Risk Management of Docking Mobile Offshore Units

(A project risk management approach to major yard stay projects)

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Risk Management of Docking Mobile Offshore Units

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Preface

This thesis is written as fulfilment of the requirements for the Master of Science in Maritime Management at Vestfold University College (HiVe). The thesis was accomplished with close collaboration of DNV- Maritime Advisory at Høvik office.

I would like to express my appreciation to my supervisors at DNV, Sarath Raj and Richard Tao both Senior Advisors in Ship Operation department. They have been instrumental in recommending a suitable topic and I am truly grateful for the given opportunity to write my thesis at their offices in Høvik. This thesis would not have been possible without their supervision. I would like to address a special thanks to Sarath Raj for invaluable guidance though all phases in this research.

My advisor at HiVe, Lars Christian Iversen, supervised me through this project I would like to thank him for assuring the quality of structure and content of my thesis.

I would also like to thank my anonymous interviewees from the industry and also participants within DNV.

Last but not least, I would like to thank my father and dedicate this work to him in appreciation of his unconditional supports through my life.

Oslo, Norway

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Mehdi Mashouri

List of Abbreviations

CC	Condition of Class
CCTV	Closed-Circuit Television
Class	Classification society
CM	Condition Monitoring
DNV	Det Norske Veritas
EPCI	Engineering, Procurement, Construction and Installation
FPSO	Floating Production Storage & Offloading
FSO	Floating Storage and Offloading
IACS	International Association of Classification Societies
IIP	In-service Inspection Program
IWS	In Water Survey
MODU	Mobile Offshore Drilling Unit
MOU	Mobile Offshore Unit
MPU	Mobile Production Unit
MUSD	Million United State Dollar
NCS	Norwegian Continental Shelf
NMA	Norwegian Maritime Authority
OEM	Original Equipment Manufacturer
PMS	Planned Maintenance System
PSA	Petroleum Safety Authority
RCA	Root Cause Analysis
ROPS	Remote Operated Pull-in System
Semi	Semi-submersible
SPS	Special Periodic Survey
TLP	Tension Legs Platform
USD	United State Dollar
UTM	Ultra-sonic Thickness Measurement
UWILD	Underwater Inspection in-Lieu of Dry-docking
WBS	Work Breakdown Structure

Abstract

This master thesis main topic is Project risk management in docking of mobile offshore units. It is written in collaboration of Maritime Advisory department at Det Norske Veritas (DNV) at Høvik, Norway. The aim of this thesis is to identify challenging areas in managing docking projects' risks and also discuss the possible solutions in handling these risks.

Moving drilling rigs into deeper waters have been associated with higher levels of technical sophistication, complexity and consequently increase on risk level in docking projects. Thereby the project risk management, by managing risks of cost and schedule overruns during docking project, now has become important to success of docking projects. In spite of the growing importance of project risk management, many projects have failed to meet the project objectives with significant overruns in term of cost and time.

This research through interviews, case studies, academic research, market analysis, company analysis and analysis of general trend within the offshore industry has identified the problem areas also tested the validity of proposed solutions in group discussions with DNV specialist.

This paper mainly discusses the challenges related to planning and control of docking related projects. Some of the challenges lies in mapping the condition of the unit and hence defining the scope of project, the competence gap in project management team for covering the technical details of the project, difficulties in assessing the magnitude of sub-activities, satisfying stakeholder expectations.

This thesis proposes a new process model within project management for docking project as a possible solution to the identified problem areas. The recommended solutions are aimed at assisting rig owners in systemizing their docking project efficiently.

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1. Introduction

1.1 Background

The current and projected activity level at the Norwegian Continental Shelf (NCS) underlines demand for mobile offshore units. Thereby from year 2000 till now, the number of drilling rigs in Norwegian water has almost doubled (Eivind Reiten 2012). As a result of high demand, the day rates have increased dramatically and rigs compete fiercely for higher up-time in this special market with high entry barriers. In such a situation, downtime of the units is probably more unfavorable than ever. However the observation from Norwegian offshore industry over the last 20 years show a developing trend of delays and cost overruns in docking projects. Instances of extreme cost overruns and lost contracts during yard stay provide evidence for this fact.

In this paper we define "docking" as major project including upgrades, modifications, maintenances and repairs activities carried out on a Mobile Offshore Units (MOU) which is associated with an off hire of the unit. Docking projects can be characterized as substantial projects in term of incurred costs, involved stakeholders, number of activities and complexities. Further, the rapid change in offshore technologies, deep water drilling techniques and changes in regulatory regime over the last two decades have increased the complexity of docking projects tremendously.

Docking projects these days turn into risky operations for rig owners. On the one hand large downtime cost of units (Approx. 0.5M USD per day loss of revenue for a Mobile Offshore Drilling Unit) and on the other hand involvement of many risk factors have made the planning and control of docking projects a challenging task for project managers.

1.2 Problem statement and propose

This study aims to identify significant challenges within the docking planning process in order to be able to facilitate to rig owners a safer and more efficient yard stay. It is expected that this research to some degree will assist managers in systemizing the maintenance and modification projects in a more efficient manner. Throughout the work with this thesis some changes regarding the problem description were made as further insight was gained with respect to understanding of the docking process. The final research questions are as follows:

A. What are the challenges leading to major overruns in docking of Mobile Offshore Units?
B. How could a third party possibly facilitate risk management of major docking projects?

1.3 Structure of the thesis

This paper consists of two main parts, the first part includes theoretical and basic knowledge about MOUs including MOU types, age and equipment also distribution of units over NCS, involved stakeholders in docking and the applicable requirements and regulations to the units which is mainly covered in chapters 3.1, 3.2 and 3.3.

The second part covered in chapters 3.4 include a general overview of the docking process as normally applied today and study on some delayed projects. Chapter 4 is concerned with challenges in docking projects and concludes with some recommendations.

Finally chapter 5 make a conclusion on research findings.

2. Methods / Research approach

A qualitative approach has been used in this thesis to present an understanding of risk and risk reduction measures in management of docking projects. In this chapter the methodology of the thesis is outlined. Further, the data collection technique as well as problems and barriers to the chosen research design and strategy is described.

Expert opinion through formal and informal interviews, case studies, academic research, market analysis, company analysis and analysis of general trend within the offshore industry are the fundamental part of this report. Interviews together with research materials have been the main source to get the necessary background knowledge about docking of MOUs, finding typical challenges and risk in docking project also to find the potential solutions and finally check the validity of solutions with industry experts.

2.1 Research design

The link between research questions, collected data, case studies and research conclusions is the research design used in this thesis (Blaikie, 2009). The idea behind this design is that the interview should be a dynamic process in order to include relevant data as much as possible based on the input from Documents. The Figure 1 illustrates the applied design in this research.

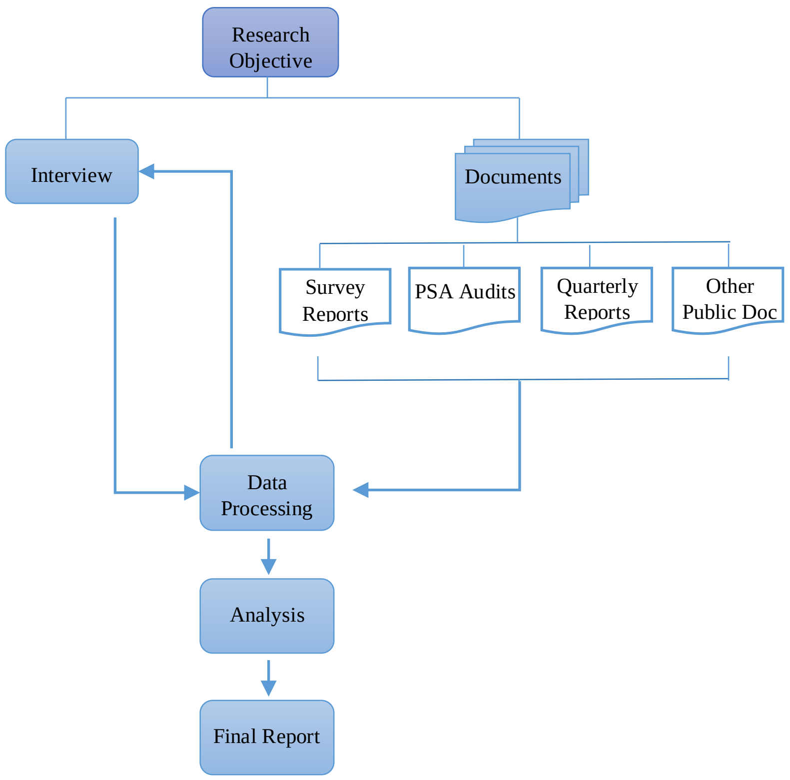

Figure 1: Research Design

This research project was kicked off by sort of a serendipity approach. Clearly such approach demands some flexibility in steering the project freely towards undiscovered values. Application of this approach by increasing the freedom to maneuver the research towards the most significant identified values could also increase the chance for creative research contribution. Changes in research plan has therefore been inevitable. For example initially the research was concerned about "dry-docking MOUs" but after some investigation it was revealed that the dry docking is not a very significant topic since units are either not dry docked or dry-dock in a very special circumstances. So the research focused on docking and not dry-docking in particular. Similar story occurred for risk analysis for unit's components which further explained in Chapter 3.1.3.

2.2 Literature review

Despite extensive search for relevant research papers, books, articles and industry guidelines it has not been possible to identify any available literature of significant relevance about docking MOUs, so unfortunately the literature review has only a low contribution in this research.

Instead, this research has benefited from studying many formal and informal documents related to docking projects. Reading these reports and documents had certain role in preparation for interviews and quality of interviews. Guiding questions for each interview has been designed by support of these documents also the results achieved from previous interviews. Considering the limited time of interviews and also the extensive details associated with the topic; managing discussions would not be functional without preparation of appropriate guiding questions.

These supplementary sources also were very supportive in data processing and analysis of final result by assisting in refining and tuning the research findings. The utilized documents in this research could be classified into two groups:

Public Documents

Public documents include the sources that cited in this paper also the sources that studied to get better understanding. For instance, along with the research particularly the regulation and requirements mandating docking also offering alternatives for dry-docking was studied. These documents include MODU Code, IACS and flag requirements. The other public sources are Petroleum Safety Authority (PSA) audit reports in term of Acknowledge of Compliance (AoC) on studied rigs. These reports are available to the public on PSA website. The PSA's audits was investigated for identifying the common areas of non-conformities.

Above all, the published documents from drilling companies under investigation was studied in detail; including annual reports, quarter reports, presentations and broadcasts. These documents give valuable information about executed projects and general scope of work. Basically the significance of candidate docking projects for further investigations was evaluated by information from these documents. The chosen projects were followed with investigation on class survey reports (Internal Documents) and interviews.

Internal Documents

The documents under this group have been subjected to non-disclosure agreement and are therefore mainly used to the get better understanding about under investigation matters and to improve the process of interviews. Clearly, in order to maintain the confidentiality the content of this type of documentation is not quoted or directly referred to in this paper. Such documentation includes DNV survey reports and other DNV internal documents as well as documents accrued from companies like dry-docking procedure, quality assurance and repair handbooks are in this group. DNV survey reports have been the most used internal document within investigations.

As described earlier in this chapter there is only little public literature about docking projects and many research kept internally within companies. There is little information available as this is a very narrow industry for which reputation is important and hence any adverse reports are likely to affect the business. Any shortfalls that are pubic knowledge could hurt a company’s prospects to operate in the industry as this is a high risk industry who adverse effects are likely to damage life, property and environment. On the other hand, the evidence demonstrates considerable challenges in management of docking project. Clearly these aspects highlight the significant needs for further academic research contribution in this field. Hopefully, the result of this study will be a starting point for further researches.

2.3 Interviews

Interviews as main information source to this research have been fundamental for data gathering. The interviews have also functioned as sounding board for validity of results in this thesis. Therefore, selection of interview method and interviewees also the data processing has of great contribution to achieved result.

Myers and Newman offered three methods for qualitative research in their paper.(Myers & Newman, 2007, p. 4)

a. *Structured interview. In* this sort of interview complete scrip of question prepared in advance. There is no room for improvisation in interview and the interviewer is not necessary professional researcher.

b. *Unstructured or semi-structured interview.* In this sort of interviews the researcher may prepare an incomplete script of questions beforehand and improvise around the incomplete script. This method is either done by a researcher or a member of a team.

c. *Group interview.* This type of interview could be structured or unstructured, while two or more persons are interviewed at the same time by one or more interviewers

In this thesis a method based on semi-structured interviews has been applied. Completely unstructured interview style makes it difficult to draw patterns between interviewees' responses. Further, the structured interview also is not compatible with the needs for investigative dynamics interviews to solve complexity and ambiguity of topic. The rationale for choosing semi-structured interviews as the main method for data collection was to gather data with as much manageable details. This allowed interpretation of the received data and steer the interviews to the right direction depending on correspondent background and interview context. The other advantage of semi-structured interview is discovering important information which did not seem relevant before the interview and ask the interviewees to go further into the new topic.(Myers & Newman, 2007)

As described in Chapter 2.2, relying on available sources a list of supplementary guiding questions was defined prior to each interview. The design of the interview guide was based on findings from observations, results achieved from previous interviews and reading relevant documents. The themes of research were discussed with interview objects prior to the interviews, when the planning of the interviews took place. During the interviews initially a short PowerPoint of research proposal was previewed to the interviewees to remind the boundary of the research. During interviews the focus was on hearing the points of views from the interviewees and supplementing with the questions from the interview guide if needed.

However the interviews in this research were progressive, but also it might be described in almost two distinctive phases. In the early phase, interviews were generic and they were an informative source for educating the researcher. In contrast, the second phase interviews were much more detailed and concerned with investigating the core causes of the problems.

According to predefined and signed consent letter for each formal interview the researcher obliged to maintain the confidentiality of participants' identical information and also to discard the related digital records three months after thesis formal delivery. Most of the interviews were held in a formal tone; however occasionally and depending on the situation, it was preferred to have rather informal interviews. By conducting open and informal interviews (or rather discussions and conversations) the informants have been able to share more information. They felt comfortable to talk about subjects that they wouldn't have been comfortable talking about if it was a more formal recorded interview, or if they were quoted and referred to.

The offshore industry is very sensitive to the operational news and any news good or bad may have direct effect on companies' profile, so interview objective despite their interest for collaboration try to protect the companies from any information leakage to the market. It should be noticed due to sensitivity and confidentiality of information sometimes participants were conservative to share the details about projects. Also despite the fact the confidentiality of meeting was to be formally sustained, the researcher has strived hardly to get interviews and required information from participants. Many of the request for interview were rejected and just around 20% of requests outside DNV ended up with an interview. However, it should be noticed the conducted interviews has been with experts with high positions and experiences in offshore projects. The sample participants should therefore to a high degree be considered as representative for the industry.

2.3.1 Selection of interviewees

In selection of participants it was attempted to pick up managers with extensive experience from unit's classification or direct contribution in docking projects. In total sixteen (16) formal interviews and some informal conversations were carried out as main data source to this research:

- Ten (10) formal and some informal interviews were carried out in-house with DNV senior experts in offshore classification and offshore projects including personnel in Norway and Netherlands.
- Six (6) formal interviews plus some informal conversations were done with oil service companies, drilling companies and supplier companies.

Regrettably, due to time limitation the input from shipyards were skipped from initial interview plan. It is believed that views also from such important stakeholder would have benefitted the research.

2.4 Data processing

After each interview a transcript and summary from the records was prepared. Since the interviews have been the main source to this research, clearly data processing has high importance in this method while each interview was the building brick for the next one. Interviews and guiding questions were modified as the number of interviews progresses meaning first interview insights were used to modify and develop the next interview and so on. The intention behind such an approach was to narrow down the focus on to the possible solutions to the research questions.

Early interviews were about more general topics while the later interviews had much more detailed discussions. The main challenge during these interviews was to keep the technical details in a manageable level and constraint to the docking projects. It was experienced that investigating the root cause of the challenges in docking project might fall back to the operation phase which of course is out of the research scope. Since the respondents were often specialist experts in their own fields it was necessary to carefully restrain the discussion to the core causes and to avoid too much technical detail which overburden the data analysis.

