vessel (group interview)		X
Operator 1	Company repr.	X	
Operator 2	Company repr.		X
Norwegian Maritime Authority	Head of Section		X

Figure 4: List of interviewed personnel

Recording or videotaping the interviews was considered, but since a significant amount of the relevant information could be seen as critical towards own operations, it was considered probable that it could restrict the interviewees in sharing their knowledge. In addition to individual interviews, there was also an interview of a focus group. In this setting several persons with similar knowledge was gathered together in a group and interviewed. According to Brown & Suter (2012) this method can produce results due to group interaction. The individuals often build on each other and feel comfortable as others are coming out with similar thoughts. It could also lead to productive discussions and identifications of either misunderstandings or difference of opinions. On the other hand it could also result in biased information if no consideration is taken to which individuals are to be part of the group. In this study the individuals were the crew of one of the vessels. This crew consisted of subordinates and their leaders onboard. It was probable that the subordinates could be scared of reprisal by their leaders if they were critical or that the leaders held back in an attempt to lead by a loyal example. Therefore there was a need for clarification of the intentions of the interview. As Brown & Suter (2012) describes the method has its flaws, in particularly towards interpreting the statements and discussions. There is a risk of being biased in recording the result of the discussions. If not conscious on this issue one might record the things one wants to hear or are looking for.

The individuals that were interviewed where given the liberty of speaking freely about issues that makes their work tasks and operations ineffective, and particular towards organizational matters. Afterwards they were invited to give their view on some of the issues identified during the case studies. The third part of the interview was an invitation to suggest solutions for better information exchange, collaboration between the different parties etc. Despite of these focused questions there has been a carefulness of not asking leading questions.

3.1.3 Case analysis

Yin (2003) describes case studies as a “present time study of a phenomenon in its natural context”. He also recommends the method for answering the questions of “Why” and “How”. However, he has criticized the method due to its microscopic tendency as only a few cases are studied in the research. In this particular study one can with certainness conclude that the issues identified in the cases studied applies for the specific company. However, one can only with a certain degree of probability conclude that it will also apply for similar companies within the same field of business. The company chosen in this case is among the five largest companies in its business field in Norway, and has similar operations and equipment as the comparable companies. By the undersigned’s extensive insight into the maritime industry in Norway, the level of uncertainty related to studying only one OSV company is reduced. It is also verified by the NMA that this particular OSV company is among the five largest in Norway and are facing comparable challenges as to the rest of the OSV industry.

Yin (1994) recommended four elements in order to produce a high quality case study:

- Show that the analysis relied on all the relevant evidence.
- Include all major rival interpretations in the analysis.
- Address the most significant aspect of the case study.
- Use the researcher's prior, expert knowledge to further the analysis.

According to Alvarez et al (1990) the case study has been widely in use for critical thinking. In this particular study the ability to have a critical mind set and revolt the traditional and deeply incorporated view has been an important factor.

3.2 THE CASES TO BE STUDIED

3.2.1 Case 1 – A maintenance and modification project

During the winter of 2009-2010 a well stimulation vessel was undertaking a 30-year class[1] renewal dry docking. The vessel was also to be modified with new engines, dynamic positioning system and a modern maneuvering system. The duration of the project was planned to be 5 weeks, but the result was 10 weeks before normal operations were in effect. The project also went over budget. This case will be a study of what went wrong, and if the identified causes could have been mitigated by the implementation of the IO approach.

3.2.2 Case 2 – The Ship Energy Efficiency Management Plan

As a response to international requirements the OSV company has tried to implement a Ship Energy Efficiency Management Plan (SEEMP) for some of their vessels. They describe the implementation part to be highly frictional. During the project there has been a lack of coordination and cooperation between the maritime and petroleum management causing a delayed and inefficient implementation of the SEEMP. This study will identify the issues that caused the perceived problems and analyze if the IO approach could have altered the outcome.

3.3.3 Case 3 – An unscheduled critical maintenance operation

There seems to be too little involvement by the maritime management during normal operations, but when technical or operational elements start to fail, they take over the show immediately as the operators leave the picture. This may cause confusion, inefficient and risky situations for all stakeholders. If the first two case studies does not produce the necessary insight or there is a need to verify the findings, a third case has been planned that could complement the collection of knowledge. The third case consists

[1] The classification society’s renewal of the vessels hull and machinery certificates

of an actual critical break down of supply vessel's main propulsion thruster and the organizational implications in the following maintenance operation. During normal operations everything may seemingly be in order, but when a critical situation occurs the underlying problems emerge and hit the operations with full power. The study of this case will focus towards the frictional elements that reduced the efficiency of the operation. The focus will be on the inter-organizational collaboration and the conflict of interests between them. In this particular case the organizational bodies involved were the vessel management, the operator, the insurance company, the classification society, the flag state, the condition monitoring service supplier and the Original Equipment Manufacturer (OEM).

PART THREE: RESULTS AND ANALYSIS

4 Results

In this section the results from the three cases are presented. The cases are operational events that have been analyzed based on the relevant documentation from the OSV company, the actual participation of the undersigned and the interviews.

4.1 CASE 1- A MAINTENANCE AND MODIFICATION PROJECT

Normally a vessel is compounding maintenance days over the contract period. E.g. one day of maintenance along the quay is earned each month. When necessary the vessel can cash out the accumulated maintenance days. However, if a technical failure shuts down a system and the vessel has to be taken out of operations it will go off-hire. When a vessel is taken off-hire it loses all its income and has to cover all administrative expenses. In order to cash out the maintenance days and avoiding off-hire, the maintenance task has to be planned for and agreed upon with the petroleum operators. It is often very difficult to spend the maintenance days in order to stay on-hire, for several reasons. E.g. you have to plan for parts, special tools, service engineers, crew change, yard and quay facilities and time these elements with the when the operators can release the vessel. Unfortunately the planning of such a maintenance task often has to be done many times over. Plan changes as unexpected supply needs on the MOU require the vessel to stay operational, parts are going astray and service engineers are being booked for other jobs as yours got cancelled. The only way to be certain of no cancellation is to take the vessel off-hire, but then lose 0.5-1.0 million NOK per day.

This case is based upon a maintenance and modification (MM) project during the winter of 2009\2010. The undersigned has firsthand knowledge of the situation, functioning both as the Project Manager for the MM and this particular vessel's Manager. There will first be a short presentation of the vessel, then follows a description of the organization and management structure. The main part will be a listing of the relevant problems identified in the study. The focus of this case review is to identify and describe the difficulties that could relate to organizational and system factors.

4.1.1 Background

The well stimulation vessel, one of the few of its kind, was built in 1981. She is owned and managed by the OSV company and holds a long term contract with a major petroleum operator. The vessel is classed in Lloyds Register and carries a flag from Bahamas. The vessel is normally under daily supervision and utilization by operator's local management in Denmark. If there are any problems or internal affairs the Vessel Manager in the OSV company is contacted, either by the vessel or the operator, and takes over the operational particulars. If there are no urgent problems with the operation, there may not be any contact between the vessel and OSV company for several days.

Figure 5: The well stimulation vessel

In 2010 she was due for the 30-years class renewal dry docking. At the same time major modification tasks were planned. This involved the replacement of auxiliary engines, the maneuvering system and the entire Dynamic Positioning (DP) system. In addition to the large modification tasks there were about 200 work orders of various kinds.

4.1.2 The managerial situation

In the OSV company the responsibility of the operation and maintenance management are dedicated to the Vessel Manager (VM). The VM is the point of contact towards the operator. In supporting the VM, the OSV company has a Crew Coordinator, an accountant, a purchaser and Quality Health Safety and Environment (QHSE) coordinator. The VM reports to the Fleet Manager and the Chief Operation Officer. All of these persons are given a fleet of vessels to attend within their field of expertize and level of authority. However, the composition of the fleet varies and there really are no consistencies. E.g. the VM has four vessels dedicated to him, the Crew Coordinator has five different vessels, the Purchaser has three other vessels and so on and so forth. The communication between the different coordinators and managers is based upon phone calls, e-mails or instant messaging software tools. Basically the only criteria for placing the respective vessels into the different fleets of responsibilities are the location of the offices. There is an unwritten policy of trying to minimize a mixture of teams across vast geographical distances.

The operator has three persons involved in managing the operation. Onboard you have the Supervisor, which is responsible of managing the stimulation task at the installation site and liaising with the Captain. On shore you have the Vessel Operation Manger who coordinates all people involved with the vessel and has the responsibility of facilitating the operation. This person reports to the operator's Country Manager. The vessel has 33 persons on board. 11 of which is the maritime crew lead by the Captain. The 22 other are operator's personnel running the stimulation equipment. The Captain is Norwegian, the rest of the crew is from Poland and the operator's personnel consist of people from several other nationalities.

4.1.3 The project

The 30 year class renewal of the vessel's certificates was coming up. This involves over 100 work orders and inspections related to the vessel's hull and structure. In addition to this the maintenance task of machinery and equipment resulted in hundred more work orders. The project was budgeted to approx. 25 million NOK and duration of 5 weeks. The operator also had various work orders for their specialized equipment on board, but planned their work separately from the OSV company.

The project had to commence between the spring of 2009 and no later than January 2010. The end of this window marked the due date of the vessel's certificates and was not negotiable by the classification society. Due to the nature of the project and the size of the vessel the dry docking locations were limited. Eight different yards were invited to offer their services, several of them in Norway. It was clear that the best options were in Denmark and Sweden. The operator was making the most out of an active stimulation market and would not confirm any date to start the project. The startup date was continuously postponed. As there was no confirmed time for dry docking it became difficult to plan and confirm the yards. The yard could not keep the slot available as other companies were pressing for works as well. This added to the uncertainty in many aspects. Due to particular work orders it was necessary to dock the vessel during the warm part of the year. Despite of this being clearly communicated to the operator it was not understood or adhered to. Finally the docking was executed during the winter and Christmas holiday of 2009/2010. The planning of this project was not very effective. The final budget was overrun by 100% and the project's duration was prolonged from 5 weeks to 10 weeks. Through an extensive review of the project several issues have been identified that could explain this result. The issues describe obstacles and situations that are related to communication and cooperation in both the planning and execution of the project. The identified problems indicates a lack of integrated planning and operation, however this will be further analyzed in later chapters.

4.1.4 Identified problems and obstacles

<u>A: Lack of confirmation of time for execution</u>

The OSV company urged to commence the dry docking before the summer vacation of 2009. The temperature, daylight and transportation opportunities were all favorable for a smooth operation. However, there was no confirmation from the operator to release the vessel for the project. The market was high and the operator would not miss out on high pay projects. The OSV company had no insight into the operators' plans or priorities and was depended on continually asking for information and confirmations. The start-up of the project was postponed several times by weeks at a time, until finally commencing in the end of November 2009. The continuous postponements led to many difficulties that have been identified and listed below:

A1: As there was no confirmation of date, a fixed contract with a particular yard could not be made. There was a high building activity in the market at the time and nearly all yards were pre booked.

A2: With no fixed place to undertake the project, there were no place to send the parts and special tools. A consequence of this was suboptimal storage of parts with respect to the ambient conditions e.g. moisture and temperature. It was difficult to prepare for a fast shipment to the actual location and the yard did not manage to prepare the equipment in time.

A3: With no fixed time to perform the project it was not possible to have the OEM specialists confirmed attendance. The service engineers that finally came had to be replaced several times and did not have the required competence. There was also a need for extra crewmembers during the dry docking for tank cleaning etc., but the hiring process could not commence as the time was not fixed. In addition to all of these factors the time for docking had to comply with the availability of the classification societies' surveyors and the flag state inspectors. All of these issues made planning and coordination challenging, leaving the vessel and the project team with suboptimal solutions.

B: Winter dry docking:

When the final confirmation of releasing the vessel was received, i.e. the operators order to commence the project it was decided to dock in the end of November. Due to the winter season and Christmas holiday the completion date was set to after New Year's Eve. The following challenges have been identified in relation to this factor:

B1: The temperature was 10-15 degrees below centigrade. The cold weather delayed the hardening process of the paintwork, particularly the side and bottom tanks. These parts of the hull had to be insulated and heated by external fans in order for the paint to dry. Not only was these additional services costly, but it delayed the startup of other work orders.

B2: Even if there is a freezing ambient temperature, the seawater normally surrounding the hull heats up the vessel to some degree above the freezing point. As the hull was out of water during dry docking, the temperature in the engine room was subzero. Residual water in valves, pipes and heat exchanges froze, expanded and cracked the materials. For a 30 year old vessel original equipment is not in production anymore and it is expensive and time consuming to get a hold of new parts. The alternative is to adapt the equipment to fit new parts or refurbish the old. The icy conditions generated many new work orders and slowed down the progress of the predefined tasks. The problem was also causing similar damages to the operator's equipment on board. There was no particular cooperation or communication about these issues before or during the project.

B3: During this Christmas there was 70 cm of snow in north of Denmark. Combined with the wind the snow caused blocked roads. Even if a snow truck removed it, it blew back over the road 15 minutes later. 80 % of the yard workers were not able to travel to work. They were snowed in for several days. The work was halted and all the service engineers from the OEM were on standby, but still at normal hourly rates. Even if this was an act of nature, the effect on the project could have been reduced if there was a higher focus on integrated planning and execution of the project. Contingency plans, experience sharing and joined work capacities could have limited the consequences. This will be further analyzed in later chapters.

B4: Christmas season and the holiday caused other challenges as well. Even if the crew is onboard working as normal all other personnel attending the project had planned with a Christmas vacation. This led to an ineffective use of time at the yard. The temporarily personnel had limited competence and no real handover with those leaving.

B5: The hotels closed down for the season so there was a challenge accommodating all service engineers. Transportation of emergency spare parts or personnel was difficult due to the Christmas holiday. Both operator and the OSV company struggled with the logistics, but did not attempt to solve the problems together or share the different capacities or experiences.

B6: A Vessel Manager has a fleet of vessels to support and manage. Normally the colleagues of the Vessel Managers in the OSV company take over his other work tasks during an intensive dry docking. During Christmas vacations this is not easy to facilitate as they are all on vacation. The result was that the vessel manager had to combine managing the project of the well stimulation vessel in addition to supporting his other vessels. There was also limited support from other business areas in the OSV company during the Christmas season, adding to the vessel managers work load.

C: Communication:

There was a lack of communication and integration of plans across the organizations. This led to loosing important information, several last minute changes and missing out on small windows of opportunities. The effect and how to potentially mitigate them will be discussed in later chapter, but the issues identified during the case study are presented below:

C1: Preparation of work task was incomplete as there were misunderstandings between the vessel, the operator and the OSV company. The lack of communications resulted in equipment not being ready. E.g. tanks had not been cleaned, seals had not been checked for leakages and so on and so forth. Some preparation tasks were initiated by the OSV company, some by the crew and some by the operator, however not coordinated or controlled. When entering the yard this was discovered and caused delayed parts as orders were sent out too late. The lack of coordinated preparations added to the service engineers' and the specialist's work load.

C2: The work list from the operator was not presented to the OSV company prior to the docking. As the OSV company was oblivious to the operators work list, the opportunity of synergetic effect in planning and execution was lost. Instead there was conflicting interests of having the space, resources and equipment to perform the tasks. It also resulted in conflicts with regards to how, when and which equipment to be removed and transported to the yard's work shop. The operator did not send their work list to the yard, but handed them over as an ad hoc work list during the docking. This made it difficult for the yard to distinguish between the orders with regards to tracking costs and invoicing. It also made it difficult for the OSV company and the operator to track and verify their actual costs during the yard stay.

C3: During the project there was a complete crew change onboard. There was a difference in motivation, competence and poor communication between the two shifts. During the crew change, information got lost due to poor handovers. This led to misunderstandings, blaming and an unconstructive competiveness.

C4: The communication to the OEM service support office was poor. One example is highlighted. In order to tune the engine after the overhaul, it was necessary to acquire information about the correct timing of the fuel injection. The service engineer at the main office told the onsite vessel manager; "I have the information at the desk in front of me, but as you have been using yard personnel to some of the task related to the engine instead of us, I will not give you the information, good bye!" This statement was given despite of using the same OEM in other tasks onboard during this project. Other similar miscommunications and lack of cooperation resulted in parts not being sent on time and experienced service engineers and specialists not being prioritized to this particular project.

C5: A major challenge during this project was the mounting of a flawed part on the bow thruster. It was not discovered prior to docking out and the vessel was nearly back in service before the alarm was raised. The Chief Engineer had discovered that the oil level in the oil seal tank was increasing, but did not inform anyone of the fact. Two days later the vessel manager saw the same situation and concluded that if the seal was leaking, the propeller shaft could function as a pump and force sea water into the tank. This turned out to be correct and the vessel had to be dry docked again in order to fix the thruster. The problem now was that the previous yard was occupied and a contract had to be made with a new yard. The vessel was docked again after sailing to the other side of the country. The new part was verified to be correct by the OEM, but during mounting it was discovered that the new part had the same misalignment as the previous one. Two days later the correct machined part was located and the vessel could finally continue its normal operations. Specific problems identified during this major challenge:

C5.1: Initiative towards good and open communication between the site crew and the OEM office was met by reluctance and hostility at the OEM Office. A large insurance claim case was building up and the OEM wanted to protect themselves and started to limit their normal service functions.

C5.2: It was discovered that both the crew and the client personnel on board was withholding information for self-benefits. Their shift was coming to an end and they did not want to head out to the high seas for only five days. They saw it as beneficial for themselves if they would still be in dock during the planned crew change. This would mean easier transportation possibilities home, reduced probability of any delays and during the evenings they could all go out on the town and relax. This view led to important information not being communicated to either the operator or the VM and in some cases problems were raised that was not real or of any significance. The lack of common understanding and feeling of ownership to the project will be further discussed in later chapters.

C5.3: There was no contingency plan after realizing that the vessel was not operational after docking out or after the first initial tests. As a result the only docking alternative was on the other side of the country generating a two day transit. No yard was on stand by and an entire new cooperation environment had to be established.

C5.4: There were difficulties of making new parts function together with old parts. As 30 years old electrical components was to “communicate” with a state of the art Dynamical Positioning (DP) system several complex errors occurred. It was then discovered that a close communication and collaboration path to the OEM specialists were lacking. Another experience was made when combining different components of different suppliers and the end result does not function. This led to no one taking responsibility to make it function and as long as their own equipment was according to the specification, their policy was “hands off”. There was a lack of common understanding and unified teamwork across suppliers and managers.

C5.5: Due to the problems and delayed completion of the project, the operator missed out on attractive new contracts and lost millions of NOK.

C5.6: In normal operations the Captain and Chief Engineer is leading the work, but during a dry docking it is the VM who is in charge. It was discovered that during a dry docking the onboard leaders’ lack of direct responsibilities, caused them to distance themselves from the project. Even after docking out and during the initial live tests at sea it was necessary to instruct the Captain to take control for the safe operation of the vessel. This indicated a symptom of working as individualists rather than a team.

C5.7: As the project was delayed and the communications and cooperation with the OEM was breaking up, senior service personnel had to leave in order to attend another project. There were no qualitative hand over to the next engineer that came on board, and they were not competent to handle the problems. They also stated that they actually had been muzzled by their home office as this could be a major warranty claim case. This reduced the cooperation environment considerably and limited the exchange of important information.

The problems identified in this case study will be further analyzed in chapter 5.

4.2 CASE 2 – THE SHIP ENERGY EFFICIENCY MANAGEMENT PLAN (SEEMP)

4.2.1 Background

When the International Maritime Organization's (IMO) Maritime Environmental Protection Committee (MEPC) met for the 62nd time in July 2011, they decided to adopt the amendments to MARPOL[2] Annex VI. This made the Ship Energy Efficiency Management Plan (SMEEP) mandatory for all vessels above 400 gross ton. The ship specific SEEMP had to be approved for the OSV vessels no later than during the first certificate renewal after 1st January 2013. The purpose of a SEEMP is to have a ship specific plan to measure, mitigate and control the environmental footprint of the vessel. The effort is mainly operational as technical requirements are handled in other part of the rules and regulations. In this project the OSV company teamed up with the Class and selected three categories of vessel for which a SEEMP should be developed. These categories represented the Anker Handling and Tug Support (AHTS), Construction Support Vessels (CSV) and Platform Supply Vessels (PSV). Within these groups there are differences, but not as large as between the groups themselves. The plan was to

[2] The international mandatory code for the prevention of maritim polution (MARPOL)

develop a SEEMP for the vessel groups, adapt them within the group and make them all ship specific.

4.2.2 The Project

In order to meet the requirements from the international maritime organization the OSV company teamed up with the Class. A sub goal of the project was to increase the company's competitiveness with its increased focus on environmental sustainability. The project was based on similar studies by the Class and was defined in four steps:
Planning:
An important part of the project startup was obtaining the energy consumption situation. The OSV company established work groups with key personnel onboard and gathered good ideas and experience from the daily operations. They also collected data of different energy consumers, and clarified which parameters to measure and how to measure them. The results were 49 suggestions of how to reduce the energy consumption. These ranged from hull and propeller maintenance to turning off consumers when not in use. The different suggestions were ranked according to their effect and the ease of implementation. The final action plan consisted of nine measures.
The OSV company did not invite or include the operators during this process. Their view was that this was a local challenge on board the vessel, and that the operators could be informed of the results after the project. The OSV company discovered some reluctance towards the project by its key crew members onboard. However, when finally starting up, the motivation came along. An example of different measures for improvement and the estimated effect can be seen below in figure 6.

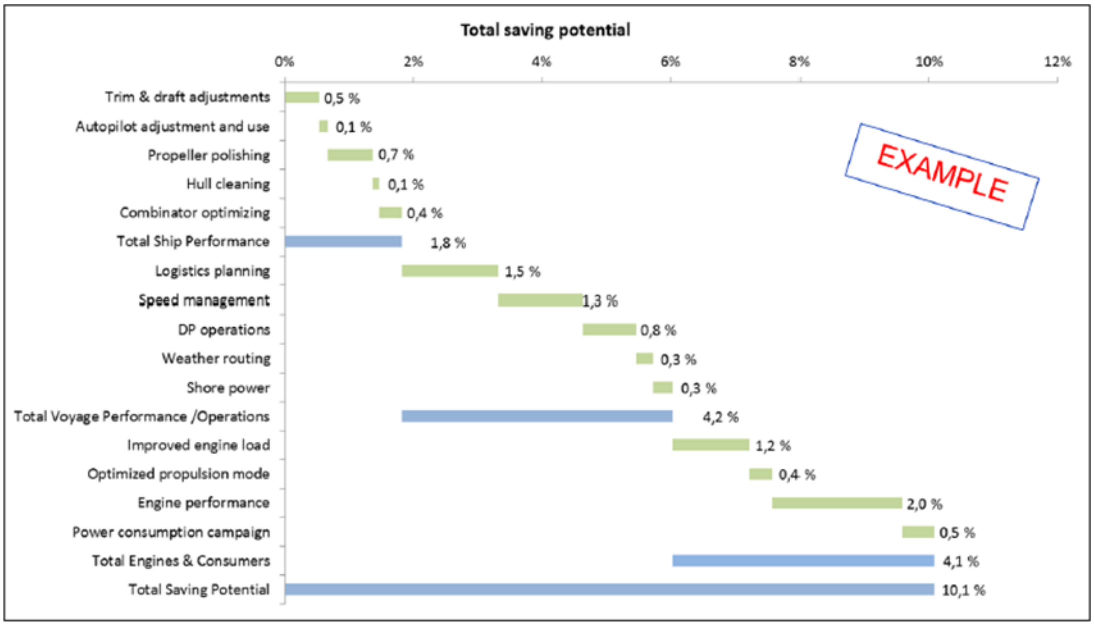

Figure 6: An example of an specific energy saving potential

As seen in figure 6, measures associated with voyage performance and operations, makes up a significant part of the potential saving. In this project the measures within this segment are:

Implementation:

The implementation of the different initiatives is divided into short term and long term actions. One of them is to develop procedures of energy management and an implementation plan according to the OSV company's routines and operational pattern. However, implementation is not considered a major part of the SEEMP in this case.

Monitoring:

After the consumption base line has been established the monitoring of fuel consumption and NOx emissions starts. If the consumption is over the baseline the reasons for this shall be investigated and followed up in order to initiate appropriate actions. If there are any operational situations that lead to deviating from the economic speed the time and reason shall be documented.

Self-evaluation and improvement:

Even after the SEEMP has been established it will be modified and altered based on the experience from implementation and monitoring. The different initiatives will be evaluated with respect to the effect of the efforts and how to increase efficiency. If some actions do not give the desired effect, it can be abandoned. These elements will function in a continuous loop and be improved over time.

In figure 7 consumption in the different modes are presented. These are the results of monitoring and registration of the operation of a PSV.

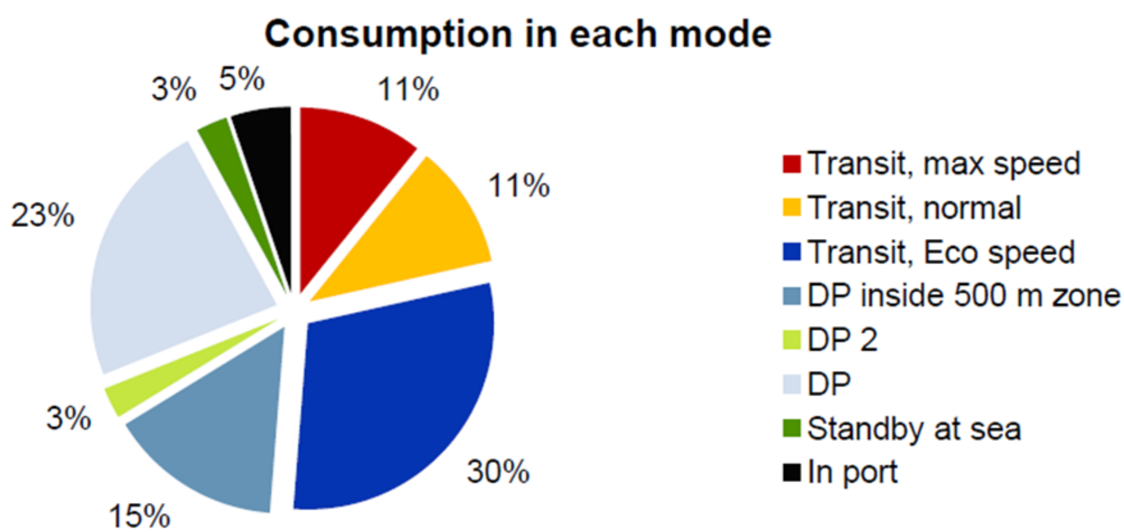

Figure 7: The specific operational mode consumptions

4.2.3 Identified problems and obstacles

Throughout the project various difficulties was identified. The issues are highlighted below and discussed further in later chapters. As some of the issues are highly technical, there is a need to first explain the functioning of the system in order to understand the problem.

<u>A: Operators requirement of running with a closed bus tie breaker:</u>
A vessel with a class notation of Dynamically Positioned with redundant machinery, have two independent main switch boards. E.g. four engine setup with two engines in each engine room. On each side you have a main switch board for electrical power. The switch boards are connected through a circuit breaker which is normally referred to as the bus-tie breaker. If this breaker is closed the switchboards are connected. If it is closed and there is a critical failure in one side of the power supply, the breaker will automatically open due to a limit of the maximum frequency or voltage deviation. When it opens, the side with the fault will be isolated and the functioning side will operate as normal. The electrical power system is designed in such a way that the critical consumers are divided between the boards. However, the operators does not always allow to run with a closed bus-tie, as there has been some situations on the NCS where the bus-tie did not opened, causing damage to both sides and a total black-out. Hence, the operators demand that the bus-tie has to be open so that a failure cannot influence the functioning side. This leads to different issues as described below:

A1: A problem is identified as the vessel has to have enough engines running in both engine rooms that can supply the entire vessel single handedly under normal operations. This means that at least a total of three engines have to be running at all time. In a closed bus-tie scenario it would be enough to have one engine in each room and a third in standby. Running with an open bus tie breaker leads to an unnecessary high fuel consumption.

A2: The issue described above leads to many engines running with low load. This is not optimal with regards to the efficiency of the engine. Normally an engine will perform most efficiently and produce least amount of emission/kW at 80-90 percent load. If only running at 30-40 percent load, soot will build up and cause poor combustion. Over time the build-up of soot leaves the engines less efficient as turbo charges becomes less effective and the clogging of the fuel injection nozzles. The latter will also generate unnecessary maintenance.

A3: Another consequence of too low engine load is the inoperability of the Selective Catalysts Reaction (SCR) plant. The NOx-reducing plant uses ammonium to clean the emissions from the exhaust, but it needs a temperature exceeding 300 C in order for the chemical reaction to start. This is not possible at low loads and the SCR plant shuts down automatically, i.e. there is no reduction in NOx emissions.

<u>B: Lack of deck utilization and priorities of cargo</u>

There is a lack of environmental risk based transportation. I.e. there is no evaluation of the environmental consequences of transporting the extra ordinary equipment.

B1: Often the PSV will be ordered to an installation only carrying a single container or other minor deck loads. The impression of the Captain is that the vessels do not seem to be utilized well enough.

B2: They might also be sent out with less important equipment, which could probably have waited until the next planned roundtrip.

<u>C: Waiting on weather</u>

According the Captain’s interview, they often burn fuel for days waiting for better weather next to the installation.

C1: The Captain describes how they are ordered to sea, even if there is only a small chance of a window opening up for work. He has experienced many times, that they have to be on site, waiting on weather for days, instead of waiting at the quay. Fuel is consumed and the crew is accumulating fatigue unnecessary.

C2: Normally the vessel will be under the operator's logistical control and regime. However, when the vessel functions as a storage facility off shore, it is the drill-leader's task to handle the local vessel operations. The Captain describes that they often wait for days without being efficiently utilized as the drill leader is not under the normal logistical control.