The data processing partially was done simultaneously along with the interviews, since interviews were interactive. During the interviews it was attempted to investigate the root cause of failures in experienced projects by applying *Five Why technique*. Through this approach it needs to keep track of the identified main causes on next levels of details. Based on consultation with my supervisors at DNV it was decided to apply *Root Cause analysis* and *Five Why techniques* during the interviews which are suitable methods for a complex and broad topics like this.

The PMBOK described the **Root Cause Analysis** (RCA) an analytical technique applied to determine the basic underlying reason that cause a variance or a defect or a risk (*A Guide to the project management body of knowledge: (PMBOK guide)*, 2004). In data processing root cause analysis is utilized to sharpen up the definition of risk in docking projects and grouping risks according the causes. So the effective risk response could be developed afterwards if the root cause of risk is addressed. Accordingly, the loss causation model demonstrate this method in a graph (See Appendix 1.)

The **Five Whys technique** helps to discover the story of causes and effects starting from back to front. It's an iterative question-asking technique assist to explore the cause-and-effect relationships underlying a particular problem. The method is very useful for complex problems that originated from multiple causes. This technique provides often more in-depth understanding than some other techniques. (Lewis, 2009). An example of application of this technique for root-cause analysis is the analysis of the crane upgrade as presented in a STEP diagram to show the systematic, ref. Fig. 14.

Since the respondents were specialist experts in their fields, for using these methods during interviews it was necessary to carefully restrain the discussions to the core causes and avoid too much technical detail which overburden the data analysis.

2.5 Case studies

In this thesis some case studies mainly from drilling companies will be presented. During the research, three projects were studied but due do to broad scope of these projects just few sub activities will be studied in detail in Chapter 3.5. Also a general description of docking project has been included to present the thematic challenge in the industry.

2.6 Analysis

The findings from interviews, internal and public documents were concluded and finally a recommendation for improvement in risk management of docking projects was proposed. During the research I had the opportunity to benefit from frequent group discussions with my supervisors in DNV to present the findings and discuss the path ahead. This research used the DNV experts' opinion in different disciplines as sounding boards for validity and practicality of recommended solutions.

3. Analysis

This chapter aims to inform the reader about different perspectives of docking projects. The first section describes the profile of active MOUs in NCS including the distribution of MOUs on NCS, segmentation and categorization, Age and characteristics of equipment. The second section, relying on literature reviews, discuss the risk management in a general context. The third section gives detailed explanations about the role and responsibility of main stakeholders in docking projects. This section has a particular reflection on the role of authorities in docking projects.

The fourth section in this chapter, after clarifying definitions, represents the commonly applied docking practice in NCS that identified through investigations. The last section after describing the studied cases, analysis the challenging practices on the presented projects.

3.1 Mobile Offshore Units

In this report the definition of Mobile Offshore Units is limited to Mobile Offshore Drilling Unit (MODU) and Mobile Production Units (MPU). Study of other types of units such as accommodation- and well intervention units are excluded from the scope. Nevertheless, it should be noticed that there is a significant difference between drilling and production rigs from the concept and design to the nature of their operation. The other main differences are the followed regulatory regime, type of ownership and management. Most of the 18 active MPUs at NCS are non-class vessels and entirely owned and managed by the operating oil companies (except Petrojarl Varg which is chartered). Contrary to that, the drilling rigs are flagged and adhere to class regulations. Further, they are owned and operated by rig owners / rig management companies and leased in on time-charter by the operating oil companies. The diversity and number of Mobile Offshore Units (MOUs) active on Norwegian Shelf is presented on Fig.2. This figure presents the number of drilling and production units categorized on their design type. We can see around 70% of the active units are drilling rigs, of

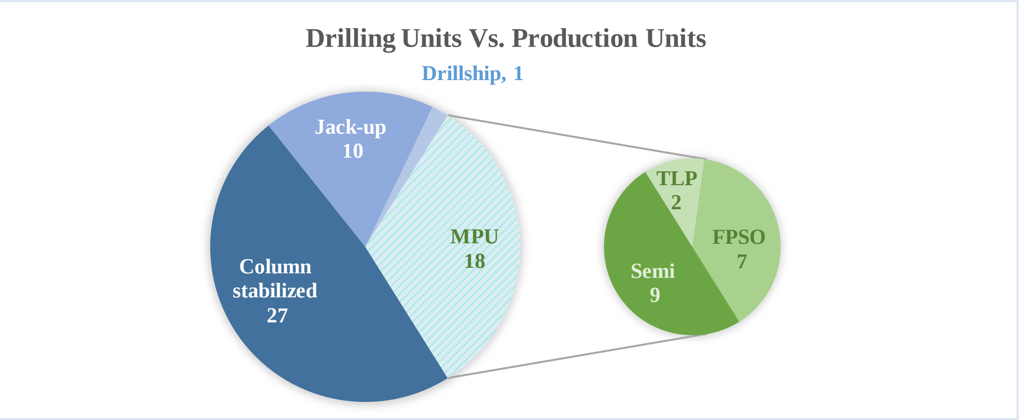

Figure 2: Fleet overview in Norwegian Continental Shelf
Source: Drawn by author from DNV database

which Semi-submersible drilling units take 70% of this share. Deep water drilling and demand for exploration on harsh environment can explain high share of semi-subs on drilling segment at NCS. Explanation about these design types are given on following chapter.

3.1.1 Type

According to DNV-OSS-101 the mobile offshore units based on their design categorized into four main groups which providing services in four different service notations.

Table 1: Class notation related to basic design ***(DNV, October 2012)***

<table>
<tr><th colspan="2">Class notations related to basic design</th><th>Services notations</th></tr>
<tr><td>Column stabilized</td><td>A structure dependent on the buoyancy of widely spaced columns for floatation and stability in all modes of operation.</td><td rowspan="4">• Production
• Drilling
• Accommodation
• Special services</td></tr>
<tr><td>Self-elevating
(Jack up)</td><td>A structure with a hull of sufficient buoyancy for safe transport which is raised above the sea surface on legs supported by the sea bed during operation.</td></tr>
<tr><td>Ship-shaped</td><td>Monohull ship and barge structures having displacement hulls with or without propulsion machinery.</td></tr>
<tr><td>Mobile Offshore</td><td>A structure not properly characterized by the above notations.</td></tr>
</table>

Self-elevating:

Self-elevating units (commonly named jack up) consist of a box-shape deck structure supporting the topside facilities e.g. drilling, production and/or accommodation. Relying on three or four vertical legs and by means of hydraulic jacking system the platform can be self-elevated out of water to a safe height clear from the waves. At the time of transit the legs are lifted up and extend upwards over the platform and the platform towed to a new location. The unit operate in the elevated condition when the platform standing on the sea bed. Normally jack-ups are used for drilling operations in shallow waters with depths up to 120 m (J.M.J. Journée, 2001).

Semi-submersible:

The semi-submersible (semi) consists of a deck supported by submerged pontoons connected by several large columns. By adjusting the amount of ballast in the pontoons, the unit can be raised or lowered. The lower the pontoons lie beneath the surface, the less they are affected by wave and current action. Semi-submersibles have small water-plane area. This implies that a semi-submersible has small vertical motions compared to a ship shaped for typical ocean wave frequencies. Thus, semisubmersibles suitable in harsh environments and most deep-water, harsh environment rigs are semisubmersibles (Kaiser & Snyder, 2013). However, semi-submersible is sensitive to deck weight changes so it has low flexibility with respect to deck load and oil storage (VERITAS, 2010).

Drillship

Drillships have conventional ship-shaped, mono-hall, structure. Drillships have sophisticated propulsion systems including bow and stern thrusters, when a drillship mobilized to the drilling location maintained by means of dynamic positioning system or alternatively it might be moored by anchors. However, mooring of drillships is done only in benign waters, not at NCS. The rig derrick is usually mounted in the middle of the vessel and drilling is conducted through a large aperture known as a ‘‘moon pool “. Drillships are the most advanced and expensive sector of the rig market and many water depth records are held by drillship. New drillships are capable of drilling in 12,000 ft. of water with wells up to 40,000 ft. deep.(J.M.J. Journée, 2001)

Floating production storage & offloading (FPSO)

The basic design of most FPSOs encompasses a ship-shaped vessel, with processing equipment on deck areas and large hydrocarbon storage below deck in the double hull tanks. FPSOs designed to receive the oil produced by nearby platforms or subsea facilities, process the oil and store it until it can be offloaded onto a shuttle tanker or pipeline (J.M.J. Journée, 2001). For more benign waters FPSOs can be converted tankers by reinforcing the structure and adding production modules on board, these equipment normally consist of water separation, gas treatment, oil processing, water injection and gas compression systems. FPSO has a large power generation system and a special mooring system. A turret mooring system allows the vessel to rotate freely in response to weather conditions, while the spread-mooring systems anchor the vessel from various locations on the seafloor. Already there are just seven FPSOs active at NCS.

3.1.2 Age

The existing drilling fleet on the Norwegian continental shelf consists of many old rigs and some of these units are expected removed permanently from operations in the coming years. Figure 3 indicates that around 46% of active drilling units in NCS are above 21 years old and mainly Semi-submersible units. Further in this chapter it will be clarified why this specific group of old units, marked within the red box in Figure 3, have more relevance to this research and why the case studies have been selected from rigs within this category.

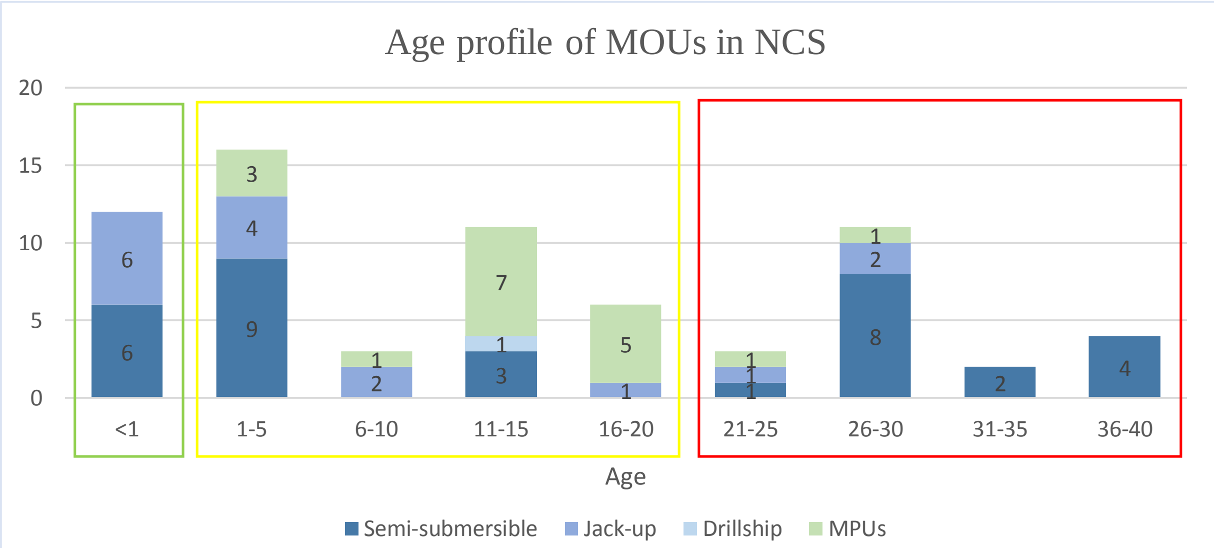

Figure 3: Age profile of Mobile Offshore Units in NCS
Source: Drawn by author from DNV database

Chapter 3.4.1 argues why the study of docking drilling units is more attractive than production units. So the categorization and the age profile of production units (MPUs) will not be discussed further in this chapter. In explanation of Fig.3 it shows the Norwegian drilling market composed of totally fresh or old rigs. The column under the green box shows the type of new built rigs under construction which are expected to come to Norway between 2014 and 2016. The old rigs under the red box composed 46% of drilling units in Norway. As discussed later in this chapter rigs under this category are more vulnerable to delays and overruns in docking projects thus more interesting to this paper.

The scope of docking projects for drilling units to large extent depends on rig type, age, size, status and system and equipment. The age of the unit has a large contribution to the scope of work in classification and modification projects. The old rigs may have a less efficient design regards inspections and maintenance compare to the new ones. Also older units may have lower redundancy than new rig which again decrease the chance for offshore maintenance and inspection. From an age perspective the scope of work may vary over the life of the rig, as demonstrated in *Bathtub Curve concept* in Figure 4.

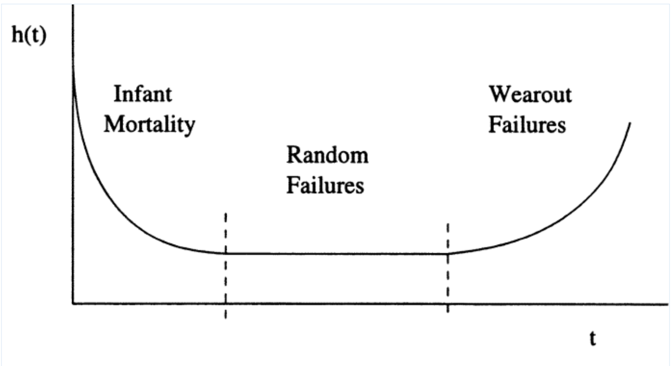

Figure 4: Reliability bathtub curve
Source: (Klutke, Kiessler, & Wortman, 2003)

This graph represents the failure rate over time (Y axes) through lifetime of the unit (X axes). The failure level represents the need for rectification of defects which also could be assumed scope of repair or corrective maintenance overtime (Klutke et al., 2003).

Assuming the technical status of a rig during the time on the Bathtub Curve within five year class renewal intervals; the first renewal survey of the rig may conceivably described on the "*infant mortality* "phase. This means that the inherited defects from shipyard like bad design, wrong material, bad workmanship and etc. identified through the first operation interval are to be rectified. So often a large extent of Non-Destructive Testing (NDT) will be used on structure to identify uncertainties with tensions, welds and so on. It might be thought that machinery and equipment are relatively new so there will not be much concern with them. But experience shows that fast development in drilling technology by application of prototype equipment may result in challenges with respect to integration with the rest of the systems. This issue with operational downtime has been of such concern that DNV has established a full department in Integrated Software Dependent Systems (ISDS) to make sure integration of equipment to the software and automation and other systems done correctly.

In the second renewal survey, the rig is on "Random Failure" phase. The unit is 10 years old now and there is less focused on the structure since it settled earlier. The machinery and equipment has been in continuous operation and needs some attention for condition testing. Depends on amount of implemented preventive maintenance the technical condition of unit in third renewal survey may linger on the constant level by "Random Failures" and then gradually influenced by aging effect. On later renewal surveys, as the rig gets older it demands more attention to the structure and machinery since the technical condition of unit degraded , the probability of corrosion , erosion and fatigue on the structure will be increased also wear and tear on machinery and equipment grow. This represents the condition on "wear-out failures" phase.

By comparing Figure 3 and Figure 4 we may conclude that rigs under the red box in Figure.3 actually are on "wear-out failures" phase on Figure 4. This means it's expected these rigs be subjected to major modifications, upgrades and repairs. While most of drilling rig under the yellow box are in "infant mortality" phase and the rest of the units in this group probably subjected to major maintenance docking project.

So clearly the scope of repair and maintenance developed as the rig gets older. Also there are some other contributing factors which may increase the likelihood of docking and its scope for older units. For instance it is likely that old rigs get less chance for offshore inspection and maintenance compared to younger units. This probably resulted from less redundant and maintenance friendly design also less reliability of old equipment to take the load of operations in parallel with maintenance on the rest of the system. These factors could weaken the general condition of the rig and increase the scope of the yard stay project. Further frequent changes in regulation regime for instance requirements for increasing the automation level on the drilling floor also retrofits on machinery and drilling equipment indicate needs for more upgrade and modification on older rigs.