D: Speed requirements

The Operators does not always consider the vessels economic or environmental friendly speed when ordering time of arrivals.

D1: The Operator's marine department plan in some cases with the vessel's max speed capacity, even if they are not able to utilize the saved time upon arrival. In one case the vessels were strongly urged to transit from the onshore supply base to the installation at full speed. Apparently the cargo was critical to the offshore operation and there was no time to loose. However, when arriving at the field site, the vessel was told to standby, due to an internal fire exercise on the rig. One and a half hour later the offloading could commence. In this particular case, the vessel could have sailed to the rig, making even less than economic speed, and still be on site prior to the required time.

E: Onshore trailer replacement

In some particular cases the Operators are using their transportation resources ineffectively with respect to the environment.

E1: According to the Captain there have been several situations where critical equipment of only a few hundred kilograms had to be transported from one particular supply base to another, and then out to the rig site. The reason for the transportation between the supply bases is the lack of an available supply vessel. In order to save a couple of hours the Operator order the supply vessel to sail along the coast of Norway, all the way to the other supply base to pick up the equipment. The vessel is empty and in ballast conditions, burning huge amount of fuel on its journey. If the operators allowed for a trailer onshore to do the transportation work, and gave more priority to the environmental factor, the environmental footprint of that particular operation would be only a few percent of what it actually was.

E2: According to the Captain, when the crew experiences these kinds of priorities, their motivation to try to reduce the energy consumption onboard is falling. Their environmental effort over the last days could be wasted when considering these unnecessary round trips.

E3: In these situations there is often a lack of communications between the crew and the operator. No explanations for the decisions were given and there was no integration of the management onshore.

F: Time for maintenance and environmental initiatives

As explained earlier, under normal offshore supply contracts the shipping company accumulates maintenance days. E.g. each month the companies receive one day to maintenance. When planned for and agreed upon by the Operator the shipping company can take the vessel out of operation, and perform the necessary maintenance and still stay on hire.

F1: The challenge here is to agree upon a fixed day for performing the maintenance. The shipping company has to order service engineers and ship parts, and is dependent on a fixed place and date. However, it is very difficult to obtain confirmation of such a date. Often the time and place are altered, which create a lot of work for the Vessel Manager. There is little or no integration of the shipping company in the operator's planning and the result is cancelations and ineffective maintenance operations. In the SEEMP project there are several maintenance initiatives, e.g. polishing of propellers and cleaning of the hull, that are difficult to plan. There is no agreement of doing these tasks on hire, so the only opportunity is to spend the normal maintenance days or taking the vessel off hire. The result is likely to be a postponement of these tasks until the semiannual dry docking and thereby reducing the potential environmental effect of these particular measures.

G: There is a continuous threat of off-hire

As mention above the accumulated maintenance days have to be planned for in order to be spend. If not, the vessel is taken off-hire when problems occurs, and lose all of its daily income.

G1: The threat of off-hire is sometimes influencing the communication between the operator and the shipping company. E.g. if you have a minor oil leak on the aft propeller seal box and it is six months until the planned dry docking, the information will not always reach the operator. Normally the oil pressure in the seal box has to correspond to the external water pressure in order to keep water from the entering the box. If a seal is broken, oil will escape to the environment as the pressure inside is slightly higher than outside. However, a "trick" is to decrease the internal pressure of the oil box when you are at the quay side (when an oil leak is easy to discover in the water), only to increase the pressure when returning to open waters. This process might continue to the next planned dry docking. If the operator knew about the oil leak, they might order the vessel off-hire, which would force the vessel into dry dock. This emergency dry docking would then come in addition to the planned docking as parts, engineers etc. are not ready. The threat of off-hire, the poor communication and lack of openness in the operation is hurting the environment. These organizational issues are not addressed in the SEEMP project.

H: Lack of information of short to medium term planning

The Captain stated in the interview that they are often waiting at quay side without information about the planes for the next couple of days.

H1: This result in constantly staying on alert, having the main machinery ready for use and auxiliary engines running. There is therefore no opportunity to connect the power supply from shore and unnecessary fuel is consumed in idling mode.

H2: Maintenance tasks that would reduce the energy consumption onboard, e.g. cleaning of the main engine's heat exchangers are not commenced. This is a result of no indications of when the vessel is needed again.

H3: The lack of information and openness about the operator's plans are hindering environmental initiatives. The vessel manager has to establish contact with the operator in order to obtain any information. Often the answers are given too late in order to establish a team of service engineers or having the necessary parts and tools shipped to the vessel.

I: Implementation and organizational factors

Based on the material analyzed and the interview of key personnel there has been identified a lack of focus towards organizational factors.

I1: There is no clear plan to mitigate the organizational obstacles, which might hinder the implementation of the different initiatives in the project.

I2: A document is produced (SEEMP), as required by international maritime law, but there is no clear plan of how to implement the initiatives in practice.

I3: The OSV company has not included the operators in the project and the results may not be in line with the operator's priorities and environmental plans. Statements in the interviews such as "the main work has to be done on board", might indicate the lack of understanding of the influence by the organizational and system factors in this project.

I4: The operators have not taken any particular initiatives towards the OSV company with respect to the new requirements of MARPOL, but is focusing towards their internal procedures and internal planning.
These issues will be further discussed in the analysis in chapter 5.

4.3 Case 3- The unscheduled critical maintenance operation

This third case to be studied is an unscheduled critical maintenance operation of a supply vessel's main propulsion thrusters. This case study is particularly interesting with regards to the conflict of interests between the stakeholders, and how this factor can influence the result. The study therefore aims to complement the information from the first two cases.

4.3.1 Background

The vessel is a PSV engaged in the North Sea, serving a long term contract with a major operator. During the summer of 2009 the PSV was working outside Ålesund in Norway. A phone call was made to the vessel's management office informing of metal shavings in their port side main propulsion thruster. The vessel could not continue working and it was immediately decided that the vessel had to be dry-docked and undertake a full overhauling of the damaged thruster. The classification society, insurance company, clients and senior management was notified. Parts and service engineers from the OEM in Finland was ordered. The vessel faced a two week off-hire of 2 million NOK and overhauling costs of 3 million NOK. The condition monitoring system had failed to predict the break down. When the vessel was docked, the decision was made to also check the starboard thruster. The same scenario was revealed. There were large metal shavings in this side as well, but not to the same extent. Additional parts for a second thruster had a 12 week delivery time. The study of this case aims to identify the frictional elements that reduced the operational efficiency and the organizational elements that diminished the communication and collaboration between the involved parties of interest.

Figure 8: The platform supply vessel before docking

4.3.2 The particular stakeholders

Due to the complexity in the conflict of interests between the stakeholders, it is necessary to briefly describe the stakeholders.

<u>The OSV company:</u> The vessel's management company which is responsible for the safe operation of the vessel and all maritime affairs. The responsible person in this company for this particular operation is the Vessel Manager (VM).

<u>The operator:</u> The oil field operator that has the vessel on contract. The operator is running the daily operation of the vessel and has the responsibilities for the petroleum affairs of the vessels operation. The responsible person is the Company's Representative (CR).

<u>OEM:</u> Is the Original Equipment Manufacturer of the main propulsion thruster, situated in Finland. The responsible person is the Service Manager (SM)

<u>The yard:</u> The yard in Rørvik, which undertakes all the work and support to the vessel and the OEM.

<u>H&M:</u> The hull and machinery insurance company for the vessel. The responsible person is the Insurance Surveyor (IS)

<u>CM:</u> Is the condition monitoring supplier for the OSV company. The responsible person is the Customer Account Manager (CAM)

<u>The Class:</u> Is the vessels classification society that approves the works and issues all necessary certificates. The responsible person is the Class Surveyor (CS)

4.3.3 The Operation

In order to fully understand the identified problems and obstacles of this operation it is also necessary to account for the main sequence of events, the different opportunities and decisions taken. The main propulsion thruster had a major break down in the upper gear house. However, the metal debris contaminated the entire thruster and required a full overhaul. This particular thruster can be seen in figures 9.

Figure 9: The main propulsion thruster

During a routine oil filter replacement the Chief Engineer (CE) found large metal shavings in the port side main thruster. The finding was reported to the VM by phone and pictures were sent by mail. Meanwhile the operations continued as normal. The VM and CE went through the last vibration and oil monitoring report without finding any indications of a break down developing. A new vibration and oil sample was sent to the respective condition monitoring (CM) service providers and a phone call to them was made by the VM. The CM had not discovered the inherent breakdown, but recommended that the thruster should be disabled. The OEM was contacted and they gave the same recommendation. The VM contacted the vessel and informed them of this recommendation. The captain answered that it already had been disabled and they were operating as normal, but with only one thruster functioning. The VM then contacted the operator and informed them of the situation. The operator immediately ordered the vessel off-hire and that the problem should be fixed before returning to normal operation.

The VM contacted the OEM in order to start the preparation of a spare lower gear and the necessary parts to the upper gear. The VM also contacted the insurance company, the OSV company's senior management, the classification society, and started to look for an available yard. The only available yard was a new dry dock in Rørvik. It was a small inexperienced yard. The service engineers from the OEM arrived and started to disconnect the equipment. The insurance surveyor (IS) came and was briefed and he documented the situation. During the initial phase of the docking it was decided to also check the starboard thruster. The same metal shavings were found there as well. Since a second spare unit was 12 weeks away it was decided not to stay in the dock waiting for the second parts after finishing the first thruster, but try to sail as normal under careful and frequent observation. Two weeks later the vessel was back in operation, but with a critical failure developing in starboard thruster. After 12 weeks the OEM gave the all clear signal that the spare unit was ready. The vessel was immediately taken off-hire and sailed to the same yard as last time and undertook the same overhauling as before. Two weeks later the vessel was back in operation with both thrusters in order.

4.3.4 Identified problems and obstacles

By studying these two maintenance operations several issues have been identified that relates to communications, cooperation and collaboration between the stakeholders which made the operation less efficient, more risky and more costly. The results of the identified issues are presented below and further analyzed in chapter 5.

<u>A: Initial information:</u>

A1: The initial finding of large metal shavings in the vessel's main propulsion unit was not immediately informed to the operator and the vessel continued its operations risking a total breakdown and collision with the platform.

A2: The CM service provider failed to inform the VM that the oil samples they had been sending in for analyzes was only checked for lubrication quality, not for machinery health. I.e. size, shape or type of metal debris was not analyzed.

A3: The CM had mounted the vibration sensors in the wrong places, not being able to identify the problem in the lower gear unit. They were competing with the OEM in supplying the same services, and were unable to obtain the necessary information to provide a high quality service.

A4: No experienced team from the OSV company was made available to process the initial information. Every VM was acting alone and independently. The complex maintenance operation was also managed by one single person.

<u>B: Learning from previous incidents:</u>

B1: The knowledge of similar breakdowns within the OEM was not communicated to the OSV company.

B2: Similar breakdowns in the OSV company had not previously been proper investigated and the underlying causes had not been identified.

B3: Breakdowns of the main propulsion thrusters were a well-known problem within the insurance company, but no measures had been taken to inform the OSV company in order to reduce the problem.

B4: The classification society or the flag state did not follow up the causes of the incidents, but merely verified that the technical condition was corrected before operation startup.

B5: The operator has had several incidents with their vessels main propulsion thrusters, but had not made any attempt to mitigate the problem.

C: The planning and execution of the docking project:

C1: There were no available yards and there was not a contingency plan for docking any of the 67 vessels in their fleet. If a situation occurred everyone started the planning from scratch.

C2: The VM, the Captain and the Docking Master at the yard were all inexperienced in their respective positions and responsibilities, but this fact was not mitigated or discussed in any circumstances.

C3: The yard did not have the quality or capacity to undertake the operation in an efficient manner.

C4: The location of the yard was in Rørvik, far from high quality maintenance facilities. The yard was simple and inexperienced in docking a modern PSV.

C5: The dry dock was half an hour drive to the yard which increased the need for logistical planning drastically.

C6: Procurement, manning and logistical issues stole focus from the vessel manager, they could have saved several days if supported by the OSV main office or even the operator's extensive logistical centers.

C7: Too many detailed orders from the higher management level in the OSV company. This led to undermining the local management and caused delayed work.

C8: There was no real interest by any stakeholder to investigate the incident and establish preventive actions.

C9: The remote location of the yard made local infrastructure, power outage, transportation of parts, etc. a significant obstacle in the normal operation. The problems were not mitigated through communication or planning.

D: The cooperation between the stakeholders

D1: The response from the thrusters OEM after the breakdown was vague and far in between. The issue of a potential insurance claim was the direct cause of this situation.

D2: Communication failed as there were barriers related to economics and liability.

E: The conflict of interests:

E1: The yard was near to bankruptcy and had limited spare parts and special tools. Everything had to be ordered after prepayment was cleared. This was not communicated before the docking and caused several days of delay.

E2: The information concerning the discovery of the metal shavings in the second thruster was kept secret, as this could lead to the vessel being off-hire for months until the next spare thruster was ready. This limited the important information flow between the vessel management, the operator, the class and the insurance company.

E3: There was a no unified understanding of the real situation concerning the second thruster and the different stakeholders had different interests in the outcome:

E3.1: The operator needed the vessel to be fit for operation, back in operation as quickly as possible, but left the vessel off-hire and was not economical liable.

E3.2: The insurance company was looking for negligence and carelessness in order to increase the deductible in the final claim. The insurance of losses connected to the off-hire comes into effect after two weeks, so they were interested in that the vessel kept sailing after the first repair. This meant that they could start a new insurance case for the second thruster and then start counting the deductible off-hire days all over again.

E3.3: The yard had increased all costs and rates in order to survive their short term financial problems. They were interested in prolonging the maintenance operations as this would increase their income.

E3.4: The classification society was mostly interested in that the problems were corrected before commencing normal operations again.

E3.5: The condition monitoring suppliers had focus on not being blamed for not discovering the inherent break down.

E3.6: The thruster's OEM was interested in blaming the break down on misalignment by the installer (new building yard) or operational error. They cut all communication for several months due to their fright of being held accountable for costs.

E3.7: The OSV company was interested in that both breakdowns were accepted as unforeseen and could be reclaimed with the insurance company, and that the vessel was allowed to operate as normal after the first breakdown and waiting for the second parts. In order to achieve this, the insurance company had to be convinced that the breakdowns were accidental and without any influence to prevent it by the vessel or management. The class, flag state and the operator had to be convinced that the damaged second thruster was working well enough to function until the spare part was ready. The risk of a total breakdown leading to a collision with the platform or the increase in repair costs had to be mitigated. However, this was a relevant scenario which would have set the vessel off-hire for months and a significant reduction in the insurance claim.

<u>F: The motivation of the crew:</u>

F1: During the final tests the thruster made noises that seemingly were louder than normal. Even if the noise was later “cleared” by the OEM, several of the crew highlighted that it was faulty and that it could break down at any time. The experienced engine crew confirmed that this was normal after an overhauling, but the other crew members constantly claimed that it should be opened up again and inspected. It became evident that some of the crew members did not desire to return to normal operations, but wanted to work the normal days in the dry dock and relax in the town during the evenings.