In addition to the above mentioned factors, another interesting fact about probability of contribution of age factor to docking project was discovered through interviews. The older rig naturally gets lower day rate on operation compared to younger rigs with higher flexibility and capabilities. So in order to get more attractive in the market older rigs trying to register a higher efficiency rate in drilling operations. This efficiency resulted by continuous operation which often associated with cutting the planned maintenance and push it back to the shipyard visit. Comparing the efficiency rate and age profile of units in Norway we can see that often the high efficiency records surprisingly connected to older units which actually need more attention on planned maintenance system.

Drilling companies may plan the classification activities in parallel with modification at yard stay in order to increase the utilization of time. This means a docking project for older drilling rigs not only is more extensive but also involve more risks and uncertainties which made them interesting to this topic.

3.1.3 Equipment

One of distinctive characteristic of docking offshore units from ships is the diversity and complexity of onboard systems. The equipment and the systems onboard a drilling unit are complex. In addition, the integration of systems adds significant complexity as several different types of software that have to work together. This sophistication sometimes underestimated within docking projects. Considering the complexity of maintenance and modification expertise from different disciplines is required for docking project Appendix 2 shows an example of the complexity in the scope of a docking project.

The other difference between ship and offshore unit is that the offshore units require higher safety margin compare to ships. This means unlike the ships, the identified pinpoints and Condition of Class on the unit have very limited due date and almost should be dealt with immediately. An example of such is the structure; in general, offshore units have lower corrosion margin than ships e.g. on special areas only 5% diminution is acceptable while in general ships have 20% corrosion margin. This means often identified corrosions demand imitate repair and replacement action.

Dependency of equipment in a system or between systems has high importance also understood as challenging issue in docking projects. Such a relation is recognizable on critical path items. The critical items which might be also long lead items, often take at early stages in the project in order to reduce the risk of delay due to unforeseen events. The critical path items not only may take more effort to obtain class approval but also may upset the schedule for other dependent job activities and force the rig to wait for them to get finalized. In many cases these equipment have to be sent to vendors or Original Equipment Manufacturer (OEM) for inspections and maintenances, which is quite time consuming.

The critical items vary from project to project. Some of typical critical items (e.g. Blowout preventer (BOP), cranes, top drive, main engines, thrusters and etc.) are characterized with difficult accessibility for offshore inspection and maintenance; in addition they may have high complexity, low redundancy and high uncertainty. These suppliers often are subcontracted to oversee the equipment on schedule basis during operation also in yard stays.

During investigation it was understood that SFI coding structure (LTD, 2013) is the most common system for addressing MOUs' components and equipment and utilized by large in the industry by different stakeholders. Using a single coding system develop a working language and possibly facilitate their contribution in setting up specifications, estimation , document handling, maintenance and repair also establish the survey manuals. So initially in this research a general map of rig's components and systems according to SFI which is recognizable for different stockholders was prepared (see Appendix.3). This map was prepared to be presented to the interviewees in order to conduct risk assessment on each individual system and equipment in more systematic approach by scaling risks on each item. However, due to huge scope of details just few interviews were held with this method. In chapter 3.5.2 the most challenging items on the studied projects presented accordingly. Following this approach in risk assessment of all systems could be beneficial in providing a list of risk indicators in docking project. Providing such practical risk assessment tool could be a great assistance in systemizing maintenance and modification projects. In this paper just a few examples are reviewed as case studies, since this method is comprehensive and needs many interviews. Such work is therefore out of limitations for this thesis. However following this approach recommend to followers in larger researches like PhD dissertation.

3.2 Risk management

Risk management is a large field of study, and only the themes relevant for this thesis will be presented.

All projects stands on three main pillars: Scope, Time and Cost. The ultimate objective of project delivery is the overall project Quality which also requires balancing these three pillars. The relationship among these factors is such if any one of the three factor changes, at least one other factor is likely to be affected (*A Guide to the project management body of knowledge: (PMBOK guide)*, 2004). The graph below shows this mechanism.

Figure 5: Project constraints
Source: ("Project Management Triangle," 2013)

Project risk concerns the circumstances that could impact the project and have positive or negative consequences with regards to the scope, quality, time, cost and benefits. Risks that could provide for positive consequences (opportunities) or could have negative consequences (threat) for the project. The objective of project risk management is to increase the opportunity and decrease the threat by changing of the probability and impact.

Rausand defines the risk management a continues process of identifying, analyzing and assessing the potential hazard to a system, related activities, people, environment or other assets (Rausand, 2011). Project risk management consists of five main steps: Planning, Risk identification, Risk analysis, Risk response and Monitor and control risks. The risk analysis could be qualitative or quantitative. The qualitative risk analysis more often comes first. Performing a qualitative risk analysis is a quicker and cost effective way for preparing a list of priorities for response planning also build the foundation for quantitative analysis (*A guide to the project management body of knowledge: (PMBOK guide)*, 2008). Besides, in early phases of the project the scope is often immature. Therefore, performing complex quantitative risk analysis would not be efficient (Husby, 1999) . In this paper a qualitative risk analysis applied during investigations on case studies, further in Chapter 4.2 also a qualitative approach recommended for risk analysis and risk assessments in workshops.

3.3 Stakeholders

3.3.1 Rig Owner

The Figure 6 shows the position of main stakeholders with respect to docking projects. The details like consulting companies, third party project management and rig management companies summarized under "Rig Owner" since these players normally are under direct supervision or control of rig owners. The rig owner has the key position in connecting the other stakeholders in docking value chain. In docking project often rig owner technical organization including fleet manager, superintendent and his engineering team, if available, administrate the docking projects. It may also have consultants and engineering companies involved in the management of the project but normally rig owner has the overall responsibility of the project. The other team within rig owner's organization in the docking project is the crew onboard the rig. This includes the rig manager, marine crew and sometimes the drilling crew as well. During the yard-stay the rig crew take the tasks with higher sensitivity and work on critical items like overhaul of machinery and equipment since often they are more familiar also more competent than yard workers.

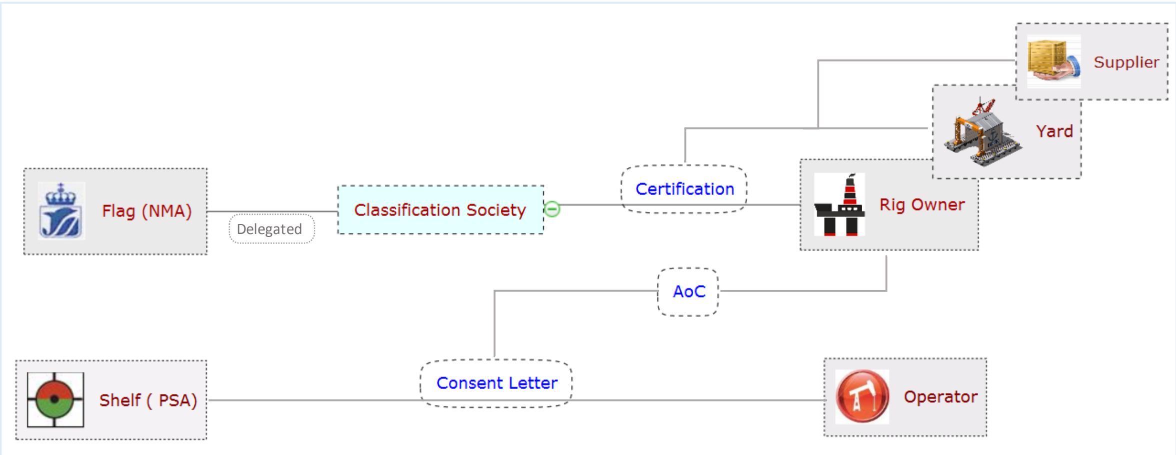

Figure 6: Major stakeholders' relation

It's understood that rig owner companies in Norway have rather small technical support organization onshore. The small technical team is often overburdened with high workloads related to the operation of the unit. So technically, they may not have enough capacity to deal with preparation and planning of docking projects. This issue particularly is more significant for small players with smaller fleet. Thus rig owners rely on consulting and engineering companies in order to supply the technical resources required in the projects. But how far these consulting companies are able to support the required expertise and interest to the project also how much they are familiar with subjected rig is questionable. Also it might be difficult for rig owner to get more interest from these stakeholders by transferring part of the project risks to them.

The research carried out by “Rig committee” on 2012 (Eivind Reiten 2012) indicate a significant learning curve associated with the Norwegian shelf requirements for rigs. Means, the next rig being built/upgraded by the same rig companies and suppliers for operation on NCS, typically will be less expensive and could be delivered in shorter time. In practice, this gives a competitive advantage to established rig owner which weakens the competition on the supply side and pushing up the day rates (Eivind Reiten 2012). In the recent years Norwegian shelf has been witness of upgrading many old rigs also entrance of new rigs.

3.3.2 Charterer (Operator)

According to HSE framework the operator is defined as “*Anyone executing on behalf of the licensee the day to day management of the petroleum activities*.” ("HSE Framework Regulations," Feb 2010) . The operator has the overall responsibility in petroleum activities within their license. The operator shall ensure that anyone participating in the activities complies with HSE legislation. ("HSE Framework Regulations" Feb 2010).

As it illustrated in Figure 6, in connection with obtaining the Consent Letter for any petroleum activity the operator should submit an AoC of the unit contracted for those particular activities. So the AoC related docking project directly connected to charterer business plans that explain their interest in these projects.

Operators’ interest on docking is especially high when they request installation of certain third party equipment on board. This interest in monitoring docking project often related to their contract with rig owners. Normally the operator specifies certain requirement for MODU in the time-charter contract with rig owner. So during modification projects the operator will pay special attention to ensure that agreed configurations are fulfilled. It is common that they make lump sum payment for the docking period at the end of the contract or support part of the rig owners upgrade project with a fixed payment.

Operation of rig is very costly for operator and in case of downtime the operator will normally experience substantial additional costs. This costs may be allocated to activities around the rig, e.g. cost of operation of Platform Supply Vessels, helicopter , specialist, drilling material like drilling mud , cement, water and etc. Due to such high cost of operation operator put pressure on rig owner for continuous operation which may result on pushing the rig’s maintenance plan back to the shipyard visit.

3.3.3 Authorities

3.3.3.1 Regulatory organization in NCS

The petroleum sector in Norway is governed as shown in the Figure below. The government has the overall responsibility and has executed this through the ministries of Petroleum and Energy, Environment and Labor.

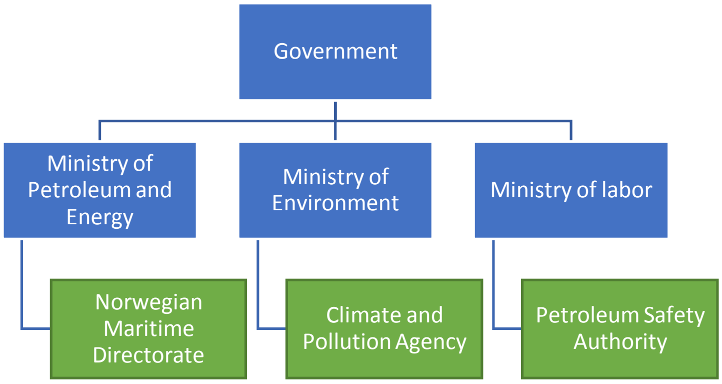

Figure 7: Governmental organization of petroleum activities (Eivind Reiten 2012)

The Ministry of Petroleum and Energy has the overall responsibility for the resource management on the Norwegian Continental Shelf (NCS). The Norwegian Petroleum Directorate (NPD) is subordinate to the Ministry of Petroleum and Energy and is the administrative authority for resource management on the NCS. The Ministry of Labor has the overall responsibility for safety, working environment and emergency preparedness on the NCS. Subordinate to the Ministry of Labor, The Petroleum Safety Authority (PSA) is the regulatory authority for offshore technical and operational safety, including emergency preparedness and working environment. Consequently, the responsibilities for offshore safety and petroleum resource management are organized within separate ministries.

3.3.3.2 The Role of PSA

In addition to regulatory function on HSE in petroleum activities and coordination between regulatory bodies, the PSA has supervisory activity on drilling. This supervisory function with respect to suitability of MODU comes to force in form of Acknowledge of Compliance which also is relevant to this study. Securing an AoC is essential if a MODU is about to operate in the petroleum activity on the Norwegian continental shelf. An AoC encompasses technical conditions, relevant parts of the applicant's management system, analyses performed, maintenance program and upgrading plans. The statement will be given based on the authority's follow-up of the applicant and the information that the applicant has provided about the installation and the organizational set-up ("Guidelines for application for Acknowledgment of Compliance (AoC)" May 2011).

Norway has a somewhat different approach than other countries, since the suitability of the

MODU to operate on the NCS is evaluated in a separate process through the Acknowledgement of Compliance. The AoC also is required in an Application for Consent. The supervisory role of PSA in connection with AoC and Consent Letter presented in Figure 6.

The AoC seems to be the most extensive evaluation of a MODU as it includes a detailed gap-analysis between regulations and the MODU technical condition, organization and relevant parts of the management systems. (Eivind Reiten 2012)

3.3.3.3 Norwegian Maritime Authority (NMA)

The Norwegian Maritime Authority is the administrative and authoritative body for issues related to safety on Norwegian- registered vessels also foreign vessels in Norwegian ports. A mobile facility registered in a national ship register, or flagged, consequently shall follow a maritime concept of operation including classification, which are regulated by the NMA. (Anita Moen, 2008). NMA assists the Norwegian Petroleum Safety Authority in the supervision of mobile offshore units on the Norwegian continental shelf. However, NMA does not have any direct involvement in the AoC application. NMA may issue a LOC (letter of compliance) to a foreign-registered vessel which is not subject to supervision by the Petroleum Safety Authority in connection with the AoC. With respect to MODUs on NCS NMA has delegated a substantial part of their authority to some few Classification Societies ; i.e. DNV GL, Lloyds and ABS ("Mobile offshore units,").

3.3.3.4 Classification societies

The classification societies' main objective is safeguarding life, properties and enviroments in offshore operation. Their main activities are carried out through certification and classification services. The classification societies received the authority from NMA and have the responsibility to carry out related design approval, inspections, initial surveys, annual surveys, Special Periodic Survey (5years) also to approve the compliance with MARPOL regulations on behalf of NMA. (*General*

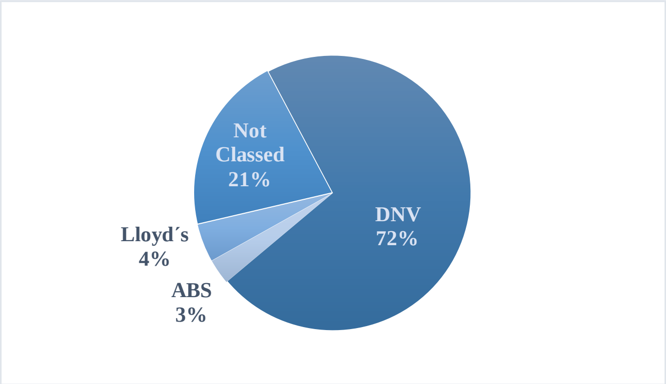

Figure 8: Class distribution in NCS
Source: Drawn by author from DNV database

authorisation from the Norwegian Maritime Authority to Classification Society for Mobile Offshore Units, 2012). The Fig.8 demonstrate DNV with 72% share is the dominant classification societies in NCS.

3.3.3.5 Class surveys

Before the surveys to be commenced the rig owner needs to submit a plan to the class covers the scope of survey including the technical status of the unit, history logs, outstanding issues, corrosion assessment, previous inspections and means of access. Also the preparatory activities related to the survey scope should be done before surveyors come onboard, for example tasks related to the means of access for undertaking surveys like staging, cleaning, ventilation, gas freeing , lighting , flushing pipeline and etc. Figure. 9 shows the class survey schedule for offshore units. The annual surveys are relatively small in scope and often carried out offshore during operation of the unit. The survey normally is just visual unless due to specific circumstances surveyor demands structure, equipment, machinery and safety systems to be covered.