The identified problems will be analyzed in chapter 5.

4.4 INTERVIEWS

The interviews were made according to the list presented in chapter 3. For practical reasons some were made by phone and others by an actual meeting. The interviews basically consisted of three parts. The first part focused on the understanding of IO in general, the second part was focused towards the case studies and the last part was an invitation to suggest improvements in the operational environment. The interview subjects ranged from senior management to deck ratings, from the public to the private sector and from petroleum operator to OSV management. Some of the results from these interviews have already been presented in the identified problems in the case studies.

4.4.1 IO familiarization

The operators were the only ones interviewed that actually were familiar with the term integrated operation. They had a clear understanding of the principles and the idea. However, with regard to the maritime sector operator 1 found IO to be relevant merely in logistical terms. During normal operations the vessel was in the IO loop with respect to their operational logistical system, but as soon as the vessel was unable to supply its designated function, it was taken off hire and out of the IO loop. This was also the case during maintenance operations. The other interviewees were all from the maritime sector and none of them were familiar with IO. During the interviews it became apparent that the maritime industry is oblivious to IO and its development in the NCS. However, both crew members and the OSV senior management acknowledged the need for closer cooperation and an increased sharing of updated and filtered information. This result was as expected, but surprisingly there was reluctance by operator 1 to foresee any realism of implementing IO in the maritime sector. He stated that there were contractual conditions that were in effect that made this approach difficult. He argued that the vessel was either working for them or not. However, operator 2 had a different view. He believed that the maritime sector will have to face the IO work processes and adapt to them some time in the future, but that they are not ready for this jet.

The vessel manager stated in his interview that he felt there was a need for more integration of the work not only towards the operator, but internally in the company. When describing the basic idea of IO to the vessel manager, he replied that it could make his and the crew’s work day a lot easier and less frustrating. However, he did not see it as likely to obtain this operational environment in practice. He felt the traditional approach and contractual segregation of the operation was too strong to be altered. The captain stated that if integrated meant that he would be a part of the decisions taken outside the local operation, he would be all for it. He was often told what to do, take the local responsibility, but without having the onshore backup if necessary. He described a lack of operational knowledge on shore and said he had really no one to discuss with if he needed a second opinion. The operators had the knowledge, but their team of engineers was sometimes difficult to influence.

The interviews confirmed the lack of knowledge of IO in the maritime sector and brought forward more insight into the current operational problems and their perception of the future.

4.4.2 The case studies

Several of the interviewees were involved with the actual cases of this study in real time. It was therefore necessary to include them in developing the problems presented in the previous chapters. A significant part of the interviews was therefore concerned with the case studies. The information obtained by these interviews has already been described in the respective case results.

4.4.3 The need for improvement

After the initial questions concerning IO and the relevant cases, the interviewees were given the opportunity to speak freely about everyday challenges. The focus was on organizational issues and the cooperation between the operator, the vessel and the OSV management. There were a lot of suggestions, but only issues relevant to this study are presented in this chapter. The results are organized in three topics.

4.4.3.1 Planning and execution of maintenance operations

The operators described a need for the OSV company to improve their planning of maintenance operations. They often experienced the vessels being delayed after MM projects. Operator 2 suggested that onshore management spent more time on board the vessel prior to the projects, in order to fully understand and prepare for the operations. The operator had taken the initiative to change the contract in order to reduce this problem. They had removed the accumulation of maintenance days and instead took the vessel off hire whenever they needed heavy maintenance. The loss of income was compensated for in the contract, taking account for a probable amount of necessary days within a year. Their theory was that the OSV company would then be more efficient during the actual maintenance and not spend unnecessary maintenance days at all.

The vessel manager described a difference between the operator and the OSV managers during docking operations. The operator could have 10-15 personnel onsite related to a few work orders, while the OSV company had one man handling 200 work orders. The OSV senior management said that they had recently started with project support engineers that help the vessel managers during large maintenance operations. Normally the project department was only concerned with new buildings, but now they also supported the ongoing operations. The vessel manager suggested that he would be given a team consisting of different business areas to fully address the challenges during a large maintenance operation. It was not just technical assistance that was needed. Procurement, QHSE and accounting were also limiting his attention to the technical perspective of the project. He added that the support would probably be very costly for the OSV company in the short term. However, he believed that the saved losses would be greater than the direct costs. The crewmembers suggested that they should be included in meetings, not just be given simple individual tasks. They claimed that their local knowledge was ignored and that this actually led to losses in cost and time.

These suggestions sprung out from experiences in previous projects and verified that the issues identified in the case studies were real. How they can be mitigated will be discussed in later chapters.

4.4.3.2 Offshore technology and the operational involvement

Operator 2 believed there was a need to improve the OSV managers' understanding of offshore technology. However, he admitted that the operator also had a responsibility to include them in briefing and updates in order for them to understand the operational framework. The maritime authority addressed this issue as a challenge rising in the industry. As the vessel becomes more and more specialized the need for knowledge increases. Offshore technology is not included in the international code for Standard of Training and Watch-keeping (STCW). However, they verified that according to

Norwegian maritime law the OSV managers are responsible for the crew having the necessary competence to safely operate and maintain their equipment. The question is if the OSV managers have enough knowledge to evaluate what the right competence level is within advanced maritime operations. The solution might be a tighter coupling between the operator and the maritime management.

4.4.3.3 Administrative burdens and communications

The captain onboard suggested reducing communication based on e-mails and paper works. He spent much of his time filing papers, writing e-mails and answering the phone. Less and less time was available for managing the local operations. Often he had to answer the same questions several times from different OSV managers in the same company. He also highlighted the lack of onshore involvement in the normal operation scenario. The captain suggested that the crew members should be included at an early stage in the planning process and when the operation was underway the managers should stay more involved and have an updated understanding of the status. To mitigate the extensive administrative tasks he recommended keeping this type of work onshore and resists the temptation to ask the vessel to help out. He felt that the home office had become ineffective as more vessels were added to the fleet. Another constraint as he saw it was the availability of the managers. He understood the normal working hours of the managers, but claimed this principal to be ineffective with regards to their operations. The vessel manager described communication as a challenge. There was too much information and it was difficult to know what was relevant or not. It had to be better filtered and distributed in another way.

4.5 The traditional maritime asset management company

In order to understand the analyses and conclusions later in this study it is necessary to briefly describe the current and traditional organization of the OSV maritime management companies. The typical business areas are technical, crewing (human relations), procurement, QHSE and accounting. These are often divided in separate department according to their business areas and each with a set of coordinators and a manager. A traditional organizational chart, however somewhat simplified, has been developed and is presented in figure 10.

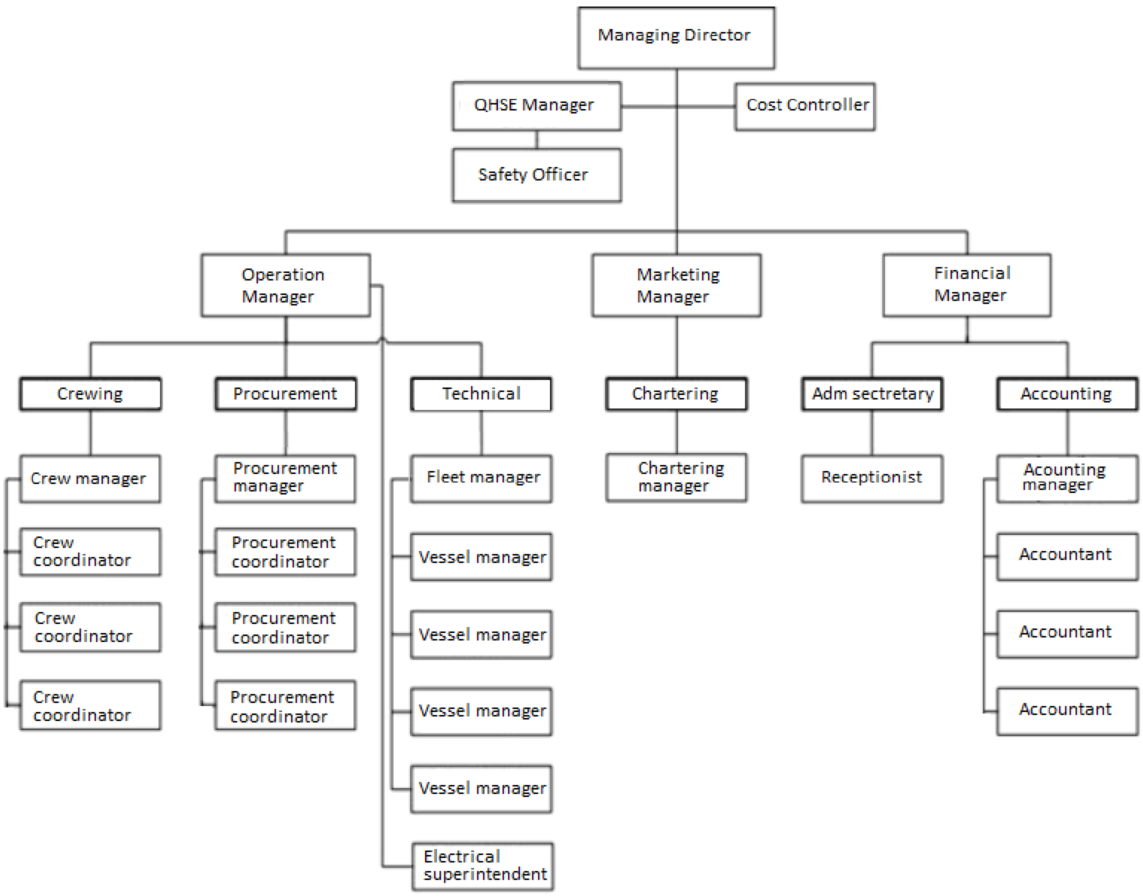

Figure 10: A simplified organizational chart of a typical OSV company

Based on the case studies, the interviews and the undersigned's experience from maritime asset management other typical problems related to the organization are:

a. Authority is only given to a very few persons which leads to bottlenecking decisions and the flow of information.

b. Communications flows vertically in the organizations and is often lost or altered along the way.

c. The crew is not involved in making decisions and does not feel ownership to new procedures or work tasks being handed over to them. This tendency has increased the psychological gap between the vessels and the onshore management.

d. Administrative task are being handed over to the crew, leaving them less time to perform their maritime related tasks without breaking the required hours of rest. The increased task level is not compensated with the correct level of manning.

e. Senior management is often more concerned with managing details in operations other than verifying strategic decisions and managing performance.

f. Experience transfer between departments is difficult.

g. Regular fixed meetings with "available" staff are ineffective and have often no relevant content.

h. The norm is to obey the operators' actions and requirements. There is no culture for asking critical questions in return or require anything back other than the contractual income. This reduces the unified operating environment.

i. A significant amount of time and money is spent on traveling between offices, yard and vessels.

Most of these issues will be further described and attempted to be mitigated in the next chapter.

5 Result analysis

In this chapter the results will be analyzed within the frame of the research questions. The perspective and focus of the analysis are the maritime organization, the collaboration between business areas and inter-organizational communication. The structure will follow the research questions.

5.1 RESEARCH QUESTION 1

The first question to be addressed is "to what extent IO is currently a part of the OSV maritime operational and managerial environment? The approach to answer this question is first to see if there is any theoretical knowledge of IO in the maritime operational environment. If this is not the case it is necessary to see if the IO principals are in use in practice, unknowingly or not. The last highly relevant part of this question is if there actually is a need for IO in maritime asset management.

5.1.1 The knowledge of IO in maritime asset management

The interviews of maritime OSV personnel, both onshore and on board revealed that the term IO was not known nor understood. None of them were familiar with IO and could not elaborate on the common understanding of it. However, as they only represented one single OSV company it raised uncertainties whether this applied for the entire OSV industry or not. In order to reduce the uncertainty factor the interview with the NMA was important. This interview confirmed that the OSV companies in general are not familiar with or use IO as a tool or philosophy in their approach to operations. NMA stated that the management companies had just recently risen to a level of matureness, where they could have the capacity of utilizing IO. According to NMA the implementation of the International Safety Management (ISM) code has made IO a future scenario also for maritime asset management. Prior to the implementation of the ISM code in 1998, the operation was more or less in the hands of the captain. The Code has defined the OSV company's responsibilities and liabilities, hence requiring a well described Safety

Management System (SMS). System is a key word in the context of this study. The Code has required the vessel's local management and the onshore management to plan, act and respond in a systematic way, incorporating not only the vessels, but all the operational stakeholders. However, even if important regulatory barriers of implementing IO have recently been removed it is still not a natural part of the maritime asset management. According to the interview with the IO consultant agency the OSV companies are not ready for IO and will face significant challenges when the operators set the same requirement of IO compatibility to the maritime industry as they have done to their offshore OEM suppliers. However, there is only one operator which has indicated this future requirement, other operators have not. Even so it is likely that the operator's size and influence on the market will cause others to follow both nationally and internationally.

The interviews also revealed that the on board management and the high level on shore management acknowledged the need for many of the same elements that one finds in IO. The crew mentioned the need for closer cooperation, sharing of relevant and filtered information in real time and a centralized decision handling process. These issues are described in the works of Bai & Liyange (2008), Frankel (2008) and Reitan & Pålhaugen (2004). So even if the term IO and the status of its implementation in the NCS were not known, the understanding of its needs was present and to some extent acknowledged. However, despite of this fact there was also reluctance towards any major changes and so called "revolutions". Several of the interviewees indicated exhaustion towards more paperwork and administrative burdens as means for improved operations, but desired a more common understanding of each other's situation and reasoning behind the decisions. There are few common decision tools and limited involvement of the sharp end of the operations. This might lead to a feeling of being overrun; lack of process ownership and thereby reluctance to decisions.

As expected the operator knew IO well, but the interviewee would only forecast IO as a logistical tool in a maritime setting on-hire. He was convinced that the maritime industry was not mature enough in order to utilize the IO approach. Despite of this statement, an interview with the IO consultant confirmed the other operator's plan to require IO compatibility in offshore operations in the near future. This leaves a question if the representative of operator 1 thinks of IO as merely an advanced down-whole operational approach to improve the petroleum recovery rate? It might be that operator 1's knowledge of IO was high within his segment, but limited towards other business area potentials. It would have improved the analysis if there were more representatives from other operators included in the interviews. It is therefore recommended to evaluate at a future stage if there still is a need to confirm this perception through a quantifiable approach.

5.1.2 Is there a practical use of IO in maritime asset management?

Even if there was no theoretical knowledge of IO among the maritime interviewees, it was of interest to see if any elements of IO or IP, were actually in use in the practical operations, consciously or not. The identified problems in the three case studies not only revealed a lack of IO in the maritime management, but also the operator's lack of incorporating the maritime management in their IO centers. The only exemption of this fact is the normal daily logistical operations when everything is functioning as normal. However, if a situation occurs that stems from the vessels technical operation, the vessel is put off-hire and left out of the logistical IO loop at the operator's site.

When looking deeper into the difficulties identified in case 1, the maintenance and modification project of the 30 year old well stimulation vessel, one can highlight several missing elements that indicate lack of the practical use of IO.

Communication:

The communication pathways during the project were erratic and to some degree chaotic. The individual dialogues occurred spontaneously and without evaluating the need for others to be included. In order to visualize the lack of IO with respect to communication the lines of information exchange has been drawn between all operational stakeholders in figure 11. Red is representing the operator's project and perspective, while the blue lines are the OSV's project.

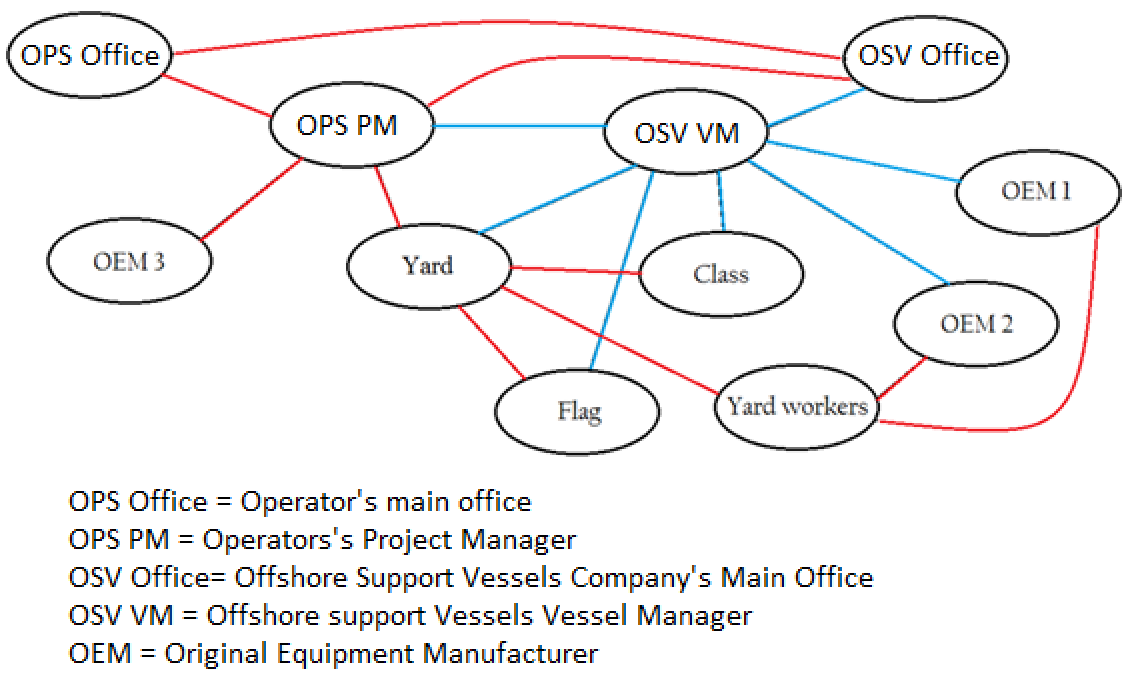

Figure 11: The lines of communications between the stakeholders in case 1

The situation led to important information being passed above the vessel manager, and led to decisions being taken without enough available information. The communication and lack of organized exchange of information was an important factor that triggered several of the identified problems. This was a strong indication of the lack of IO knowledge and practical IO utilization. Frankel (2008) states that new technology can facilitate new ways of communicating and organizing. If one was to modify the communication paths more in line with the IO approach one could have a different picture. One way of improvement could be:

1. The on-site team established an information and communication center with the main operational responsible persons. Linking the central to the different workers group at the yard.

2. Pre-arranged video and audio link to the main involved external stakeholders (Frankel, 2008).

3. A unified agreement of sharing important information as it happens, and that less important and internal information are filtered out. Develop a common information database according to Bai & Liyanage (2008)

4. Agree upon a unified goal and make sure all parties understand the intentions of the information and communication central (Reitan & Pålhagen, 2004).

5. Working together through enabling each other’s value creation and obtaining the common goal (Grønroos, 2000).

Applying these seemingly simple principles the organizational and communicational structure presented in figure 12 could have been possible.

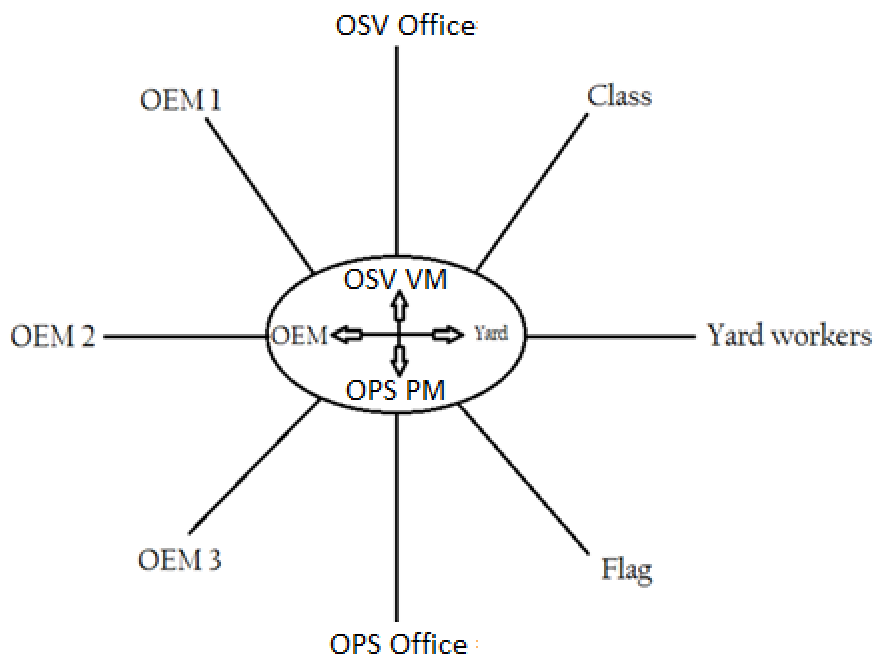

Figure 12: A possible operation central under a IO scenario

If figure 12 would have been the actual situation one could expect several positive outcomes according to the theory presented in chapter 2. The expected effects, although not limited to, could be:

- Synergetic effects with regards to transportation planning and execution
- Quality checked information across business areas
- Unified understanding and mitigation of potential delay causes.
- Updated and real information, reducing misunderstandings and frustration.
- A better foundation for making decision and alter directions as necessary.

The potential of implementing IO into maritime asset management will be further described in later chapters. However, this is merely an example of how a communication and information central could have improved the operations and confirms the lack of knowledge of IO during the project. According to Bai & Liyanage (2007) the challenges identified in the case studies of collecting and spreading data can be mitigated through establishing a web-based entry which is linked to major database within the system to facilitate integrated planning for the relevant participants. This could have helped to realize the theoretical communication and organizational structure in figure 12.

In case three, the critical maintenance project of the main propulsion thruster, there was an example of conflicting interests among the stakeholders. Issues related to liability restrained the collaboration and reduced the flow of important information. This generated forces that pulled in opposite directions and segregated the business areas and the involved stakeholders. Figure 13 visualizes this effect.

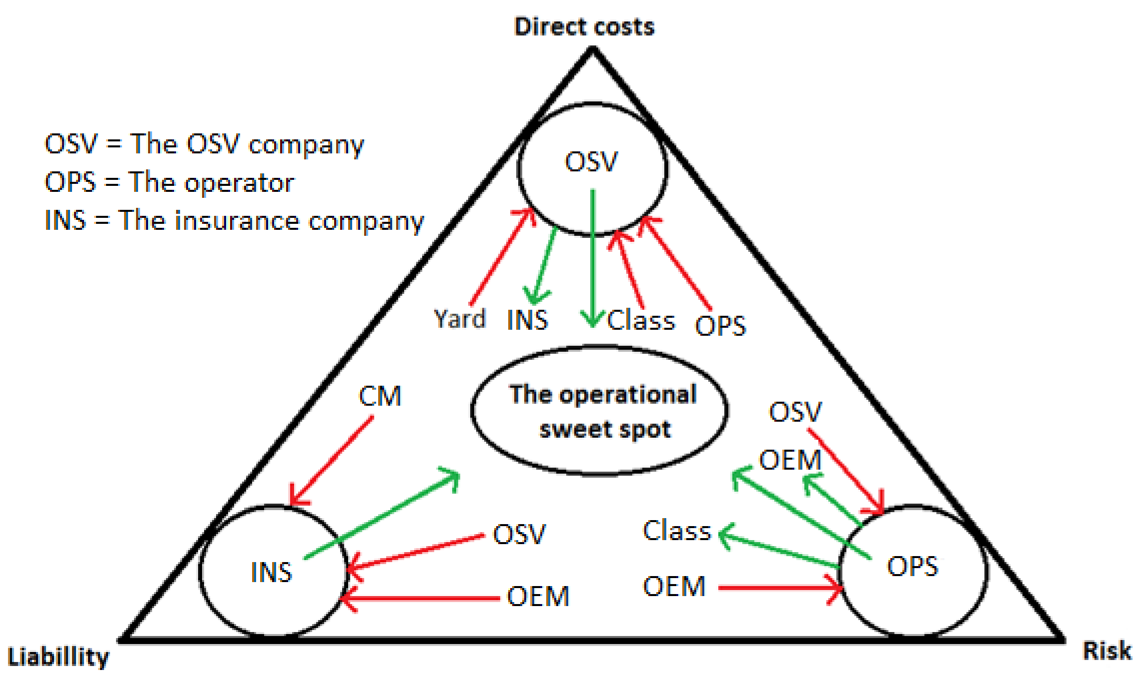

Figure 13: Representing the forces from the stakeholder's difference of interests

Conflict of interest has traditionally been a natural part of the business environment. Bai & Liyanage (2008) describe it as a potential pit fall of not having implemented IO. The results of his study confirm that conflicts of interest are still a restraining factor within the maritime industry. However, as described in the theoretical framework of this study, the research within industrial services has proven the positive effect of mutual value creation perspective and benefits of pulling in the same direction. When focusing on your customers' value creation you increase your own competiveness and hence your own value creation (Grønroos, 2000). The situation in case three led to an operation more risky than necessary. It might benefit the maritime industry to adapt to the novel development within the traditional service suppliers and alter its mind set. The problems described in the result of this case study, clearly show the lack of implementation of IO into maritime asset management and indicate some opportunities of applying new knowledge from the industrial services. As the stakeholders isolated themselves and only shared information that would keep them safe with regards to costs and liability. The total breakdown and potential accident that could have occurred would have been the result of disintegrated operations. The interviews also confirmed that this situation was to some extent acceptable and there is therefore a need to remove the economic incentives and contractual barriers that could root cause organizational accidents.

Bai & Liyanage (2008) classified the degree of IP implementation into four levels, whereas level 1 is limited and level 4 is high. Looking at the case results one can easily argue that the maritime industry is not even complying with level 1. At the first level the different disciplines are supposed to plan their activities for themselves and then come up with a list of work. Through a multi-discipline work shop the different disciplines agree upon a priority list, taking different constraints under consideration. In case 1, the well stimulation vessel, the different parties came up with an individual list of work, but the multi- discipline work shop never came together. The tasks from the OSV company and the operator was never compared or prioritized. Looking at the next levels of IP implementation, one can confirm that the description did not apply for this particular case and that the knowledge or willingness to comply with IP was not present.

During case 2, the SEEMP, it was discovered that the OSV company did not believe that is was necessary to include the operators during the project. This shows the lack of understanding the benefits of integrating all important stakeholders. It led to the lack of operator's ownership towards the OSV company's environmental effort and was not in line with the operator's own environmental initiatives. Later it turned out that the operator's influence on the OSV company's action plan was crucial for the project's success. The potential positive effect of IO in this project will be further discussed in chapter 5.2. The case studies and the interviews have revealed the lack of theoretical and practical knowledge of IO in the maritime industry.

The first two sub chapters have shown that there is no theoretical knowledge of IO in maritime asset management, nor is the principals used in practice. This answers the research question by showing that there is no IO implementation in the maritime industry. However, the study has also identified the acknowledgement and desire for the fundamental elements of IO. This desire was based on years of experiencing the symptoms of the lack of IO. Many of these symptoms are presented as the problems from the case studies. There clearly had to be a need for IO.

5.1.3 The need for IO in maritime asset management

The obstacles identified in the three case studies have been systematically categorized in order to further describe the lack of knowledge and implementation of IO in the maritime industry. Through the insight of the theoretical framework five important categories have been developed, that represent the main issues of IO within the frame of this study. The categories are briefly described below.

1. Technical Communication: A portable hardware and software system for audio and visual communication between all stakeholders at all relevant locations.

2. Contractual requirements: The need for flexibility and openness in the contracts that promote sharing of information and preventive actions. Today the contracts have incentives that hinder collaboration and open communication.

3. Real time and sincere information: The updated, filtered and honest information of the current situation which is sent to the right person at the appropriate level in the organization.

4. Organize for efficient work processes and decisions: The internal and inter-organizational structure that allows information and decisions to be processed effectively and with a high grade of quality.

5. Unified understanding of the common goal and the true intentions: The system thinking working environment and the common understanding of mutual value creation. Decisions according to the managers intentions.

The identified problems from the case studies were allowed to have causes related to more than one of these categories. E.g., case 2, obstacle B1: *Often the PSV will be ordered out to an installation only carrying a single container or other minor deck loads. The impression of the Captain is that the vessels do not seem to be utilized well enough*, will be related and hence placed in category 1, 3 and 4. The result of this analysis was 137 connections within the causal categories and the sector diagram of the distribution can be seen in figure 14.

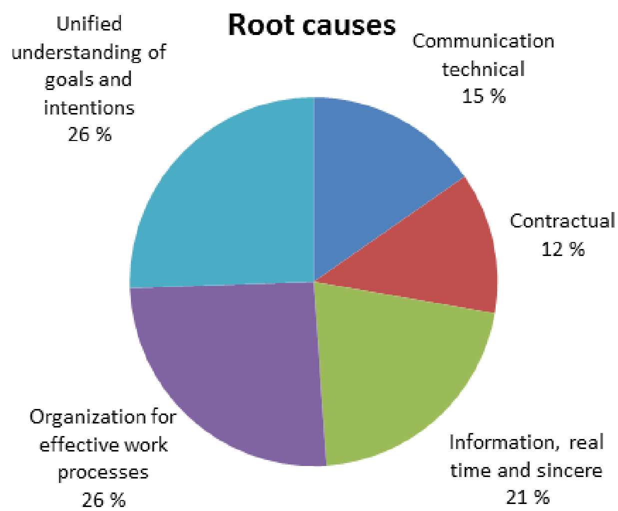

Figure 14: The distribution of the obstacles in relation to the IO categories

It could be argued that the identified obstacles are related to all categories in some way or another, but in this exercise only the most relevant ones have been used. It should be pointed out that the connections to the categories are potentially biased as a single person's experience and logical interpretations may differ from others. The result could be more accurate if several persons were to evaluate the connections, supported by proper statistical principals and methodology. However, the qualitative approach based on the available information indicates the need for IO and help answering the research questions. The results show that all of the IO principals are important elements, but there should be a focus towards unified understanding and effective organizations. It seems that contractual issues are less relevant in this setting. The results also show the issues identified in the case studies are relevant to the basic elements of IO.