The intermediate survey shall coincide with second or third annual survey, and normally the scope of work is twice as comprehensive as for annual surveys. Compared to annual surveys, the intermediate surveys partially have challenges in planning also hull survey. The hull survey is often more extensive as the rig needs to be de-ballasted in order to access to the submerged parts of the hull. Is should be noted the scope may vary from survey to survey and to large extend depends on size, age, type and condition of the unit.

The renewal survey is the most comprehensive among periodical survey arrangements. The survey is normally done in shallow waters at a shipyard and covers all systems that are applicable for classification. Special Periodic Survey (SPS) has more extensive scope compare to annual and intermediate surveys. This puts higher demands on planning of the project. SPS has a considerable share of the project scope and might be a driver to the need for shipyard visits, even if the SPS is not the main scope of docking project. Because offshore rectification of pinpoints and condition of class identified in previous surveys or by the recent survey is disproportional in term of costs, time,

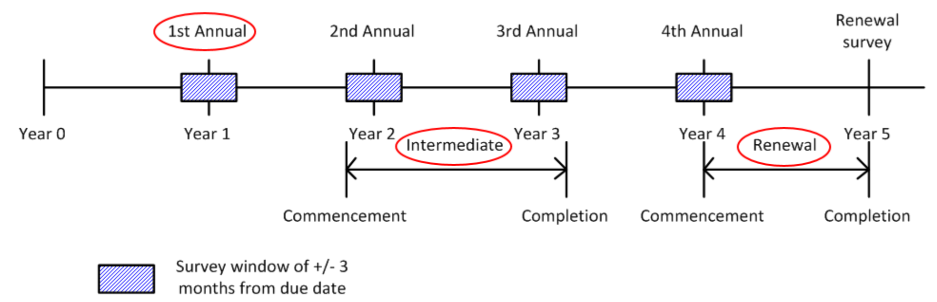

Figure 9: Class survey schedule
Adapted from: DNV presentation (Håland, 2013)

accessibility and benefit, compared to classification at shipyard. So it's very likely that a drilling unit which carries an accumulated load of repairs and maintenance jobs resulted from continuous operation carry out the intermediate and renewal surveys at shipyard. Mainly due to the risks of ever increasing scope owing to SPS, surprises during the inspections, commercial obligations, availability of required resources and etc.

Considering the large downtime cost of rig it is favorable for rig owner to arrange the intermediate or renewal surveys together with modification and upgrade plans at shipyard. Especially if a rig receives rate for modification work, then it will not lose potential income for classification activities carried out simultaneously with modification, which would otherwise be carried out when the rig is off rate. Such arrangement, however, demand special attention with respect to project planning and control; mainly due to huge scope, complexity and dependencies of job activities. Examples of this challenge will be further discussed within case studies in Chapter 3.5.

It's important to notice that however the class scope is rather large on docking project but do not cover all activities on yard stay. Figure 10 illustrates the fact that the actual class approval only requires satisfying the minimum requirements. The Rig Owner and the Operator (through the contract with the Rig Owner) may impose requirements exceeding the minimum requirements of the class. In normal condition, class scope could be closed on up to 2 or 3 weeks. Though the time for docking depends on the extent of preparation and planning could be lower of extremely higher.

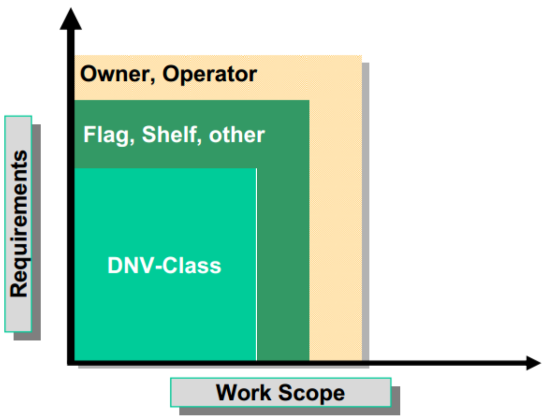

Figure 10: Covered regulatory requirements by Operator, Shelf and Class
Source: DNV presentation (Håland, 2013)

Notwithstanding that the renewal survey can start 15 months before the due date (See Fig.9), it is frequently observed that some rig owners are not prepared and struggle to close planning of the related activities. Good planning and also an accurate estimate on the scope of work for renewal survey are the main success factors in such cases. As part of planning a clear understanding of rig condition is necessary to minimize the unforeseen events that may prolong at yard-stay. Also classification of critical path items traditionally has high contribution on delays. Equipment on critical path often has high complexity, difficult to access and normally sent to vendors for overhaul which is time-consuming too. Examples of such equipment are Blowout Preventer (BOP), cranes, thrusters and etc. Instances of these challenges discussed in more detail in Chapter 3.5.2.

In spite of high operational costs drilling rigs are very profitable so preferably class surveys are carried out offshore to avoid downtime as far as possible. Today technically eligible units can obtain the class renewal certificate on site by means of alternative survey arrangements. By using continues survey schemes like In-service Inspection Program (IIP) for hull, drilling and equipment, Planned Maintenance Systems (PMS) for structure and PMS RCM (Reliability Center Maintenance) for machinery, thrusters Condition Monitoring (CM), and Underwater Inspection in-Lieu of Dry-docking (UWILD) or In Water Survey (IWS) techniques for sea valves, sea chest and bottom surveys. But offshore classification sometimes involves with challenges in accessibility, redundancy, accommodation, weather and preparedness. Classification of systems that are in service not always possible; for example when the rig is on drilling operation, performing classification on the drilling floor even though the subjected equipment is not in service is not possible since it located on “red zone”.

Also the degree of redundancy and flexibility of systems directly constrains offshore class renewal related activities. This means ability to shut down a line and still be on a safe condition; in order to do close inspection or refurbishments on the system limited to the design of the unit also the governing regulations. It should be noticed that MOUs have limited Personnel On-Board (POB) capacity and often few spare beds are available for the personnel who carry out the classification activities. Many classification activities require good weather condition, in particular heavy equipment above the deck, such as riser tensioners, drilling string compensators, crown block and etc. which overhauling these type of equipment involves high lifts and demand calm weather. Preparatory activities are also important and could hinder the survey, rig often concentrated on operation and do not assign time for such tasks. In addition accessibility may also restrict the preparedness, for example cleaning of drilling equipment in many cases not performed during operation, also areas with difficult access like crane pedestal often neglected.

So by considering the situation owner may decide to do the classification ashore, due to better accessibility to rig structure and its equipment, better weather condition , personnel accommodation, access to resources and easier involvements of class and authorities in surveys.

3.3.3.6 Regulative Mechanism in NCS

Figure 11 illustrates the hierarchy of acts, regulations, guidelines, and industry norms and standards governing offshore activities on the NCS. The upper two layers set mandatory requirements. The requirements in the regulations are prevailing under the provision of the acts in level one. Hence, the requirements for HSE are stipulated in the second level of the pyramid through the Framework Regulations, Management Regulations, Activities Regulations and the Facilities Regulations. Regulation in Norway recommends specific industry guidelines, norms and standards.
These are not directly required in the regulations but recommended in the guidelines for each requirement. The recommended industry guideline, norms or standards are considered to define the required safety level. Thus, participants in the offshore activities are in principle free to use other recognized standards, but have to be able through a responsible party, document that the chosen solution fulfills the regulatory requirements. (HSE Framework Sec24, Feb 2010).

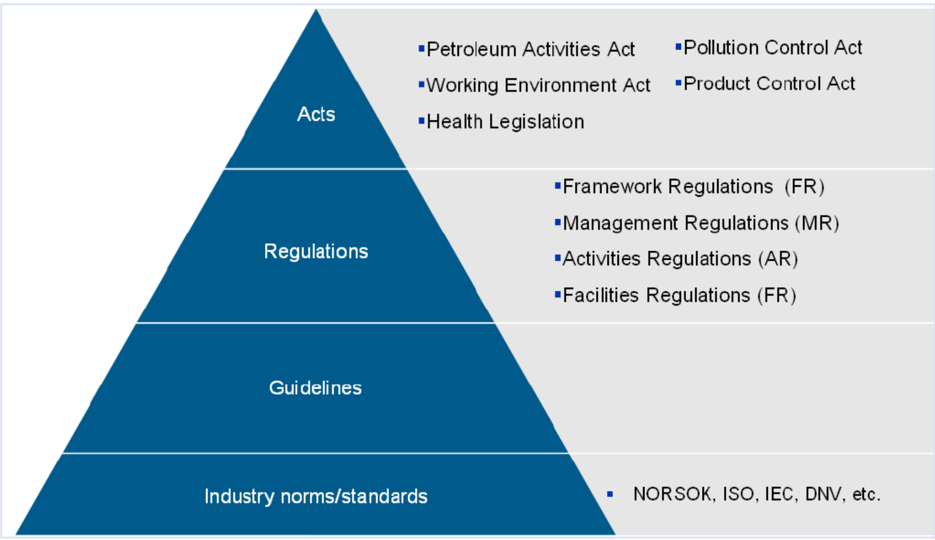

Figure 11: The Legislation Hierarchy in Norway
Adapted from: (Eivind Reiten 2012)

3.3.3.7 Regulative challenges in NCS

During interviews and by studying industry reports the ambiguity in shelf regulations was pronounced as a contributing factor in delayed and cost overrun projects. The difficulties in interpreting the requirements may cause rig owners to specify higher level or more flexible solutions of what actually required to get approval. Clearly this issue will result in an unnecessary complexity and cost increase in docking projects.

The research done in 2012 by an expert group committee organized on behalf of the Ministry of Oil and Energy (Eivind Reiten 2012), by interviewing rig owners' representatives and other industry suppliers concluded that the current regulatory requirements in NCS are not transparent. Also the research pointed out that the requirements in NCS may frequently change over time and may also vary from person to person in the PSA. The research indicate that this situation possibly put rig owners in challenging situation to clarify the lines of responsibility on their contracts with yards and subcontractors. In other words it would be more difficult to transfer part of the project risks to the involved stakeholders. This probably is more problematic, these days, during periods of pressure on market supply capacity (Eivind Reiten 2012).

The challenges associated with the AoC are more critical for upgrade and modification of the units entered from other market sectors compared to units already operating on NCS (Eivind Reiten 2012). Drilling companies with previous experiences of activity on the NCS are in a better position to outline the scope of work that the yard needs to carry out. Owning to proficiency in understanding the implication of enforced regulatory requirements at NCS that require years of experiences.

The regulative challenges, will not be further discussed in this thesis. However this topic is out of the scope of this research but also recommended for further studies.

3.3.4 Shipyards

This research mainly concern about the docking project on active drilling units on Norwegian shelf which is normally carried out at Norwegian shipyards. It should be noted that such shipyards are specialized for repair and modification work and should be distinguished from new-building shipyards. In Norway the shipyards offering services to the offshore industry are mainly located on the West Coast areas where they are close to the oil fields and the offshore units. The three large Norwegian shipyards for such services includes Westcon Yard, Hanøytangen yard and Coast Center Base (CCB). These are the yards identified by this research as main hosts for major docking projects. However there are some smaller yards which have contribution or partially have been the destination for MOUs shipyard visits; examples are Keppel in Sandnes and Tromsø yard. Hanøytangen, being part of Bergen Group, has the only dry dock large enough to accommodate a semisubmersible drilling unit. However the old dry-dock built in 90s is not able to take rigs anymore and used with open gate as a normal wet dock.

The contribution of yards in docking projects may vary from project to project. It depends on the capacity of shipyard and offered services. While small shipyards merely offer simple manpower in welding, piping, cleaning, and facilities like cranes, surface treatment, scaffolding and etc. the larger yards take bigger role on project management and advance engineering services too. It's very important for superintendents to choose the yard with compatible facilities to the scope of work, including the number and capacity of cranes, cherry pickers, welding machines and etc. Normally, before yard selection superintendents make evaluation on yard capacity and availability on the planned docking. In general the shorter yard stay of 15 to 20 days are often undertaken by smaller shipyards where the project need general manpower. While the larger projects take on specialized shipyards which could have worthwhile contribution on execution of complex tasks. However, the reputation of the yard also familiarization of yard personnel on rig from previous docking are other common factors in yard selection.

If the rig is managed by a rig management company outside the organization of the rig owner it is still likely that the management of docking project given to the rig manager company because of their knowledge and understanding on the technical condition of the unit. Sometimes the yard may take the management of the project but in both cases often major tasks in project sub-contracted to supplier and engineering companies. The role of sub-contractor in docking project is further discussed on following chapter.

3.3.4.1 Subcontracting

This section explain the normal sub-contracting process in docking project which presented in Figure 12. Subcontracting is quite common and often done for big ticket items in docking projects For these jobs the subcontractors is in charge of making detailed specification, class approval, fabrication and sometimes installation . However, the project manager monitors the subcontractors in the process of their participation in project. In normal process the subcontractor, which often are the "grand suppliers", send the prepared detailed specification and drawings to the class for approval. The class review on specification often starts after three weeks or even more. After reviewing the documents the class may ask for more technical details on submitted specification. Finally, after calculating involved factors on the design the class would approve or give comments on drawings for correction. The

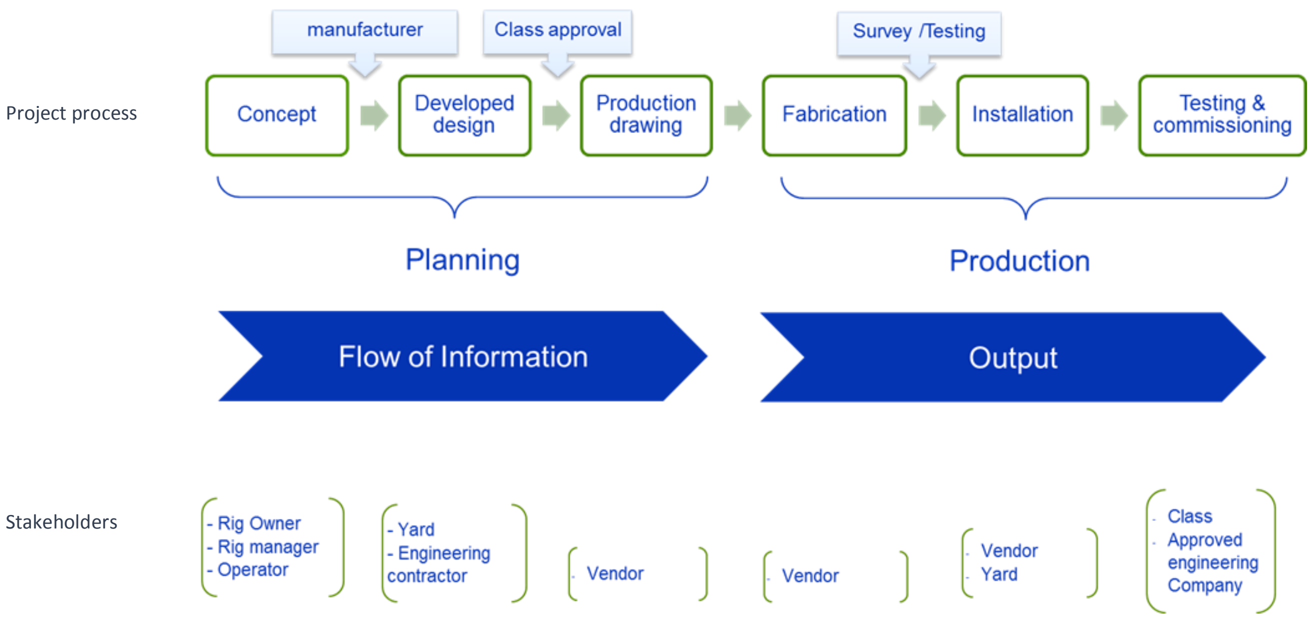

Figure 12: Sub-contracting process

outstanding items which got class comment are to be closed by subcontractor with further adjustment in design, material or etc. Provide drawings with high quality on “Developed Design” phase, have high importance with respect to time management. The approval process is time consuming and needs to start in good time before project startup, since incomplete design will need further communication and recalculations on the design that take time. After class approval subcontractor send the drawings to the construction site for fabrication and the components are transported to the shipyard for installation. Depending on the contract the installation is done by subcontractor, yard project team or third-party engineering company. The fabrication and installation process is monitored by class to check the execution of job according to the approved drawings also application of good quality and workmanship. The installed product tested for possible defects in operation and finally successful test will end up with a certification.

It should be noticed that 3rd party supplier play a significant role in major docking project. Several suppliers may be involved in coordination, monitoring and quality assurance of delivered equipment of high importance. According to the results of a master thesis study on drilling rig maintenance , the main contributor to the downtime of drilling rig has been poor design and quality of the delivered equipment caused by 3rd party suppliers (Rognerud, 2011). As we will see later in Chapter 3.5 in some case studies the poor quality and late delivery of ordered equipment has been drivers to substantial delay and cost overrun in the project.

3.4 Yard stay

3.4.1 Docking

Earlier in this thesis, by discussion of age and quantity of MODU and MPU, it was concluded MODUs are more attractive to investigate with respect to the topic for the thesis. In this chapter it is discussed why from operation point of view docking drilling unit is more significant than production units. As clarified earlier in this paper we define "docking" as major project including upgrades, modifications, maintenances and repair activities carried out on MOUs which associated with off hire of the unit. This operation might be done offshore, alongside at shipyard or on dry-dock. The reason for such categorization is that due to the shape and operation of units docking constrained to specific condition. For example FPSO and FSO are more stationary and preferably do the docking on the operation site, semi-submersibles and jack-ups, due to their shape and size, are often docked alongside while the ship shaped units can easily get accommodate in dry-docks if necessary.

Figure 8 indicates that 21% of MOUs in NCS in Norwegian water are not classed. These units are all production units and do not follow the MODU Code.

3.4.1.1 Regulatory requirement

The requirement for dry-docking MOUs have been a challenging topic between shelf authorities, Classification Societies, IMO and rig owners with regards to reach to an agreement upon safety satisfactory levels. For example according to IACS , 1989 MODU Code and the 2001MODU Code the administration will accept an underwater inspection in lieu of dry-docking when conditions provide an equivalent ((IACS); International Maritime, 1990, 2001), 2010 #41). However, recently some shelf authorities (i.e. Singapore) demands for dry-docking inspections which eventually has turned to a hot discussion in the industry. Since the Norwegian shelf administration accepted the alternative solutions in lieu of dry-docking this matter will not be discussed any further in this research.

3.4.1.2 Mobile Production Units (MPUs)

However as mentioned in the previous chapter from the regulatory requirement point of view there is not a constraint for (dry) docking MOUs. But we observe that some units approach the shipyards periodically doing a series of repairs, modifications and upgrades. The insight received from industry experts indicate that drilling unit, with an average of two times in 5 years, more often visit shipyards, while FPSO very seldom seen on shipyards. The reason for this might be hidden on the associated higher downtime costs also the cost and time of connecting and disconnecting the mooring lines and risers from the reservoir (depends on mooring pattern or turret design). Besides the fact that disconnecting the production units from the reservoirs with heavy oil properties imposes the risk of clogged tubular and thus imposed large cost of well recovery or even losing the reservoir. The production units, unlike the drilling units, are mainly stationary on the operation field. The required maintenance and upgrades will then be performed offshore. The other reason for the infrequent shipyard visit could be the lifetime of their operation since the production units normally have long term contracts, normally trough the lifetime of the reservoir, with very limited off-hire allowance. Commonly the typical scope of planned shipyard visit for FPSO might be regular modification on capacity of the compressor and separation systems due to changes in reservoir condition or renovation for new missions on new reservoir. For FPSOs such decision for implementing the docking activities offshore or ashore affected by cost-benefit of available choices also accessibility to the required resources.

Furthermore the MPUs in NCS normally owned and operated by the oil companies which inherently have strong project management and risk management culture. So, in case of major modification and upgrade project probably the project would receive adequate technical expertise. This means there is probably lower value for contribution of this research on docking MPUs.

In addition to the above mentioned factor, by considering the nature of production units' operation and the number and age of active production units in Norwegian shelf, we may presume to do not follow the MPUs any further in this research.

3.4.2 Docking process

This chapter describes the main steps of the normal docking process identified and prepared by this research (See Figure 13).

Strategic Decision; before concluding to head for docking the rig, the managers discuss why they should go for it and if such investment is economically viable or not. Before planning and specifying repairs and upgrades and further investment, the rig owner shall carefully consider the need, the long-term financial consequences and payback of the investment; by taking into account the remained lifetime and capital value of the unit, its influence on running expenses, an estimation of project time, cost and the resulting downtime, the quality requirements for docking, operational reliability after docking and the technical standards required by stakeholders. Clearly marketability of the rig after possible docking with regard to actual or the potential contract with operators, have a strong impact on decision making for docking.

Registration of jobs as the main source for specification and planning has very high importance in the project. Registration of docking items is done by data acquisition from owner internal inspections, class surveys, repair (yard) listing onboard rig, modifications required by new legislation, results of previous docking , received Condition of Class (CC), damage history of the unit and condition assessment based on Machinery and equipment PMS , Hull Integrity Management , Ultrasonic Thickness Measurement (UTM) also vibration test on machineries. In addition the specifications required by operator and/or rig owner which are mainly upgrades and modification are input to the registration of job. Registration of jobs may start with grouping the maintenance and modification activities. During the investigation it was observed that superintendents to large extent rely on Classification Societies' reports and surveys for mapping the scope related to class renewal. While, as discussed in Chapter 3.3.3.4, the class surveys concern about satisfying the minimum acceptance criteria. Beside the fact that during surveys, the class surveyors often do some spot checks on the unit which clearly do not represent the overall technical condition of units. What observed today is that job registration prolong even to the execution phase after the rig has arrived at the shipyard. More defects or other work items may then be identified which naturally increases the scope and upset the project schedule. Clearly such poor performance in job registration and condition monitoring would result in serious challenges in the project. Chapter 3.5 study some of these challenges in job registration and specification within case studies.

The specification is the input to activity definition which is the input data for activity scheduling and cost estimation. The specification is often prepared by the assigned superintendent and gives a description of each individual job, the scope of the tasks and related activities. The specification is a critical document. The success of docking project is directly connected to the quality of the specification. The specification needs to be comprehensive which means that every item requiring some action during the docking have to be itemized. Also, the specification need to be logical and consistent this feature facilitate grouping of related work items also assist to avoid oversight. In addition, the specification should be clear and accurate, especially on items identified as being on the critical path (Advisers, 2005).

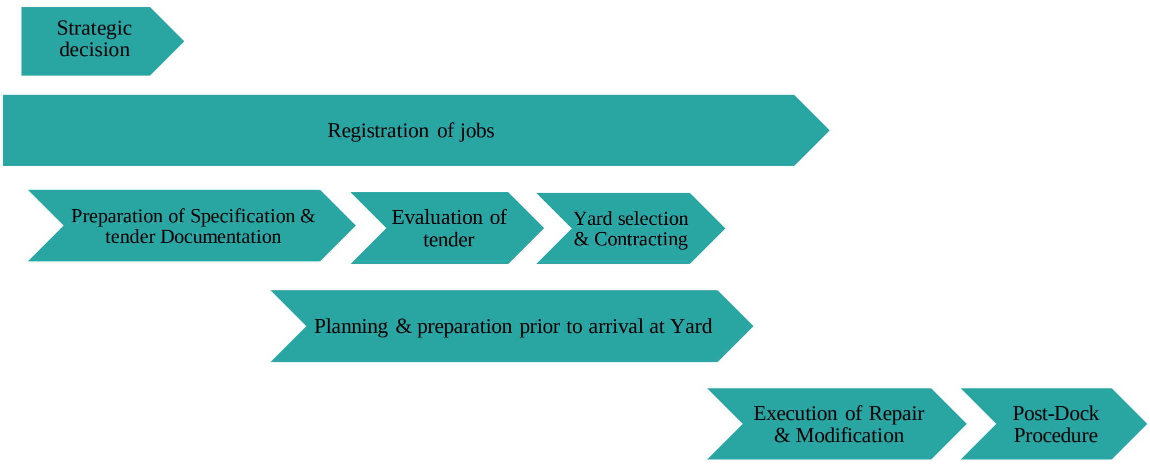

Figure 13: Normal Docking Process Today

Note: Docking process from project to project may differ also the assigned time frames in the above figure are inductive and based on observed cases. So this Figure may not represent necessarily a general picture for the whole industry.

The specification should also give information about required preparatory activities like pre-cleaning, access work, scaffolding and etc. Also details about required spare parts and equipment are cleared in specification often according SFI coding system. In some cases unavailability of spare parts in repair and retrofit jobs has resulted in unscheduled cost, late delivery and reduced quality of work in the project. In general, insufficient specification will cause problems for both for the owner as well as for the yard. Such problems include higher costs for the rig owner as well as serious interference for the yard with respect other contracts. Other consequences could be unscheduled hiring of subcontractors, inconvenient changing of schedules and etc. (Advisers, 2005).

The prepared list of specifications is submitted to the quoting yards and suppliers. After receiving replies on quotations the owner decides upon the best option for docking the rig. The factors like extent and complexity of repair, shipyard facility, shipyard reputation, shipyard capacity and availability, experience from previous dockings, geographical location and etc. have contribution on evaluation and selection of yard. Concurrently, with tender evaluation often the specification revised for including and excluding work items.

The objective of planning is to establish work schedule and progress plans defining what to do, when and how also who should take the job. According to PMI the planning process starts with scope definition by creating work breakdown structure (WBS) ; activity definition which was created by specification assist the project manager in activity scheduling , cost estimation , resource planning , quality planning, communication planning , risk management planning also plan contracting (*A guide to the project management body of knowledge: (PMBOK guide)* 2008)). Planning documents which often prepared by rig owner' superintendent and his team have high importance and require good project management skills.

The preparatory activities are mainly physical and preparatory works carried out at the yard and onboard rig prior arrival to the yard. Sometimes due to uncertainties on the technical condition of the rig and late job registration or other external factors like stakeholder the planning process continues to a significant extent during the execution of the project which probably result on time and cost overrun.

3.5 Case studies

3.5.1 Case description

During the research several challenging cases have been investigated. In this chapter just three of the most significant instances of costly projects and some of their main activities are discussed. These docking projects have been carried out within the last five years on semi-submersible drilling units. In order to protect the anonymity of the companies first the general characteristics of each project are described - later, more details about some challenging sub-activities in the three projects which organized in Table 2 will be discussed in detail in the next chapter.

Project A

The main objective of this docking project was 15 year life extension perspective to obtain class renewal certificate. Though the decision for docking was made in a good time beforehand two months before the start of the project it was decided to delay docking for one more month compared with the initial plan. Such issues are normal for docking project often because of unplanned extension on the contract with operator. The project was scheduled for 40 days consist of repair and maintenance jobs including few refurbishments and upgrades. The initial cost estimate for the project was 25 MUSD with zero day rate for yard stay. The rig departure the yard after 70 days, although according to rig owner announcement, in the last two weeks the rig had difficulty for mobilization due to unfavorable weather condition. During the docking period the unit received many Condition of Class (CC). Still many of these items had not been closed when unit departure the yard. Also, the rig had experienced some surprises and some major overhauls at the yard. So finally the rig after 30 days delay and 40% cost overrun exceeded the original cost, departure the yard to start her new contract. The costs incurred above the planned costs approximately is 31MUSD for 70 days downtime on 0.45MUSD day rate plus around 10 MUSD for extra spent at yard. Thus, the total overrun was about 55%. Note that rig had zero day rate for yard stay

Project B

The project scope constitutes of special periodic survey and major upgrade and modification. The project was estimated for 64 days stay at the shipyard with approximate 122 MUSD. The project was supported by 245000 USD day rate for 64 days and approx. 70 MUSD coverage of the upgrade job by operator. Clearly these supports linked to operator's large list of modifications and upgrades required for the future contract. The project was intended for 10 year life extension to enhance operational capacity and marketability of the unit. The project had extensive refurbishment and retrofit list on machinery and equipment, especially on electronics and drilling equipment. The operator scope was mainly in drilling equipment plus some upgrades on lifting appliances and structure. Almost three weeks after the project start the owner accept to increase the scope of the upgrades on drilling equipment upon request of the operator. The new items were expected to add three weeks to the planned schedule. But the repair and replacement scope of drilling components was continually increasing and extend for more than four weeks. The unit later got nonconformity in PSA audit which followed by late delivery of ordered equipment and even worse they faced with mechanical failure of equipment which were earlier overhauled, installed and certified. Finally the rig owner completed the scope after 183 days and left the remained two weeks upgrade job on the mud system to the operator. The project roughly had a four month delay with more than 110% overrun on yard cost. Although the initial plan was concerned on upgrades it revealed that the SPS and related rectification took 170 MUSD out of the total of 260 MUSD of incurred project costs. This means the SPS scope has stood for the main part of time and cost overruns. The financial reports after project shows that operator covered only 55 out of 70 MUSD. The reason is unclear, but we may speculate it resulted from unfulfilled requirements of the contract with rig owner. By assuming 365000 USD day rate after docking, the incurred losses to the owner have been around 45 MUSD downtime cost in addition to approximate 100-130 MUSD extra spent in the yard.

Project C

A semi-submersible rig which has been on special periodic survey six months ago was about to go under 40 days' extensive upgrade and modification. The project cost was estimated to be 50-55 MUSD which 30 MUSD of this upgrade cost was to be covered by the operator. The rig has received a large list of upgrades from operator on equipment especially on drilling side. However the rig was not on day rate during this upgrade project. Despite the initial plan, just three months prior to scheduled yard-stay, the owner decides to kick off the project one month earlier. The initial inspection after docking revealed that the rig structure was in worse shape than estimated. The technical status of the rig which had been surveyed together with class on the previous SPS was actually worse than anticipated. The project got an extensive scope increase related to structural repairs. More than an additional of 4500 m^2 steel under deck areas had to be replaced. This interference in the project caused subsequent delays. The surprises related to structural status at least delayed the schedule by four weeks.

The execution of docking project was sub-contracted to a project management company and the yard merely provided simple manpower. It seems that the project management company had a lacking understanding of the rig technical status. The project management company therefore had a challenging time in organizing, following and control of the project. These challenges in scope definition like earlier discussed in Chapter 3.4.2 might be related to registration of jobs which could result from inadequate maintenance and inspection in the operation phase of the rig. But it could have been caused by lack of technical knowledge and as well as incompetence in making accurate assessments of activities and their dependencies. Furthermore, the project had underestimation in capital expenditure of required configuration for operator's field development equipment. The project duration was prolonged by 68 days' delay which is more than twice of the estimated time. Further, it was an overrun of about 180% in cost. Assuming the 450000USD day rate after planned docking incurred losses roughly has been about 30 MUSD extra downtime cost plus 85-90 MUSD extra spent in the yard.

To sum up, on the above presented project challenges, the repair projects mainly have been concerned with scoping the project also understanding the implication of enforced regulatory requirements on project scope. Likewise, in upgrade projects challenges have been in relation with oversight on identifying sub-activities and dependencies, too optimistic estimations and inefficient contingency planning.

3.5.2 Challenging job items

Based on investigations during research the most significant job items on the above presented projects are identified and listed in Table 2. The items are classified according to SFI coding system as presented in Appendix 3. These items are mainly critical path item which shortly discussed in previous chapters. In this chapter some instances of these challenging tasks are further discussed in detail to represent their contribution on earlier mentioned overruns.