IO scenarios and the knowledge and utilization of the IO experiences in the NCS are not present in the maritime asset management of today. However, there seems to be opportunities for improvements by implementing the IO operational scenario.

5.2 RESEARCH QUESTION 2

The second research question to be discussed is “what are the opportunities and limitations of implementing the IO approach in the maritime asset management”? The answers to this question will not be quantified in dollars or in the reduced number of accidents. However, an attempt will be made to show how IO in the maritime asset management could mitigate the identified problems in the case studies. The potential positive effect of implementing IO is already well documented in the petroleum industry (OLF, 2006). However, there is little or no research related to the potential effects of an IO approach to MAM. In this section a new way of organizing the maritime management will be developed in order to see the potential effect on reducing the obstacles and problems identified in the three case studies. As the business area of MAM and the nature of the vessels differ from the petroleum sector, there are also limitations that need to be described. In this context there is a need to clarify the understanding of limitations and distinguish them from problems and challenges.

5.2.1 The opportunities in implementing IO in MAM

The potential positive effects of introducing the IO approach into maritime asset management are best described by which frictional elements of operations that can be removed today. During the three case studies approximately 60 issues were identified as elements that either increased costs directly or delayed the completion of the project. In one or more ways these were related to the five elements of IO presented in the previous chapter. It is likely that if communication, cooperation and unified understanding of intentions and goals, and smarter organization of work tasks were well established some or most of the problems would have been removed. However, it is also possible that other circumstances outside the framework of IO influence the work processes in such a manner that the issues would still apply. E.g. lack of training and certification of crew and yard workers could have contributed significantly in some of the problems identified and the root cause could be international maritime legislation, i.e. outside the direct influence of IO compliant companies. It is therefore not certain that the IO approach would have removed the problems and obstacles, but it is likely that most of them could have been mitigated. In order to understand the potential effects of an IO approach to maritime operations it is necessary to view the issues under the light of a new theoretical maritime organization that is in line with the basic elements of IO. The next chapter will describe a novel way of organizing the work processes of a modern maritime asset management company.

The new organization and operation of MAM

Based on the theoretical framework in this study, the practical experience of the undersigned's experience in vessel management, the interviews and the issues identified in the case studies, key elements have been identified which needs to be in place in a novel maritime management organization. These elements are:

1. The individual stakeholders need to be independent from their geographical location.
2. A technical solution for live audio and visual communication between all stakeholders.
    a. Operation Centers should be established at key locations.
    b. Compatible software and hardware that is personal and portable.
    c. Increased data exchange capacity between OSVs and shore.
3. A database with information of the stakeholders work orders, project description, logs etc., open to all parties involved, and restricted to others.
4. A software program that can set up and handle communications groups according to projects, fleets and various scenarios.
5. An open communication policy.

   a. Contractual flexibility, i.e. no indirect off-hire incentives.
   b. Unified understanding and acceptance of stated goals and intentions.
   c. Filtered information, live and specialized information packages upon request.

6. An established and maintained communication path to all relevant stakeholders and centers.
7. A seamless change of working groups and processes between projects and normal operations.
8. A team based solution of working.
   a. Fixed participants from the OSV company.
   b. The authority to manage short term objectives.
   c. The fixed team members have the same fleet of vessels.
9. The traditional line mangers focus on managing medium to long term objectives and measure performance.

Based on these necessary elements, the principals of IO and the intent to mitigate the identified problems in the case studies, the following organization have been developed.

The common description and attributes:

The new organization is based on operation teams. Each team has the responsibility of a small fleet of vessels. The team is led by the vessel manager and consists of one person from each business area within the OSV company. The persons are on coordinator (sub-managerial) level and their respective manages are normally not in the daily operational loop. Their respective business area managers are instead concerned of verifying that operations within their segments are according to the company's strategic decisions and medium to long term goals. The geographical location of the team members is irrelevant as they communicate visually and by audio via their personal laptop or smart phone. Within the maritime management company the team members are fixed. However, there are several positions flexible according to the different scenarios. These available spots are filled by operator representatives, OEMs, Captain and Chief Engineers, project managers at yards etc., i.e. flexibility based on the actual situation. The different scenarios are described in detail later in this chapter.

The fixed team from the maritime onshore management will not change based on the scenario. However, there will be a seamless change between normal operation, MM projects or critical situations. The changeover will mainly be seen in the composition of the external stakeholders in the loop. The geographical independency is vital for the team's success. Even if the vessel manager is on the far side of the world, e.g. on the docking facility or the procurement coordinator is on a conference in southern Europe, establishing the team is as easy as if they were next door office neighbors. The necessary expansion of the teams based on the scenario will be modified as needed as they have compatible equipment locally and understand the new work process. An important part of this new operating scenario is the acknowledgement and unified understanding by the operator, OEMs and the vessel's crew. There is a need for including them in the development of the system in order for them to feel ownership to the suggested change. The potential positive effects should be highlighted to establish a willingness to change. The organizational change will have to be fronted and supported by senior management. The different scenarios are visually presented below.

The normal operation scenario:

In the normal operation scenario the MAM team is established when necessary, not at fixed intervals. The day to day operation of the vessel fleet is supported as usual and their respective operators are in the loop. Having the operator connected and understanding the operating scenario, mutual exchange is easier. It is likely that the operators will keep the

MAM team in the operator's IO loop as well. In the future there might even be only one single and unified loop. The information about current operation is exchanged and all stakeholders are updated. The individuals can work with their respective business task separately, but when needed the team hooks up and coordinate their effort in the IO loop. Figure 15 show how the elements are connected in the new MAM scenario. In this scenario vessel 2 and 4 have the same operator and the normal daily tasks are supported by the MAM team as necessary.

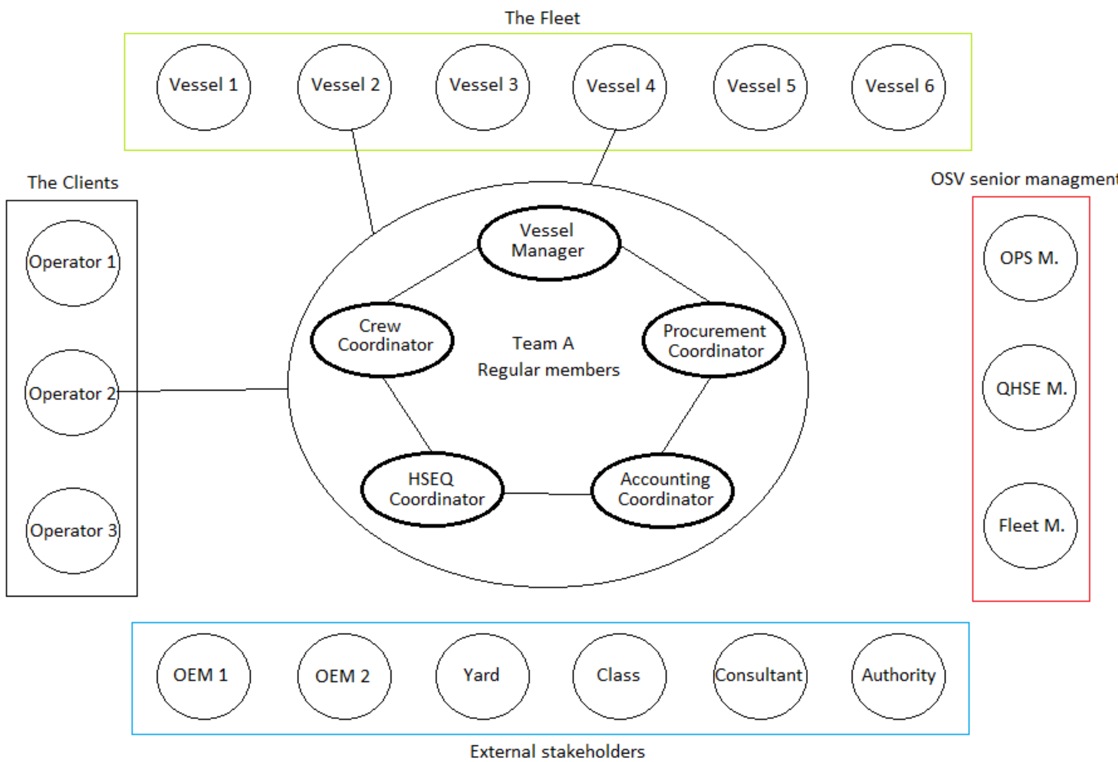

Figure 15: The normal operation scenario of the new IO MAM

If the new organizational structure in figure 15 is compared to the traditional organizational chart in chapter 4, the advantages of the new structure is intuitively obvious. The constraints of communication and efficient cooperation are reduced.

The project based scenario:

An important attribute of the new organization is the seamless shift between operation scenarios. It is favorable if the communication method, tools and teams change as little as possible, even if the work task changes dramatically. This will reduce time spent in establishing groups, connecting etc. In an MM scenario the same MAM team is already established, but other managers and external experts are connected to the loop when needed. An example of how these elements can be connected is shown in figure 16.

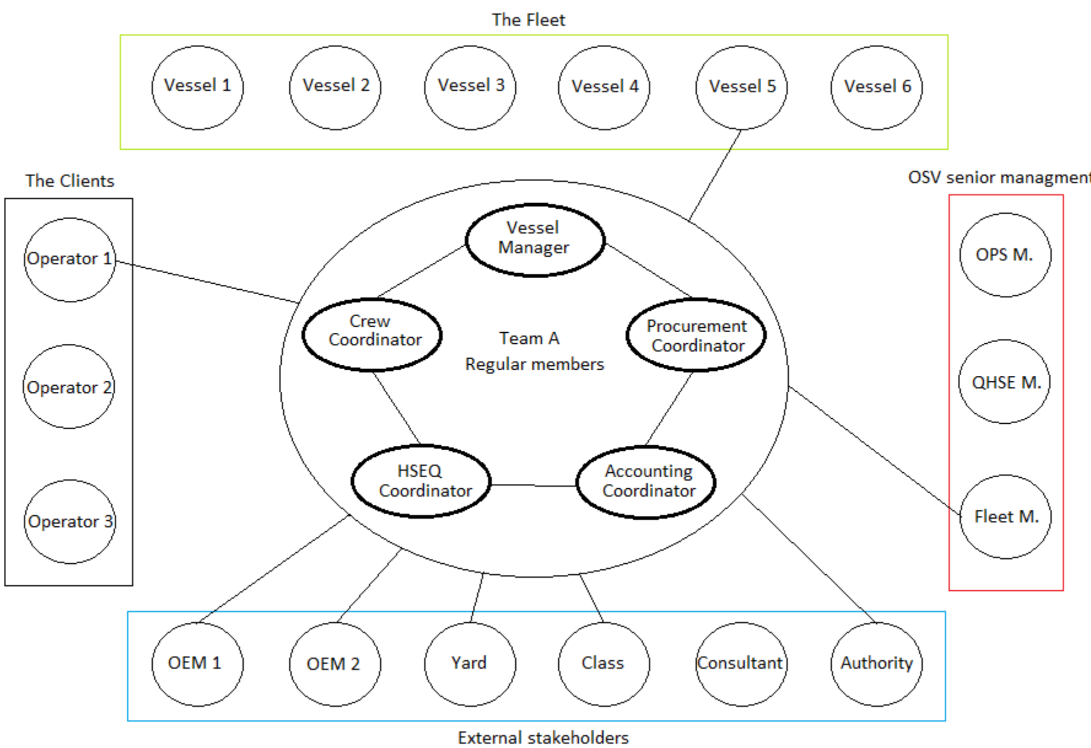

Figure 16: A MM operation scenario of the new maritime asset management

The internal loop is virtual and drawn for helping to understand the process. It is important that the external addition to the loop feels included and not only additives. This way of organizing and communicating could remove the problem that the vessel manager is alone at the yard, handling all business areas alone locally. The support team will be more present, and the other vessels will be handled as normal only by shifting between operation scenarios in the IO software. It will also ease the necessary support during holidays as the team members can connect from home or wherever they spend their vacation.

The critical situation scenario:

If a critical situation occurs during normal operations it is important to have system experts, decision authority and support elements informed quickly in order to overcome the uncertainty and to quickly mitigate risk. By changing the operating scenario and connecting the necessary stakeholders, the expanded team is established within minutes and ready to act. A typical communication network of this scenario is presented in figure 17.

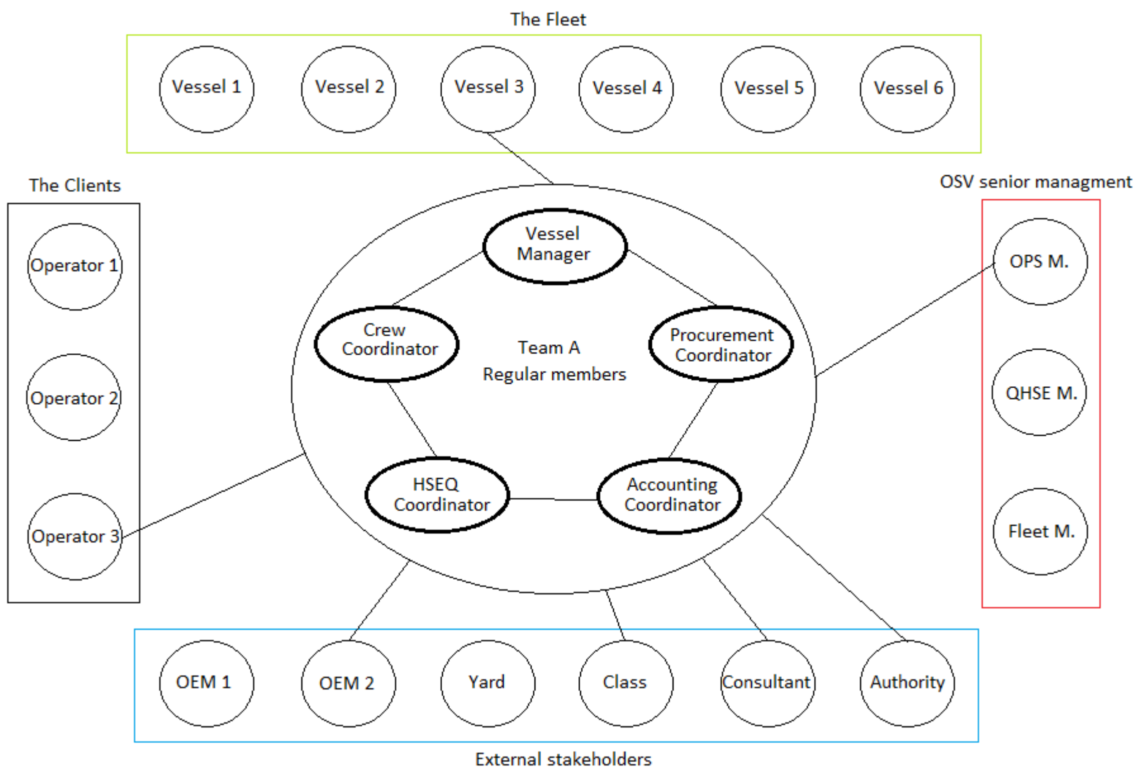

Figure 17: The critical situation scenario in the new MAM

Traditionally, critical situations are handled in a company by establishing an Emergency Response Team (ERT). There are several problems with these groups and they are often identified through exercises. Some of the typical problems are:
- The team members are rarely cooperating in this kind of an environment and it takes time before for the team organization is effective.
- The senior managers are often travelling and not able to participate.
- The knowledge of the operation or the technical challenges is not understood.
- It takes a long time to establish the team.

If the new MAM team approach as described above is used, all of these problems will be reduced or removed entirely. The operational cooperation and communications between the stakeholders has become streamlined.

5.2.2 Other positive outcomes

The opportunities of implementing an IO approach to MAM are many. Some of them are already mentioned and are quite intuitive. If the identified problems in the case studies are revisited, one fine that there are several examples of issues that could have been avoided.

Case 1, problem A2: *With no fixed place to undertake the project, there were no place to send the parts and special tools. A consequence of this was sub-optimal storage of parts with respect to the ambient conditions such as moisture and temperature. It was difficult to prepare for a fast shipment to the actual location when the decision was made, or the ability for the yard to prepare the equipment.* If all elements of IO described above where in place and the MAM team was established and function as in figure 16, it is likely that this situation could have been avoided. It is probable that solutions would have emerged in the close cooperation and information scenario.

E.g.:

- The operator's storage facility could have been used.

- The OSV company's acknowledgment of the operator's market position at the time could have initiated a request to the class for a postponement. This would have enabled a fixed place and time for undertaking the project after the operator's high value market had closed.

- The exchange of the real time information of the deterioration onboard, could have led to the acknowledgment and understanding of the critical urge for commencing the project.

- The OEM included in the loop would have increased the probability of having parts ready to be sent in very short notice or be stored at the OEM local store house.

If case two is revisited one can for instance find probable positive alternative outcomes in problem A1: *A problem is identified as the vessel has to have enough engines running in both engine rooms that can supply the entire vessel single handedly. This means that a total of three engines have to be running at all time. In a closed bus-tie it would be enough to have one engine in each room and a third in standby. Running with an open bus tie breaker leads to an unnecessary high fuel consumption.* Examples of probable actions in a new MAM team based IO scenario are:

- The close communication in the team would have allowed the OEM to verify the safe mode of using closed bus-tie, as the vessel was designed that way.

- It is likely that the operator would have changed their view after including the class and flag state which could confirm that this was a safe and legal way of operating the power grid onboard.

- The OSV company together with the OEM, could argue better for their action plan to remove the probability of a flawed bus tie breaker. I.e. the use of condition monitoring, testing and concentrated inspection campaigns etc. could have convinced the operator of the equipment working as intended.

- The team could have included the insurance company in transferring the lessons learned from the previous incidents. Connecting the entire fleet, with all captains and chief engineers would have facilitated the broad experience transfer from the accidents, hence reducing the probability of similar situation occurring and convincing the operators to allow running with a closed bus tie.

- The team could have easier explained the environmental need and effect of shutting down the extra engine.

- A compromise would have been obtained easier. E.g. the vessel could perform a risk analysis before every required DP2[3] operation if it was safe to run with a closed bus tie.

All of the problems identified in the case studies could have been listed in this chapter and been used to argue how the new MAM team under the IO philosophy could have improved the business. However, it should be underlined that the word could is used with intent. It is not certain that the problems would have been removed, but is highly probable that the situation would improve. The theoretical “solutions” described above could have been utilized under the current traditional approach to MAM as well. However, as this study has shown, seemingly simple solutions become difficult to implement under the existing organizational constraints.

[3] DP2 – Are the second safety level of a dynamically positioned vessel, i.e. the requirement of always having 50 % residual capacity after a single failure.

Other positive opportunities by the use of IO in MAM

Other likely potential positive effects of the new way of running maritime operations could be:

- The petroleum industry and the NMA have stated that the on shore management are not updated on the operations and does not acknowledge the responsibility they carry according to maritime law. IO would have facilitated an increase in operational awareness between the Vessel Manager and the operator and between the Vessel Manager and the crew. It would have forced an awareness of the operational risk and the responsibility of the Vessel Manager.

- The normal working task of running the vessel manager's fleet when undertaking an MM project could have improved. It would be easier to contact the other vessels, the communication between the vessel and the different coordinators would have been improved. Often the vessel manger acts like a bottle neck when having to relay information or questions from the coordinator to the vessel. This would have led to less work, more efficient dialogue and less need of administrative tasks for the onboard crew.

- The response to critical situations could have improved. The prearranged communication and information exchange with the OEM, class and flag state would enable the correct interpretation of information and making decisions that improves the situation faster. The measurement and evaluation of the decision could be relayed live and altered as necessary.

- The utilization of the operator's vast network of knowledge and resources. E.g. storage facilities, OEM network, transportation arrangements, system knowledge of operations. A unified understanding of the common goal and focus towards the partner's value creation would have removed the incentive to withhold information or prey on others misfortune. E.g. if there is a periodic failure on any equipment on board, the operators often accepts to continue operations. However, if the weather stops the operations, the operator may be tempted to suddenly take the vessel off-hire due to the failure of equipment. This could lead to the OSV company withholding this kind of information next time, making the situation worse for all involved stakeholders. This situation is quite common and leads to mistrust and removes the unified value creation initiatives. If however, the elements of IO presented above are well established, this situation would not be allowed to occur.

- A major problem in the maritime industry according the NMA is the implementation process. Several high quality action plans may be developed after an accident or similar, but the action is not always implemented and even more seldom are the implementation verified or measured for effect. The new MAM way of operating would ease both the implementation part and the verification. The easy connection to the vessels, the expert personnel and the authority could improve this situation.

- The sharing of live and updated information, the understanding of the current operation and the closer involvement of management on shore could reduce the risk associated with the complex operations in the NCS.

- As communication has become easier by modern hardware, the OSV company will save travelling costs for their employees.

- The psychological distance between the crew and the office back home will be reduced as visual and audio communication is more frequent.

There is a tremendous amount of opportunities for positive effects from developing a new approach to maritime operations. In many ways only the imagination sets the limit for what is likely to be improved. However, in reality there are some limitations one should be aware of.

5.2.3 The limitations

First of all it is necessary to distinguish between identified problems, challenges and limitations. In this study they are related, but might be mitigated in different ways. The identified issues in the case studies are concise, seemingly small and direct. These issues should be seen as the problems in this context. The root causes behind the problems are the challenges. As some of the challenges are so deeply incorporated or require a global approach or business effort outside the influence of industrial asset management, they should be acknowledged as limitations. These elements could limit the possibility of develop, implement or use IO as an operational approach to maritime management. Both the problems and the challenges that could be overcome have been presented in previous chapters. However, the challenges that are more long term and defined as limitations are presented in this section. Understanding the concept of limitations as described above there are only a few rightfully placed in this category.

- Contractual: The normal contracts today in the OSV business area include elements that leave the vessel off-hire. This might be elements of equipment failure, lack of proper manning, superfluous to operation etc. They vary according to the operators and geographical areas. The limiting factor is that some of the contractual requirements function as incentives to withhold important information, hide future plans and remove the potential synergetic effects. These contracts are based on international standards and are difficult to alter within the segment of industrial asset management.

- Offshore data transfer: Recent years the internet capacities for OSV have increased and the cost of Kbit/s has been reduced, however this is still an important limiting factor when the vessel is on the high seas. It is expected that this problem will be mitigated shortly as the internet capacity by satellite communication improves exponentially over time.

- Unified understanding across business areas: Traditional departmental segregation in the organization and the top-down hierarchical management way is not just an identified problem. The lack of understanding change management or willingness to change is so significant that it have become a limiting factor of implementing IO. It will improve over time, but it is expected to be a timely process. Senior management in OSV companies in Norway is very often former captains or fishermen from the very foundation of the company. Through a highly developed business instinct they managed to create a credible company even if they lacked formal education. However, in the modern global market this is no longer the only ingredient. The knowledge of organizational theory, change management and decision engineering is lacking and limit the immediate implementation of IO.

There might be other limiting factors not identified in this chapter, but under the current understanding of what a limiting factor really is, most problem and the corresponding challenges fall outside of this category. Near all the identified problems can be mitigated by acknowledging and facing up to the challenges. The limiting factors of implementing IO in maritime asset management are therefore few in this study, but it is recommended to revisit the previously identified problems in order to take the appropriate action.

5.2.4 Action plan

It might be helpful for an OSV company to have a road map for implementing IO. Even if it is beyond the scope of this study, some recommended action areas have been developed. Specific action points will be highlighted in summarizing this study. However, there is a need to develop the list further and customize it according to the different maritime environment.

<u>To the operators:</u>

In order for the OSV companies to take the step into IO the operators needs to take the responsibility to kick start the process. The operators have to start requiring the same level of IO compatibility from the OSV suppliers as they do from their other suppliers. Before the requirements take full effect they need to inform and educate. The operators have to inform of the experience from the implementation process in the NCS and educate about the benefits that IO have facilitated and how to achieve this operational approach. There are normally several dialogue meetings and conferences during the year and thereby many opportunities to start setting IO on the MAM's agenda. The operators need to prepare for including the OSV companies and their vessel in their onshore IO centers other than in the pure logistical context. They have to start facilitating to provide more assistance and support during different operational scenarios, also those that rise during off-hire periods. As long as the vessel is on long term contract with the operator, it is in the highest interests for the operator that the vessel returns to normal services as soon as possible and with the problems truly solved. The operator needs to take more responsibility to include, inform and to some degree informal educate the OSV managers of the current offshore operations. If the technical operational perspective is really understood, it is more likely that the vessel manager will foresee obstacles and mitigated them before they come into effect. The information and education could be a part of the dialogue meetings, the daily correspondence or relevant courses could be made targeting the OSV managers specifically.

The operators need to acknowledge the OSV as important tools integrated in their petroleum activities and abandon the perception of them being external maritime additives. Due to the operational and technical complexity with well intervention and subsea construction, the vessels are not merely maritime assets, but important assets in the petroleum sector as well. This raise the need for a clarification with regards to maritime and petroleum laws and regulations.

The problems identified with planning and spending the accumulated maintenance days led to the postponement or abandonment of environmental initiatives. The operator should evaluate the need for having extra maintenance days on-hire intended for environmental maintenance. E.g. polishing of propellers, cleaning of heat exchanger or high pressure cleaning of the hull.

To the authority:

For IO to take full effect there is a need for clarification of rules and regulation in the intersectional area of maritime and petroleum activities. The traditional maritime regulation does not cover the new challenges in these operations. The maritime assets onboard are so interconnected with the petroleum asset onboard that it is no longer distinguishable. The petroleum law of the NCS does not cover these assets either. The Norwegian Petroleum Safety Authority (PSA) stated to the NMA that they were only concerned with maritime assets directly storing or handling hydrocarbons. By this definition the OSV are not included. This leaves a regulation gap that needs to be bridged. In order for IO to be fully utilized in the NCS there is a need for clear and concise laws and regulations that place the responsibility and liability in the right hands. If this void is not filled it is not likely that the cooperation during off-hire and during complex operations will improve.

The authority also needs to give room for the OSV companies to operate in a novel manner. E.g. the condition monitoring of rotating equipment and postponement of bearing replacement based on the actual condition was previously rejected. The calendar or hourly based maintenance routine had to be done regardless of the actual condition of the equipment. This has later been accepted, but exemplifies how rules and regulation can work against the novel way of working. Inspection campaigns and revisions of the safety management system have to be modified in order to promote IO. The authority should also take responsibility to inform and champion the benefits from IO in the NCS and highlight this through their regular contact with the industry.

<u>To the OSV companies:</u>

The OSV companies have to take the largest steps. There is need for them to abandon the traditional hierarchical organization and communication pathways. The OSV companies needs to reorganize in order to promote internal communication and horizontal cooperation. The business areas of the company need to be integrated and operated on a lower level. The senior management needs to state their goals and intentions, verify that it is understood, and then leave it to lower staff to handle the operations within this frame. The senior management needs to focus towards controlling the path towards their strategic decisions. Measure if their goals are reached; alter directions as necessary and benchmark with high performing companies in order to increase their competitiveness.

The OSV company should pursuit the new knowledge of industrial services and IO in order to understand the larger picture or their actions and organizations. It might be necessary to motivate senior management to take courses and classes in order to be inspired with new thoughts and insights. They should take the initiative to invite the operators to share their experience within the field of IO and should visit their onshore IO centers for inspirations and ideas. They should set up a meeting with different IO consultant companies to compare what they can offer and how their company can benefit from implementing the approach.

The OSV company should make an investment analysis of implementing IO. An external expert should be hired to analyze the present value of the costs and savings from changing to the IO approach. It is often so that money talks and if the senior management can see for themselves a positive present value, they just might make the investment. If the OSV company undertakes the necessary changes and investments and truly understand and believe in IO they should gain an advantage over other OSV companies that has not. The OSV companies which are future oriented towards operations should increase their competitiveness and profit from the investment.

5.3 Any need for further research?

The literature search and the contact with the relevant industrial knowledge hubs have revealed a need for further research. The need is particularly towards maritime asset management within the frame of IO. It was not possible to locate any ongoing research that focused on the asset management of OSV vessels and the complex cooperation environment with the operators. There is several ongoing projects within IO, but these are mainly aimed at increasing oil recovery, accelerate production, reducing operating costs and enhancing safety and environmental standards. NTNU[4] has an IO research center that undertakes these tasks, but they are limited towards the offshore installations and the petroleum perspective. If the vessels are involved it is merely with respect to logistics during normal operations. Within the petroleum related activities such as drilling, reservoir management etc., the research activity within IO is high. Within the maritime perspective IO seems to only be studied in Norway in the context of simulation and training capacities of anchor handling and tug support vessels. Høgskolen i Ålesund has research programs which study the working relationship and integration of the MOU and the vessel. However, there has not been any identified ongoing research of IO into maritime asset management.

There is need for further research, particularly into maritime asset management and how IO can be utilized in this sector. The complex business area of the intersection of petroleum and maritime activities has never been more present than now. This complexity requires more cooperation between previous segregated business areas. There is a need for further research into the synergetic possibilities of the integration of business areas in the NCS. The identified need for further research has been divided into two main categories:

[4] Norges Tekniske og Naturvitenskapelige Universitet, in Trondheim

The intersection of the petroleum and maritime asset management:

As the intersection widens, the borderline between the traditional maritime and petroleum activities have disappeared. This has created challenges related to the following subjects:

- The gap between and in some cases duplication of the maritime and petroleum law and regulations.