Table 2: The most challenging systems – Organized according to SFI coding system *(Appendix 3)*

2. Hull & Structure	3. Drilling Equipment & System	4.Platform Equipment	5. Equipment For Crew	7. System For Machinery Main Components	8. Platform Common Systems
2.2 Pontoon Tanks 2.3 Add Blisters 2.5 Underdeck Steel Replacement 2.9 Living Quarter	302. Drilling String Compensator 330.Mud System Control Shale Shaker, Degasser, 352. Pipe Handling 361. Deck Cranes 342. BOP Control System 345. Choke and Kill 345. ROPS	4.4 Winches 4.9 CCTV System	575.Helicopter Platforms W/Equipment	7.3 Cooling System 7.4 Exhaust System 7.6 Machinery and Marine Piping 7.8 Integrated Control System	8.1 Ballast System 8.2 Fir & Gas Fire Water System Fire Detection Fire Alarm System ESD 8.7 Power Supply Generator AVR Rectifier (SCR) 8.8 Main Switchboard Cabling

Remotely operated pull-in system (ROPS)

The ROPS is a prototype technology. It is a remotely, hydraulic operated system which eliminates the need for man-riding in the moon pool area when connecting and disconnecting control lines from the marine drilling riser to the rig coflex hoses. The system reduces the hazard risk to the personnel during offshore operation. The technology is rather new. Only few rigs have been subjected to such upgrade. According to the manufacturer the modification project for already prefabricated equipment would take 6-8 weeks as a best case scenario. Considering the required accuracy and the delicacy of the job besides the limited experience with the installation of such new equipment the required time for installation should be expected to be longer.

Although this sophisticated equipment is a long lead item, the order request for ROPS was submitted almost three weeks after the start of the project. Such late decision for a rather old rig which had high uncertainty on structure imposed high risk to the project schedule. Particularly low reliability of old steel in installation areas also the interference of extensive steel repair activities, on the moon pool area, with ROPS upgrade had a high contribution on upsetting the schedule of ROPS upgrade. In this case, to achieve a successful execution it sounds essential to be well prepared in advance, have a good plan in place and have control over critical path items.

Crane Upgrade

The Upgrade on crane configuration was decided upon operator requirements for future contract. The upgrade was included in the scope, the upgrade was to be financially supported by the operator. The decision for installation of new crane made in good time before the start of the project by acceptance of operator request. The purchase order was accompanied with an order for new pedestal afterwards. The purchase order was made in good time before the start of docking although the date for the start of the project was not established yet. The new crane was sub-contracted based on an EPCI type of contract. The pre-engineering by the sub-contractor pre-engineering was planned to start by 18 months before the start of the project which normally would be sufficient time for evaluation and calculation of the scope of work and required resources. Similar to the normal subcontracting process described on 3.3.9.1, in this case also the sub-contractor was in charge of providing detailed specification, fabrication and installation. The performance of the subcontractor was monitored by the project manager. The crane pedestal was not the main item itself in planned yard-stay but was a critical path item for upgrading the crane. Production and installation of the new pedestal required for the new carne was creating some unexpected challenges in the project. The issue is investigated by root cause analysis and presented in the STEP diagram in Figure 14.

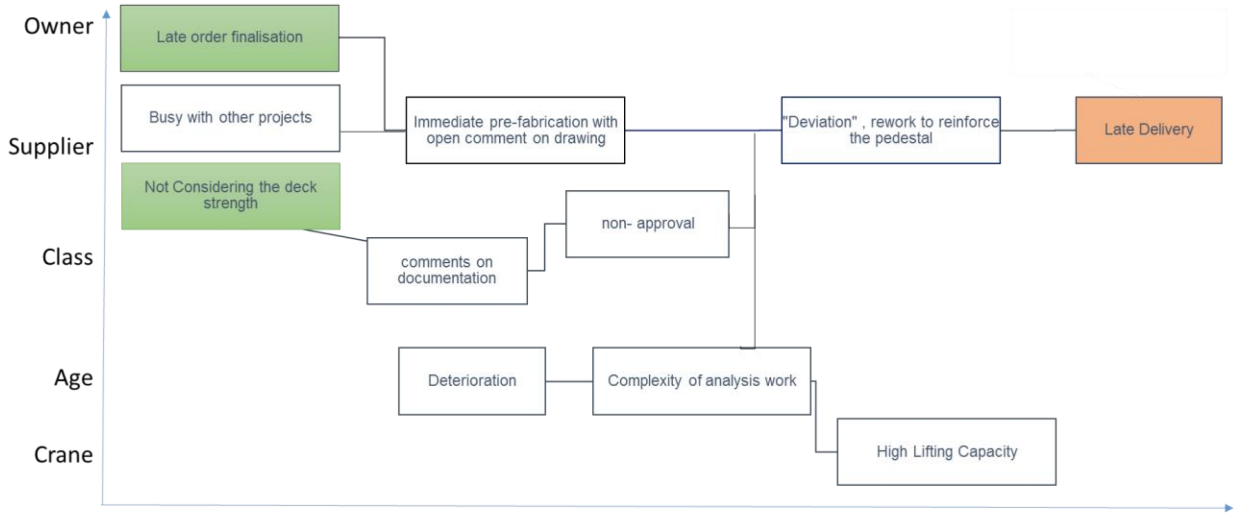

Figure 14: STEP diagram for Root-cause analysis on Crane upgrade

It is clear that the criticality of crane pedestal had been underestimated by subcontractor and owner. Underestimating the required time for calculation and preparation of drawing for the new cranes and pedestals and ambiguity of project startup date, put the busy vendor in a tight situation. By finalizing the startup date attention was drawn on preparation of pedestal drawings and its fabrication. The new designed crane had higher lifting capacity compared to the existing crane. Therefore, not only there was a need for a new stronger pedestal but also the strength of surrounding foundation had to be considered. In this case it seems as if the owner and the subcontractor had not been fully aware about the condition and the strength of foundation steels. This resulted from inadequate inspection and UTM tests around the crane location. The strength evaluation of the old steel structure under the pedestal proved to be more time consuming and more complex than estimated. The crane vendor had been already two months behind the schedule and could not wait for class reply. The vendor therefore submitted drawings to the class. Fabrication at a Polish yard was started immediately. Class reply on drawing came almost five weeks after submission when the pedestal was already fabricated, shipped to Norway and installed onboard the rig. The class comments on drawings revealed that outstanding loads acting on the pedestal and the steel underneath had been omitted in the design. Although later vendor has done several local reinforcements inside the pedestal also on the supporting structure, the structure still did not get the sufficient strength to take the nominated crane. Finally the new crane with lower configuration was installed to suite the already installed pedestal. As we see there have been series of factors like incomplete information about the foundation and location of crane also incomplete knowledge or oversight on the real scope of work which caused the subsequent events during the project. These challenges through the project process are presented in Figure 15.

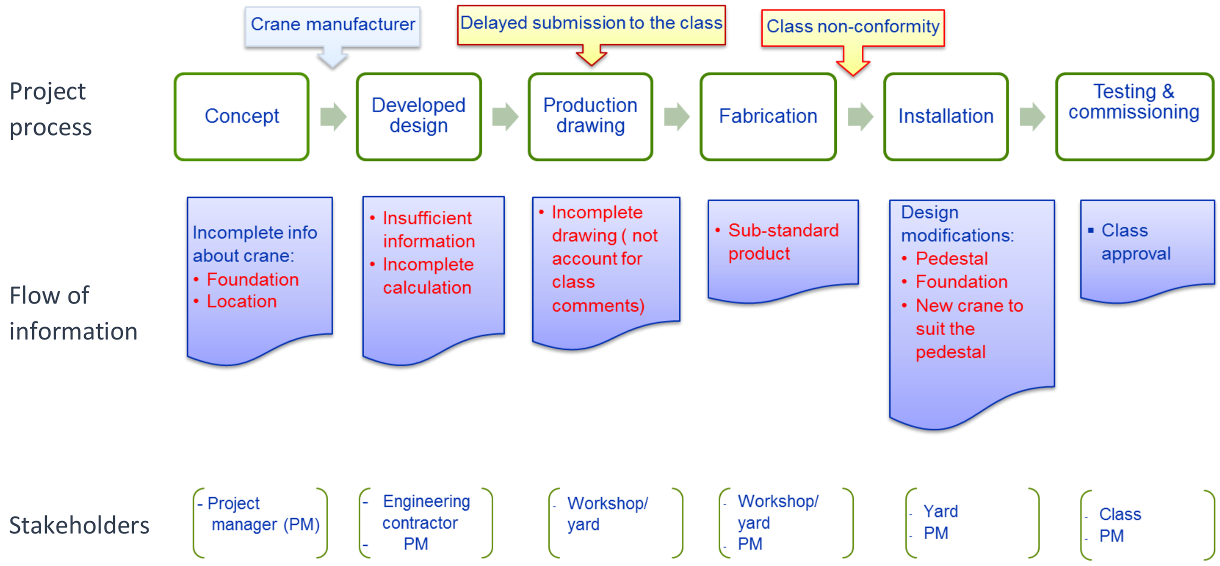

Figure 15: Crane Upgrade

New Helideck and accommodation module:

The decisions related to increase the personnel on board (POB) capacity from 100 to 116 was made more than a year before the yard-stay project. The solution was to add a new living quarter modules on the top of the existing helicopter deck (Helideck) and install a new helideck on top of the new living quarter floor. Like any other big item fabrication and installation of specified accommodation module and helideck was subcontracted. The new installations imposed a weight of more than 150 tonnes which required reinforcement to give the helideck structural forces down to the rig structure. Also, the point loads from the weight of new helideck on accommodation module and existing helideck needed to be dealt with by the supporting structure. The living quarter module and helideck were prefabricated and shipped to the yard in time. However, preparation for installation of new modules were not considered properly beforehand. Also, other modifications which had to be done in connection with installation had not been planned accordingly. The need for supporting structure was identified very late. Therefore, the design, fabrication, and installation stages for the new supports had to start immediately.

Clearly, the drawings for foundation of module were delivered to the class quite late so the outstanding comments on design came very late and class had not followed the fabrication and installation too. Lots of rectification and rework was done on the foundation and finally the supporting structure was accepted as deviation to be dealt in future. Figure 16 explains the challenges in project process as described above. It should noticed that in such projects it is likely to neglect interrelated activities to the main job. It is therefore important that all activities have been reviewed thoroughly before the start of the project. In an upgrade project like this other sub-activities may turn to be crucial , items like installation or relocation of Helifuel system in connection with the new helideck or electrical and fire & gas system for the living quarters in connection to upgrade on living quarters might be relevant. For instance, in this project the helifuel platform came late to the scope. Due to insufficient study it had to be relocated after installation. During this research similar cases of upgrade on living quarter with oversight on installation plan have been observed, which again highlights the need for a comprehensive review on the scope of main items at planning phase.

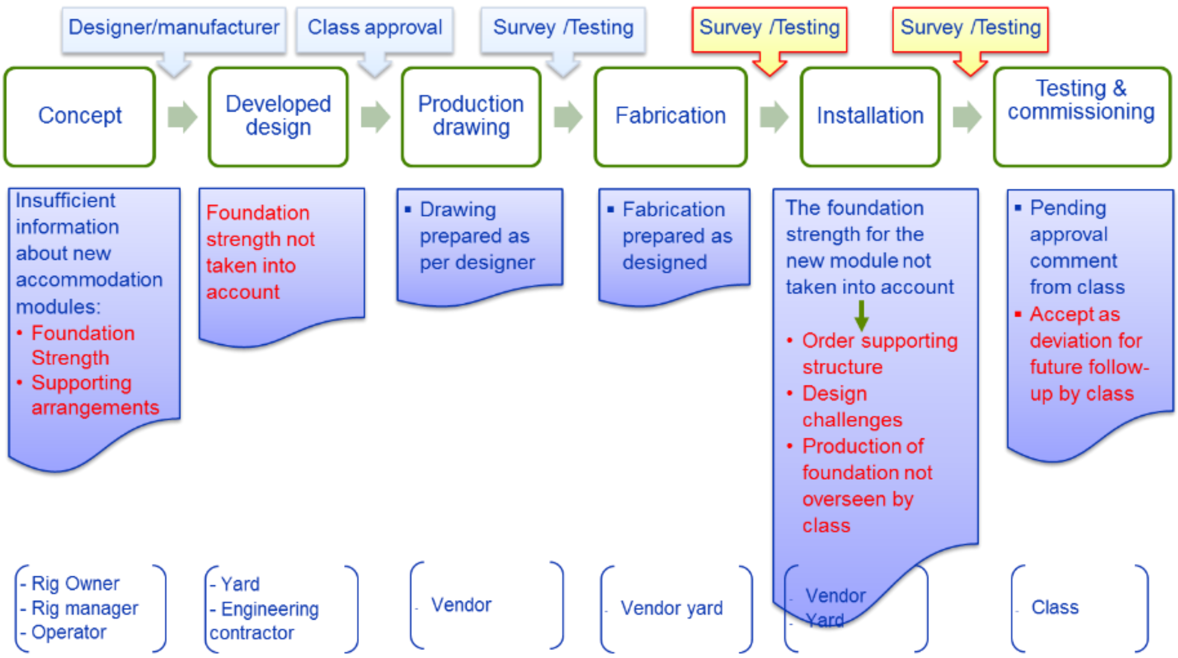

Figure 16: Living quarter upgrade

4. Discussions

The aim of this chapter is to describe and discuss the challenging areas in managing docking projects previously presented in Chapter 3.5

The findings in this section are based on subjective answers from the interviewees and subsequent analysis. Consequently the separation between analysis and description of the findings is not clear. The subjective answers from the interviewees become an integrated part of the analysis. Definitely, the answers collected through interviews are not objective because the interviewees have all made up their personal opinion about the discussed topics.

This chapter discuss the Planning and Control as most challenging practices in managing docking project. These issues were identified on the presented cases also the experiences of interviewees from other projects. Further, the other identified external and internal risk factors won't be discussed in this chapter.

Finally, a general approach as a potential solution to the identified challenges suggested in this chapter.

4.1 Challenges in project management

PMI describes the project process with five phases; initiating, planning, execution, control and closing. In studied docking projects the planning and control of the project identified the most challenging tasks in project management.

Planning

Planning process for docking projects requires the support of three main elements; Time, Recourse and Data on the status of the unit. First of all, the project management team needs enough time to create a precise plan for the project, sometimes because of pressure of operator (charterer) or incident the rig owners are reluctant to rush for docking which may lead to a large list of unplanned activities and delays.

Secondly, rig owners in Norway seems to have difficulties in providing enough resources to the planning process. Docking projects have high complexity and demands high project management skills for superintendents and sufficient capacity on his project team. What is commonly observed is that rig owners have a rather small technical organization which naturally overfilled with operational tasks of their fleet. In docking projects, due to numerous activities in a multidisciplinary context there may be a competence gap for project manager and his team to cover the entire range of activities. Also, planning needs knowledge about the technical details of each activity and interdependency in involved sub-activities. Accurate estimation on Time cost and scope require high project management experience and broad knowledge on technical issues also correct understanding from regulatory requirement implication on the scope. Today the changes in technology and regulatory regimes make the resourcing of project planning even more difficult.

The third source for planning is the accurate data on status of the unit. These data gathered from inspections, reports, yard list and etc. and are the main input to the specification and activity definition. Like what discussed earlier in Chapter 3.4.2 a good planning document needs concise and comprehensive, consistent and accurate specification. The more accurate condition of unit mapped the less risk and surprise during yard-stay. How close this information is to the real condition of unit depends on how much attention and resources have been assigned by the asset integrity management of the unit. Of course, other factors like knowledge of crews and quality of reports have a contribution to the quality of the specification. It is observed that in offshore drilling market planned maintenance program is often under pressure. When the day rates in the market are low rig owner reduce the number of maintenance crew and the extent of maintenance in order to reduce the huge cost of offshore maintenance. However, also when the day rate is high the rig is on intense operation, trying to increase the efficiency and get more contracts also satisfy the operator. So in both cases planned maintenance and associated inspections is under pressure and carried out on opportunity basis. Clearly in this situation mapping the real condition of unit is much more difficult. In this relation the experience shows that in particular the structural condition of the rig suffers most from negligence. So a project manager by considering the maintenance records of unit should be able to make an accurate evaluation on the real technical status of unit and associated uncertainties.

Control

Docking projects are also demanding with respect to project control. Many stakeholders in different disciplines with different objectives are involved in the project. Dependencies between these activities makes control of the project even more difficult. Managing and coordinating a large number of activities of which some of these activities actually are small projects by themselves demands a high project management capacity and also concrete plans including good contingency planning. In some cases it has been observed that when surprises comes up the rig owner has not been able to efficiently keep track of activities and monitor the project. Another fact is that in docking project not only rig deal with different stakeholders but also deal with shared resources and the project in fact compete with other projects or external elements. For instance yard, suppliers, classification society, crew and etc. often have other ongoing activities and are therefore not able nor obliged to execute the unplanned activities coming up during the project. This again encompasses the importance of overall control on the project.

In short the identified main challenges in managing of docking projects are:

- The project manager has difficulties in mapping the real condition of their units
- Project manager don't have an active role in control of project and partly the plans are made along the project execution
- The project manager has difficulties in scheduling the technical details laid on planned activities
- Coordination problem; stakeholders with different objectives

4.2 Recommendation

In this chapter the research solutions are suggested to risk management of docking project. The proposed solutions are result of consideration of the parameters discussed in previous chapters and also the challenges identified through the case studies.

One of the challenges in repair projects, especially SPS projects, is the high uncertainty and scope development during docking which resulted from disability to map the real condition of the unit. This problem probably could be facilitated by inviting third party engineering companies or even better request for pre-inspection from classification society in a good time before start of the project. For example it could be on the 4th annual survey when there is enough time for preparation for docking. In this case the SPS scope could start with 4th annual survey which means the owner starts to class the rig offshore as far as possible thus it could be possible to cover 70-80% of SPS before rig come to the shipyard. So, what remained would be the areas with difficult offshore accessibility like hull external and inside pontoon tanks. Following this approach the project manager would get good knowledge on technical status of the unit and would therefore be able to concentrate on modifications and upgrade scope for the yard-stay.

This research concludes with a new project process model to deal with the identified challenges in docking mobile offshore units. As discussed in previous chapter, one of the crucial issues in planning docking project is related to resourcing the technical expertise to the project management. The project involved with several disciplines and practically a superintendent may not be able to fill the competence gap in all fields to a high degree. In general is understood that in upgrade and modification projects rig owners often are clear about what they want but are not aware about the magnitude of works that actually comes in dealing with these issues. The best solution to this problem could be getting assistance from the industry experts in relevant fields. In this respect the new process model designed to facilitate dealing with the identified crucial problems. See Figure 17.

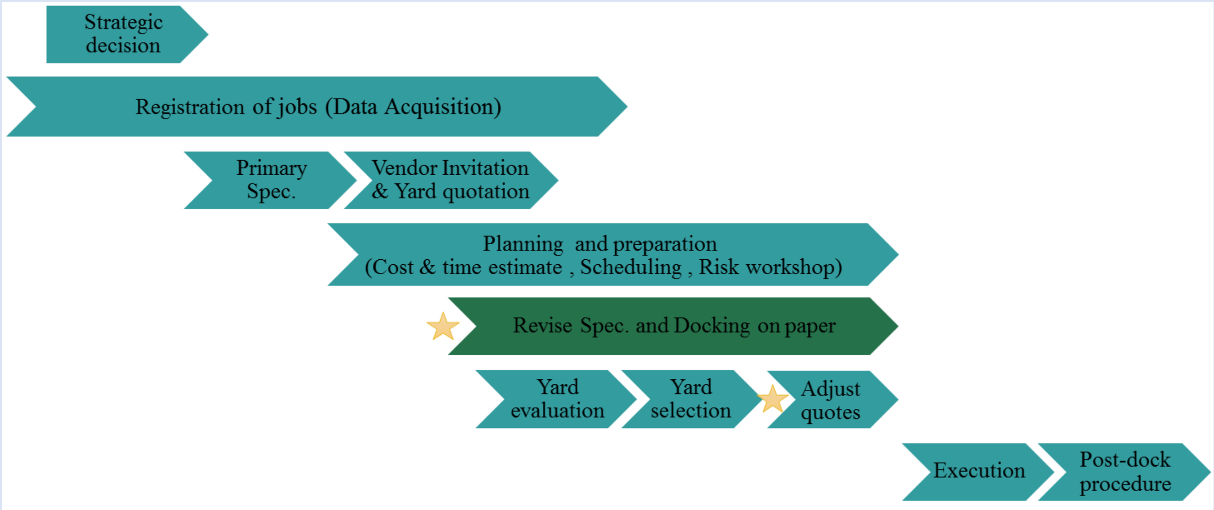

Figure 17. The new process model

Participation of external experts in planning occurs on Risk workshops, marked with golden stars in figure 17. The Risk workshops may consist of rig manager, rig superintendent and his team members including those responsible for cost estimate and schedule and contractor teams including key supplier, yard technical manager, technical specialist in specific disciplines and specialist adept on regulatory requirements. The workshops also managed by a neutral facilitator to glue up all pieces and make it work. The workshop would then be an opportunity to get opinions of the experts in the industry. The result of workshop would assist the project manager to verify that risks have been assessed, quantified, managed and communicated to decision makers correctly. Within early risk workshops project manager could discuss the scope of project with participants and improve the understanding of scope by means of risk identifications and risk assessments in the workshop.

The first risk workshop have focus on the scope of work with the objective of clarifying, completing and outlining the scope of work within the docking specification. The key members in this workshop could be Rig owner representative, Rig manager, Docking superintendent, Senior Crew, Charterer (if possible), Facilitator, scribe and etc. This risk workshop concern with risk identification and qualitative risk assessment. Within the workshop the docking specification will be evaluated and a project plan will be developed. The developed work scope plan obviously will have some gaps of information; during the workshop relevant follow ups will be addressed accordingly. For instance need for more UTM tests on specific areas. Resource overview

In the first risk workshop initially critical items in project plan will be identified, then sub-activities, relations and dependencies between the main items classified. Also the workshop give opportunity to review the recourse plan of main items with the experts. The output of this stage would assist project managers to get a real picture of the magnitude of each activity with associated sub-activities. After identifying the uncertainties it would be beneficial to have the expert group's opinion on cost and time estimation of activities to make strategic decisions. So , relying on received estimation on cost, time and scope of planned job also the overall risk picture of project, the project manager would be able to revise the scope on early stage, by include or exclude the job items depends on their risk implication.

The second workshop takes place after yard selection and have focus on the schedule with the objective of minimizing the delay. Unlike the first workshop which was limited to project generality the second workshop is more specific with respect to each activity. Extra participant in this workshop could be the specialist in required fields, yard technical manager and suppliers of key items. Concluding with the yard and being aware about yard capacity and facility it would be more practical to conduct a risk assessment with the presence of yard's technical managers at this stage. However it might be not easy to motivate the yard for participation in the workshop. But worth mentioning that, the inputs from the yard could be very fruitful since they are dealing with docking projects on a daily basis and have rather a fair idea about the involved risks, based on their experiences.

The second workshop has detailed evaluation on the scope followed by qualitative and quantitative risk analysis. The expert group will have contribution on the assessment of risks and uncertainties in the plan, scheduling the activities also preparing a risk response plan. At this stage the expert group has agreed on the scope also the activities and sub-activities already grouped and the dependencies are highlighted. This information could be presented in a bar chart that we call *docking on paper*. Docking on paper would be a good aid in monitoring and coordinating the project during execution.

After the second workshop it's likely that the final specification had some changes compare to the one submitted to the shipyard. The rig owner may need to request an adjustment on yard quotes to achieve favorable price before the project startup. Finally, after doing the pre-identified preparatory works rig is ready to dock at the shipyard.

Two examples of studied cases in Chapter 3.5.2, the upgrade projects on living quarter and crane, were selected to examine the application of the new process model. See Figures 18 and 19.

These two cases have been analyzed in risk workshops. During the workshops the involved risk parameters also related responsible stakeholders to work items, are identified. Comparing the case studies in Chapter 3.5.2 with the final risk application, based on the new model, we conclude that by application of new process model the project would be executed smoothly as the risk parameters for each task are identified and planned accordingly.

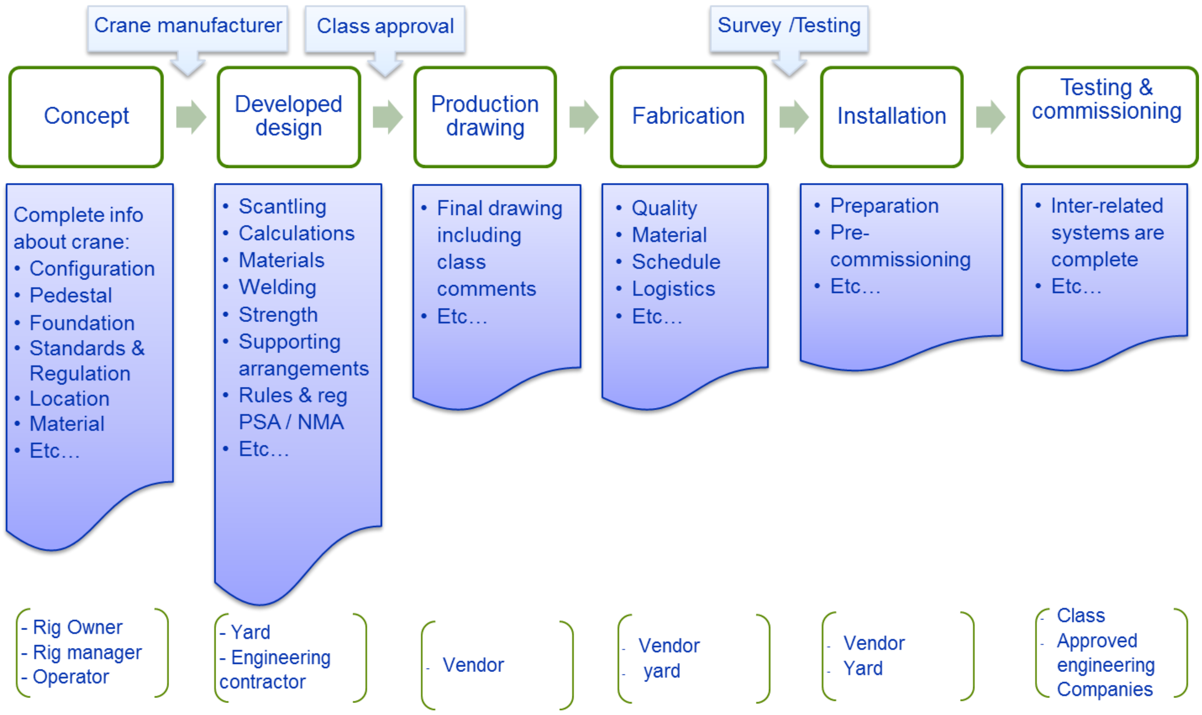

Figure 18: Risk workshop I - Crane Risk Application

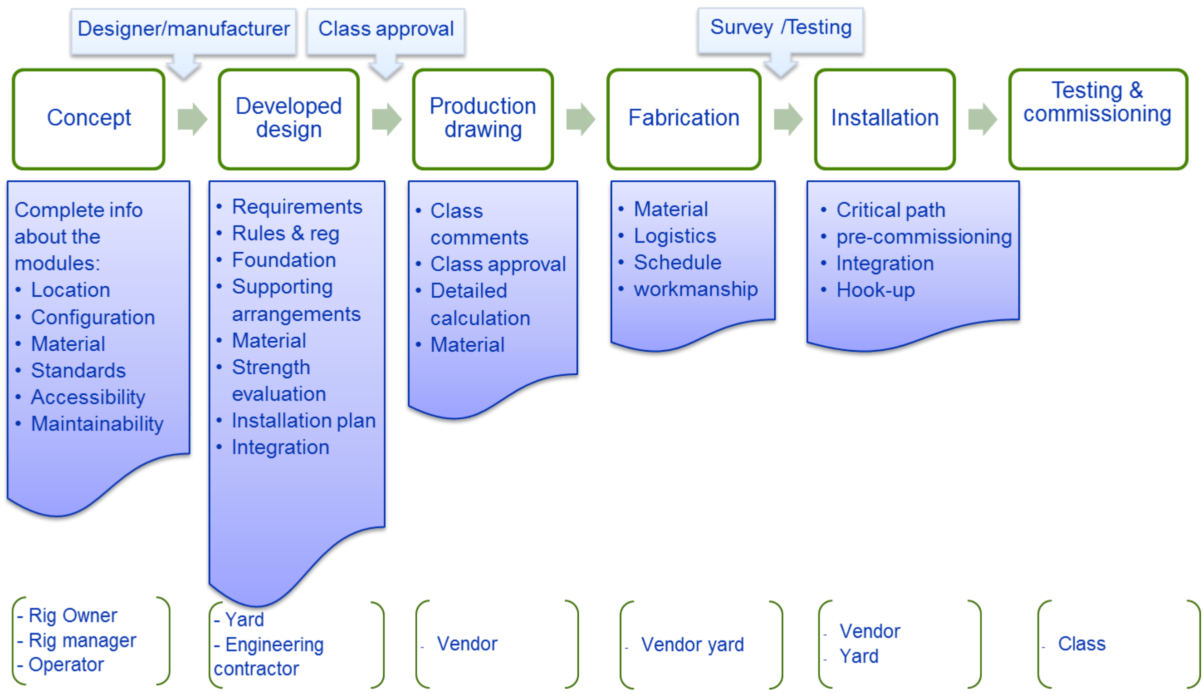

Figure 19: Risk workshop II - Living quarter Risk Application

The risk management process for offshore development project presented by E. Westney at Offshore Technology Conference to some degree is addressable to the applied risk management approach on the New Process Model in this paper. The Westney's project risk management model presented in Figure 20 composed of four main steps which followed by a workshop.

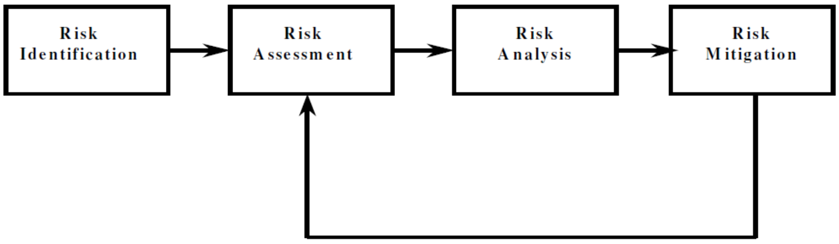

Figure 20: Project Risk Management Process
Sourse : OTC 2001 (Westney, 2001)

The presented process in Figure 20 could also apply to the risk workshops in our *new process model*; possibly with one more step in "Testing with scenarios" between the *Risk analysis* and *Risk mitigation* steps. Following each step described respectively;

In Risk Identification stage, the project team and other stakeholders participating in group setting asked to brainstorm possible risks to the project success. Getting input of all participants' perception of risks, at this stage the risks are identified and categorized. At this stage, it might be more efficient if the group gets a prepared risk categories and develop the risks of each one (Westney, 2001). The output of this stage is *Risk Identification table.*

In Risk Assessment the same members who identified the risks now assess the impact of each risk category on each cost and schedule element individually. Relying on the identified risks the group by describing the scenarios will evaluate the associated costs and time implication with each individual risk. Risk assessment on each element will wrap up on a *Risk Assessment Matrix*. Note that the first risk workshop will be limited to qualitative approach in risk identification and risk assessment. The quantitative risk assessment could be followed on the second workshop when experienced specialist can facilitate. There could be an opportunity to run a quantitative simulation of schedule by evaluation of discussed scenarios (Westney, 2001).

Risk Analysis for the second workshop in addition to qualitative analysis have quantitative analysis. Risk analysis in second workshop focused on reducing the uncertainty and subsequently delays. The output of this stage could be a precise *Risk Picture* of the project. In addition, the output of quantitative risk analysis could be cost and time Cumulative Probability Curve. Also by the second workshop cost and schedule contingency required for high priority risks established and defined.

Contingency planning and its scope discussed and included in the project scope for further preparation.