- The need for knowledge of offshore technology in the traditional maritime industry. The need for training and education of specialists in addition to the traditional certification of the maritime crew. I.e. the area of certification and education of both crew members and on shore managers.

- The clarification of roles and responsibilities between installation personnel and maritime personnel onboard. I.e. the Offshore Installation Manager and the maritime Captain.

- The role and responsibility between the NMA and the PSA.

Integrated maritime operations

The focus towards down whole solutions and the increased use of subsea installations have created a need for novel maritime operations. The study into the field of integrated maritime operations has identified several needs for further research. These focus areas are:

- A roadmap for adapting IO in the maritime industry.

- A study that attempts to quantify the potential value creation of implementing the IO approach to maritime operations.

- A study of the practical on board solutions for IO communication to shore.

PART FOUR: SUMMARIZATION

6 Conclusions

The recent development of advanced offshore support vessels (OSV), engaged in complex subsea operations has challenged the traditional Norwegian maritime industry. From merely transporting passengers and cargo over vast distances, modern ships have developed into precision tools in the Oil & Gas sector. Due to their mobility and multi-purpose opportunities, maritime vessels have become increasingly attractive assets in this sector. As this inter sectional area has widened, the borderline between the maritime and the petroleum industry has become more diffuse. The knowledge based and technology driven development requires a modern managerial approach. As a response to the challenges the petroleum industry was facing during the 1990's, they restructured its approach to operations by smarter and more efficient work processes. The petroleum industry began to successfully implement these advanced solutions under its novel operational scenario, termed Integrated Operations (IO). However, despite of this effort the maritime industry seemed oblivious to the new approach and its documented effect. There was a need to acquire more knowledge of the current operational situation in a modern OSV company and search for a future solution for a sustainable operational approach across the business areas.

This study's main objective was to identify the opportunities and limitations of implementing IO into maritime asset management. However, it was first necessary to describe to what extent IO already was a part of the daily operational environment. By the use of three case studies and supported by interviews, several operational and organizational problems have been identified. The problems were specific symptoms of poor communication and the lack of a collaborative environment between the operational stakeholders. By combining the theoretical framework and the study of the identified problems, a novel approach to maritime asset management has been developed. The new approach is an adaptation of the fundamental IO principles, modified to fit the maritime organization and the challenges they are facing. The results show few limitations and many opportunities in applying IO in maritime asset management. The study shows that it is probable, although not easily quantifiable, that several of the identified problems can be mitigated. Based on the theoretical framework, the novel operational scenario and the identified problems, several recommendations have been developed. These are addressed to the petroleum operators, the authority and the OSV companies.

6.1 RESEARCH QUESTION 1

There was a need to find out if IO already was a part of the maritime operational environment, to what extent and if utilized consciously or not. The results showed that none of the maritime interviewees were familiar with the term. They could not elaborate of its meaning and had no knowledge of its principles or use. The representatives for the petroleum operators knew the term well. As expected they understood IO and were familiar with the efficiency leaps in the NCS. However, they viewed IO merely as a tool for the petroleum industry with regards to increasing the recovery rate, drilling operation efficiency etc., and not to be used in a maritime context. The only connection they could foresee was during normal operations. According to the interview there was a contractual need to keep distance between the operators and the OSV companies when the vessel was off-hire. However, the interview with the IO consultant verified that other petroleum operators planned to require IO compatibility from the OSV companies in the near future. The interviews verified the lack of knowledge of IO within the maritime sector, and showed a difference of opinions with regards to the IO opportunities in the maritime market. The interviews also revealed that the crew and the senior management on shore acknowledged the need for many of the same elements that one finds in IO. The crew wanted closer cooperation, sharing of relevant and filtered information in real time and a centralized decision handling process.

In order to verify these results it was decided to analyze the three case studies for any signs of practical use of the IO approach. The results showed no signs of use, instead verified the lack of IO in maritime asset management. It was highlighted that the results contained a significant degree of uncertainty as the case studies were represented by a single OSV company. It might be that other OSV companies had come further in developing IO. The uncertainty factor was reduced by two main elements. The first was the fact that this particular OSV company was one of the five major OSV companies in Norway and one of the largest in the world. The four other OSV companies had similar vessels, organizations, operators and operational areas. It was likely to also experience the same operational and organizational challenges. The second mean of reducing the level of uncertainty was the interview with the NMA and the operators. They both confirmed that as far as they could witness, the situation was similar in the other major companies and that this particular OSV company was representable for the industry.

Bai & Liyanage (2008) classified the degree of IP into four levels, whereas level 1 is limited and level 4 is high. The results of the case studies showed that the maritime industry was not even complying with level 1. Looking at the next levels of IP implementation, one could also confirm that the description did not apply and that the knowledge or willingness to comply with integrated planning was not present. The latter part of the analysis verified that there actually is a need for IO in maritime asset management. The chaotic and erratic communication paths between the OSV company and its external stakeholders, the ineffective organizational structure during projects, the lack of management involvement and limited knowledge of the ongoing operations and the segregated business areas, showed a need for integrated operations in maritime asset management.

6.2 RESEARCH QUESTION 2

The second research question addressed the opportunities and limitations of implementing IO into maritime asset management. In order to describe the limitations the term had to be distinguished from problems and challenges. The identified problems in the case studies are concise, seemingly small and direct. These were the problems. The root causes behind the problems were the challenges. As some of the challenges are so deeply incorporated in the industry or require a global effort outside the influence of the companies, they should be regarded as the limitations. There were mainly two areas that might limit the implementation of IO under the described definition. The first issue is the data transfer capacity offshore. As the petroleum sector has solved this problem by using a broad band fiber network at the bottom of the sea, the vessels still needs to use satellite communication. This restricts the amount of data to be transferred and increase the costs. However, the development in this field is tremendous and it is likely to be mitigated in the near future. The second major limitations are the level of knowledge and education. The onshore staff in maritime organizations normally come from positions onboard the vessels, and holds maritime certifications and education. Currently this education does not have organizational theory, decision engineering and performance management as subjects. The utilization of integrated operations requires a different approach to maritime education, updated to fit modern organizational theory, change management and understanding across business sectors. Without the unified understanding of goals and intentions, the acknowledgement of your partners' value creation and novel industrial service approach, it is likely that the implementation of IO in maritime asset management will fail or have its potential effect limited.

The opportunities of implementing IO in maritime asset management are many. This study has shown how a novel approach to the organization and communication within the maritime asset management environment is likely to mitigate specific problems during operations. By three case studies approximately 60 problems were identified as elements

that either increased costs directly or delayed the completion of the project. The analysis showed that these were related to the organizational and systems perspective of causation. The opportunities of mitigating these problems have not been quantified, but the amount of potential saving in time and direct costs are significant. By analyzing the problems and modifying the theoretical framework of this study, it was possible to develop a novel approach to integrated maritime operations. Several key elements were developed that framed the structure of the operational approach. The common description and attributes of the new operational approach are:
The new organization is based on operation teams. Each team has the responsibility of a small fleet of vessels. The team is led by the vessel manager and consists of one person from each business area within the OSV company. The persons are on coordinator (sub-managerial) level and their respective manages are normally not in the daily operational loop. Their respective business area managers are instead concerned with verifying that operations within their segments are according to the company's strategic decisions and medium to long term goals. The geographical location of the team members is irrelevant as they communicate visually and by audio via their personal laptop or smart phone. Within the maritime management company the team members are fixed. However, there are several positions flexible according to the different scenarios. These available spots are filled by operator representatives, OEMs, Captain and Chief Engineers, project managers at yards etc., i.e. flexibility based on the actual situation.

The fixed team from the maritime onshore management will not change based on the scenario. However, there will be a seamless change between normal operation, maintenance and modification projects or critical situations. The changeover will mainly be seen in the composition of the external stakeholders in the loop. The necessary expansion of the team will be enabled by compatible equipment locally and an understanding of the new work processes. An important part of this new operating scenario is the acknowledgement and unified understanding by the operator, OEMs and the vessel's crew. There is a need for including them in the development in order for them to feel ownership to the suggested change. The potential positive effects should be highlighted in order to establish a willingness to change. The organizational change will have to be fronted and supported by senior management.

The study shows examples of how the new integrated maritime operational scenario is likely to mitigate the identified problems in the three case studies and how all stakeholders will increase their value, based on the partners' increased performance. In order to achieve this operating scenario there are several obstacles that needs to be acknowledged and overcome. These are highlighted in the recommendation to the industry in chapter 7.

6.3 THE NEED FOR FURTHER KNOWLEDGE

Throughout this study several ongoing research programs within the subject of IO has been identified. However, the only study of IO within the maritime perspective seems to be in the context of simulation and training capacities of anchor handling and tug support vessels. Høgskolen i Ålesund has started a research program looking at the working relationship and integration of the MOU and the vessel during an operation. However, none of these programs focus on maritime asset management. One of the most relevant studies in this respect is at the Center for Industrial Asset Management at the University of Stavanger. Their research within maintenance management and integrated planning has been relevant for the problems identified in the case studies. However, there is need for further research, particularly into maritime asset management and how IO can be utilized in this sector. The identified need for further research has been divided into the following areas:

The intersection of the petroleum and maritime asset management

As the intersection widens, the borderline between the traditional maritime and petroleum activities have disappeared. This has created challenges related to the following subjects:

- The gap between and in some cases duplication of the maritime and petroleum law and regulations.
- The need for knowledge of offshore technology in the traditional maritime industry. The need for training and education of specialists in addition to the traditional certification of the maritime crew. I.e. the area of certification and education of both crew members and onshore managers.
- The clarification of roles and responsibilities between installation personnel and maritime personnel onboard. I.e. the Offshore Installation Manager and the maritime Captain.
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Integrated maritime operations:

The focus towards down-whole solutions and the increased use of subsea installation has created a need for novel maritime operations. The study into the field of the integrated maritime operations has identified several needs for further research. These focus areas are:

- A roadmap for adapting IO in the maritime industry.
- A study that attempt to quantify the potential value creation of implementing the IO approach to maritime operations.
- A study of the practical on board solutions for IO communication to shore.

7 Recommendations

In order for IO to be fully implemented into the maritime asset management environment there is a need for a joint effort between the oil field operators, the OSV companies and the authorities. However, this study has concluded with 13 recommended actions specified to each part of the industry. For the different stakeholders it is easy to argue that the specific recommendations below are not a part of their responsibility. They might be correct according to the law. However, if the implementation of IO is to be successful it is necessary to look beyond the normal distribution of responsibility.

7.1 To the petroleum industry

To enable the OSV companies to take the first step into IO, the operators need to accept the responsibility of kick starting the process. There are several initiatives the operator could take responsibility for. The following actions are recommended for the petroleum operators:

I. Prepare to require the same level of IO compatibility from the OSV companies as they already do from their offshore OEM suppliers.

II. Before the requirements take full effect they need to inform and educate the OSV companies. The operators have to inform of the experience from the implementation process in the NCS and educate about the benefits that IO have made possible. They should also describe how the operators undertook the process of restructuring.

III. The operators need to prepare for including the OSV companies and their long term vessels in their current onshore IO centers beyond the logistical context. They have to start facilitating to provide more assistance and support during different operational scenarios, also those that rise during off-hire periods. As long as the vessel is on long term contract with the operator, it is in the highest interests of the operator that the vessel returns to normal services as soon as possible and with the problems corrected.

IV. The operator should consider taking more responsibility to include, inform and to some extent educate the OSV managers about the current offshore operations. If the operational situation is understood, it is more likely that the vessel manager will foresee obstacles and mitigated them before they come into effect. The information and training could be part of the normal dialogue meetings, the daily reporting or specific courses.

V. The problems identified with regards to planning and spending the accumulated maintenance days led to the postponement or abandonment of environmental initiatives. The operator should consider the need for having extra maintenance days on-hire tagged for environmental maintenance purposes. E.g. polishing of propellers, cleaning of heat exchanger or high pressure cleaning of the hull.

As the operators are likely to benefit from the implementation of IO into maritime asset management it is in their interest that these actions are further developed. However, there are also actions to be taken by the authorities.

7.2 To the authority

For IO to take full effect there is a need for the clarification of rules and regulation in the intersectional area of maritime and petroleum activities. The traditional maritime regulation does not cover the new challenges in these operations. The maritime assets onboard are so interconnected with the petroleum assets that it is no longer distinguishable. There is a need for action to be taken by the authorities in the following areas:

VI. The NMA and the PSA should compare their set of rules and regulations relevant to the inter section areas and perform a gap analysis.

VII. The NMA should discuss with the classification societies and evaluate if the current rules and regulations of cargo ships are complete with regards to the new operating scenarios and technical development of OSVs.

VIII. The authority should take the responsibility to inform the maritime industry of the documented outcomes from IO in the NCS with regards to safer operations and motivate the industry to undertake the same efficiency leap.

The maritime and the petroleum safety authority have the opportunity to influence the implementations process of IO in the maritime industry and clarify the responsibilities and liabilities with regards to the tight couplings of the operating scenario. However, it is the maritime management companies which carry the largest responsibilities to act.

7.3 To the maritime management

There is need for the OSV companies to abandon the traditional hierarchical organizational structure and vertical communication pathways. The OSV companies needs to reorganize in order to promote internal communication and horizontal cooperation. In order to develop and implement IO into maritime asset management, there are several recommended actions that should be considered. These are:

IX. The business areas of the company need to be integrated and operated on a lower level. The senior management should state their goals and intentions, verify that it is understood, and then leave it to lower staff to handle the operations within this frame.

X. The senior management needs to focus towards controlling the path towards their strategic decisions. Measure if their goals are reached; alter directions as necessary and benchmark with high performing companies in order to increase their competitiveness.

XI. The OSV companies should pursuit the new knowledge of industrial services and IO in order to understand the larger picture or their actions and organizations. It might be necessary to motivate senior management to take courses and classes in order to be inspired with new thoughts and insight.

XII. The OSV companies should take initiative to invite the operators to share their experience within the field of IO and should visit their onshore IO centers for inspirations and ideas. They should set up meetings with different IO consultant companies to compare what they can offer and how their company can benefit.

XIII. The OSV companies should make an investment analysis of implementing IO. An external expert could be engaged in order to analyze the present value of the costs and savings from changing to the IO approach.

If an OSV company undertakes the necessary changes and investments and truly understand IO they should gain an advantage over other OSV companies. The OSV companies which are future oriented towards operations should be able to increase their competitiveness and profit from the investment. However, the willingness to revolt the deeply incorporated ineffective traditions and change according to the pace of global market requirements will prove favorable for all stakeholders in general and for the OSV companies in particular.

To all the responsible industrial managers, I leave you with the famous words[5] of Reinhold Niebuhr (1892-1971):

God, grant me the serenity to accept the things I cannot change,
the courage to change the things I can
and the wisdom to know the difference

[5] Also sometimes attributed to St. Francis of Assisi (1182-1226)

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