This research suggests to include one more step on above presented Project Risk Management Process. The new stage is “Testing with Scenarios” which run after Risk Analysis (see Appendix 4). At this stage all assumptions considered in previous stages that concluded in the “*Docking on Paper*” are to be tested. It is an opportunity to develop the scenarios, test the project plan and identify the alternatives. So by rechecking the final bar chart the possible oversights and underestimations in the planning will be identified and filled up.

The Risk Mitigation stage stands for risk response plan for high priority risks marked in the result of risk analysis. At this stage the most critical risk categories highlighted and plans for reducing the probability of high-probability risks prepared. The output of this stage is the *Risk Response Plan*. The risk response plan should present a path forward plan, including steps need to be taken and responsibilities for mitigating risks (Westney, 2001).

4.2.1 Advantages of the New Docking Process Model and risk workshops

We have seen that the projects primarily authorized based on financial criteria such as profitability and return on investment, with inadequate consideration of the project’s cost and schedule risks relative to other potential projects. The result is making decisions based on incomplete awareness of potential risks.

The new model by setting up workshops gather the key members of the project around a table to freely exchange their opinions. This gives opportunity to make more efficient decisions and define the best course of action. Furthermore having the key members of rig owner and contractors teams together with a neutral facilitator in risk workshops has the following advantages:

- Open communications on risks and uncertainties improve the members’ effectiveness in the project by :
    - Eliminate mutual distrust atmosphere in the project.
    - Clarify the risk understanding in the context of the project. Since there is not a consistent method for defining the “Risk” and different managers have different understanding of risk.
    - Clarify the acceptable risk level. Managers have different risk appetite so it’s the time for stakeholders to get in line with rig owner’s project criteria.
    - Clarifying the lines of responsibilities.
- The risk workshops provide a platform for richer discussions on the risks and possible impact on cost and schedule of the project.

- The discussions would assist rig owner to determine the level of the best estimate on time and cost of the project.
- Members by using the outcome of their risk analysis create a risk mitigation plan and establish the optimal degree of risk response. Which all are committed to it.
- The team members get a sense of ownership and commitment on the cost and schedule resulted from the workshops.
- The risk workshop gives opportunity to evaluate the technical capability of nominated yards and suppliers

The resulted bar chart or "Docking on paper" on the final workshop may give below opportunities in control and monitoring the project:

- Assist project manager to get more active role in controlling of the project process and monitoring the project progress
- Easily monitor the project and evaluate contribution of contractors within the project progress on each individual job item.
- Better control on overall activities and maneuverability in case of surprises.
- Opportunity to include or exclude the scope of activities based on criticality (e.g. Depend on time limitations for yard stay, the scope could be cut to the items with higher implication).

4.2.2 Possible difficulties in risk workshops

Despite the mentioned advantage of the workshop also there might be some difficulties in having group setting as described. Some of these issues could be:

- It might be difficult to get the yard on risk workshops.
- It might be difficult to get Class surveyors at the meeting because of possible contradiction with classification and certification duties.
- The group members may not freely share information due to distrust. However the confidentiality of the meetings could be maintained through formal agreements, still some members may do not feel comfortable to share critical internal information.
- Confidentiality of information; the rig owner is reluctant to share their risk perception to the external members
- Etc.

4.3 Limitations of the current study

This master thesis is written by a Maritime Management student with little project management and no offshore experience. So this report instead of following the predefined academic approaches, through interviews try to demonstrate the industry real concerns and challenges to be able offer a more practical solution. In other word it is aimed at identifying the predominant challenges across a complexity with fresh eyes. Therefore the focus of this report is to build a multidimensional risk picture according to different stakeholders definitions of risk connected to docking projects. Geared to such insight some case studies have been developed in more details.

This thesis by studying several cases has attempted to conclude with commonly applied practices of docking. Also this study is geared with the expert's opinion regards the cause of delays in projects and challenges in planning phase.

The interviews have been main tool in this study; for educating the researcher on offshore technical subjects, developing research questions and identifying the possible solutions. Although, this research also benefited from internal and public documents as supporting literature to the interviews. These documents are the information presented under Investor Relation's documents in the subjected companies together with class survey reports and PSA audits. It is important to note that this research has had participation neither in the docking project of the studied projects, nor their risk workshops. Since, the requests for access to the project plan, internal reports and interview with project key members of the subjected projects was rejected. So this report have outside-in approach to the investigated project cases.

Note that, the findings of this study are inductive and limited to followed approach also limited to the numbers and the extent of interviews. So the findings of this research may not comply with every docking project. Beside the fact that data gathering and interviews mainly have been investigative rather than empirical study on ongoing projects.

Furthermore, it was understood quantitative approach is not appropriate for this research because of the dissimilarities in docking projects and their scopes also the limited number of potential sample project.

Also it should be noticed that investigations in this research have been limited to Norwegian Shelf, means the docking projects on active units in Norway. Further, the research is limited to dockings cases performed at Norwegian shipyards, although the shipyards have not been investigated nor interviewed in this research.

5. Conclusion

This thesis is set out to determine the most significant challenges in docking mobile offshore units in operation on the NCS. In this research the aim has been to identify the risks in the previously executed projects and also to find possible solutions for such challenges.

Returning to the question posed in the beginning of this study, it is now possible to state that in repair and maintenance projects rig owners have challenges in defining the scope of work as well as predicting uncertainties. Likewise, for modification and upgrade projects the rig owners have challenges in scheduling the magnitude of work associated with the planned upgrades. These challenges in upgrade and modifications are mainly due to the complexity of systems and also lack of sufficient technical resources in rig owners project management departments. Reviewing some unsuccessful docking projects has shown that important decisions in the project often are made based on scope evaluation, cost estimates and time schedules whose accuracy and contingency requirements are little more than “guesstimates”.

The answer to the second research question comes together with the recommendation. In light of this thesis a new process model for docking projects has been proposed. According to the proposed model some of the involved stakeholders in the project plus some other key experts are invited in risk workshops by a third party neutral facilitator. The results from this group would facilitate the risk management of the project in a good time before start of the project. Namely, the scope of the yard stay is set and the associated risks analyzed and the mitigating measures are in place.

The first risk workshop would result in a more realistic picture of the actual scope of work, including more accurate estimation of cost and schedule for the main items. These estimations are important input for strategic decisions. At this stage the needs for more data on the status of the unit may emerge in the risk workshop; for instance running more extensive Ultrasonic Thickness Measurement (UTM) on specific areas. The first workshop should be held in good time (typically 9 to 12 months before or even earlier) before project start. So the risks will then be discussed more openly and high risk issues can be improved, or alternatively cancelled at an early stage, before point of no return.

The second risk workshop have focus on the schedule with the objective of minimizing the delay. This risk workshop will be supported with more details and will therefore assist in making a comprehensive project plan with more accurate estimation of schedule and involved risks. This workshop gives a complete *risk picture* of the project. The other product of second risk workshop is “Docking on paper”. This document possibly will be a great aid in testing the project plan and also a tool for monitoring and control of the project during the execution.

Hence, through such workshops the rig owner will be enabled to bridge the competence gap in project management with technical expertise from the expert who are involved in the execution of the job.

This would not only improve the communication link between the project members but also commit the project team to follow the agreed paths from the workshops.

To sum up the proposed model would potentially give rig owners the opportunity to reduce the required contingency for projects through effective risk mitigation plans. Also it would assist in preparing a more efficient risk response plan for both internal and external risk factors. By applying this process potentially better decisions would be made which also increase the value of the project portfolio.

The suggested solution offered in this thesis has been addressed in group discussions with personnel in DNV. The suggestions have received positive feedback with respect to their validity.

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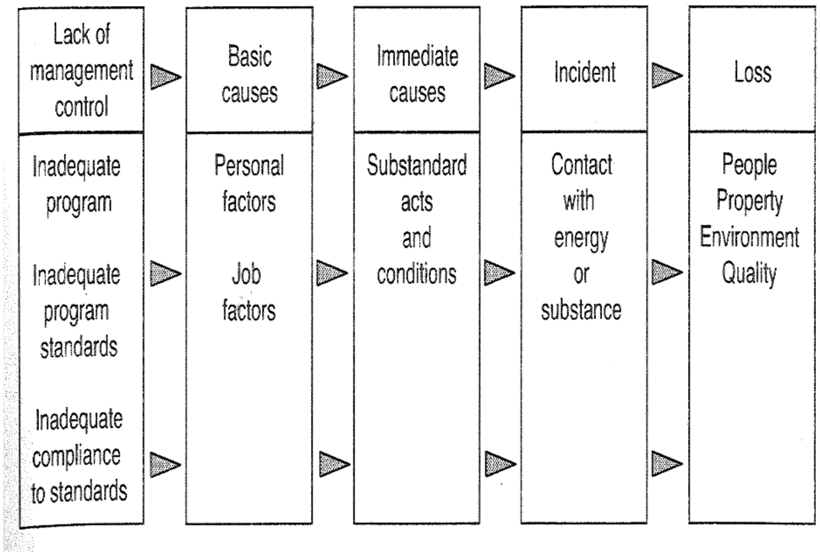
Appendixes

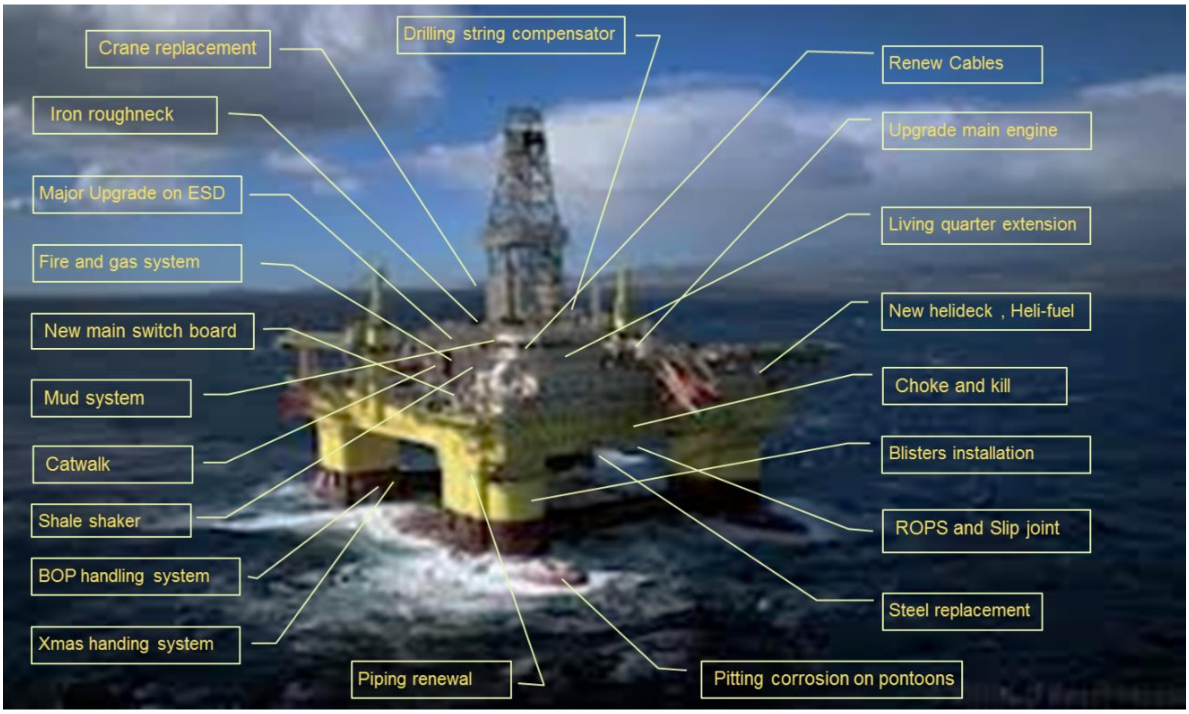
Appendix 1- Root cause analysis

The five levels in Root Cause of failures represented on **The main elements of the loss causation model** (Rausand, 2011) -p149.



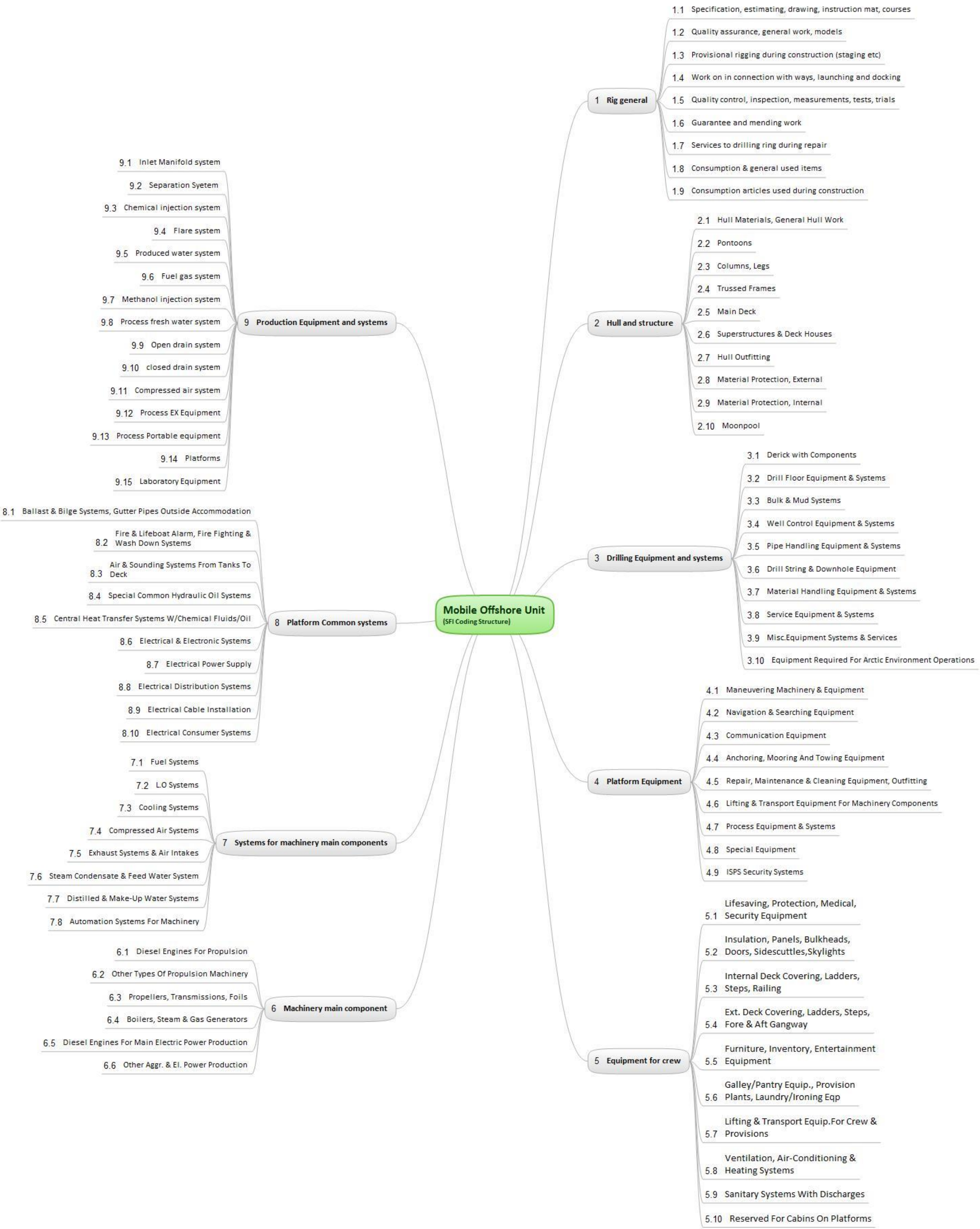
Appendix 2- Complexly in docking project

Sophistication and varieties of activities on an exemplary scope of docking project.



Appendix 3- SFI Coding system

SFI Coding Structure (LTD, 2013), A composition of coding systems for drilling and production units.



Appendix 4- Project Risk Management Process in risk workshops

Developed from Westney's project risk management process (Westney, 2001) presented on Figure 20.