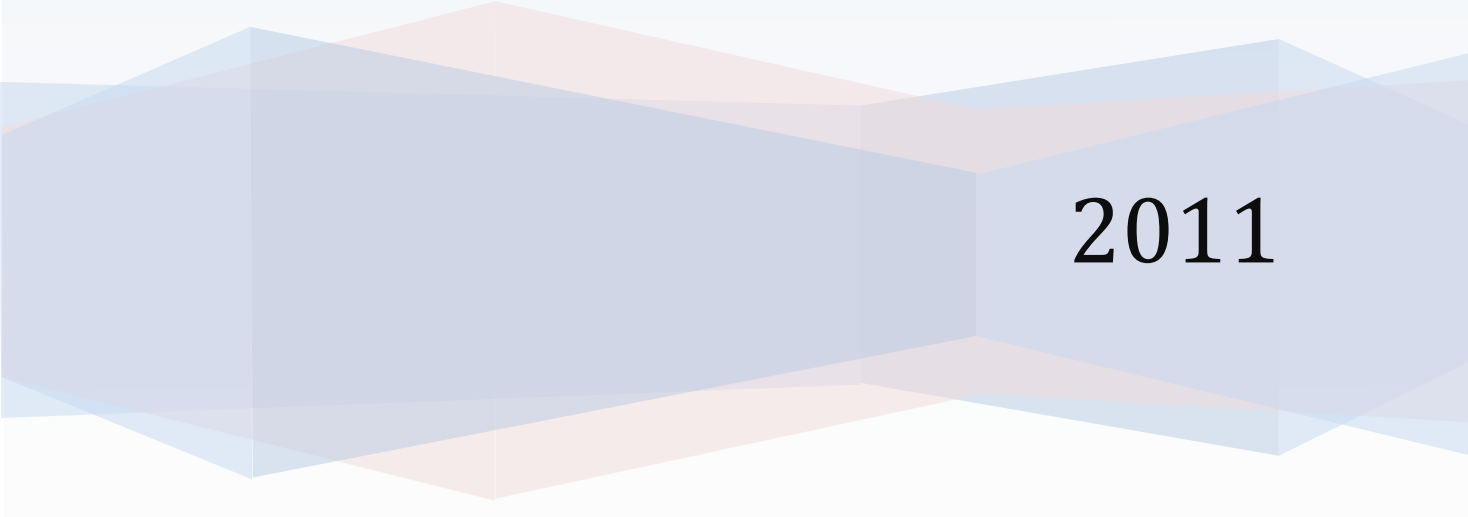


Master student projects

Center for Industrial Asset management



2011

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Title: **Vurdering av metode og praksis for funksjon- og lekkasjetest av ESD ventiler**

Status: **CONFIDENTIAL**

Abstract: Oppgaven har tatt for seg vurdering av metode og praksis for testing av ESD ventiler på Kårstø. ESD ventiltesting består i dag av:

- Funksjonstest av alle ESD ventiler
- PPS test (Pipeline Protection System)
- PST (Partial Stroke Test)
- Lekkasjetest

Metoden som benyttes kan ha svakheter som kompleks, ikke realistisk, ikke pålitelig osv. Metodene som benyttes skal vurderes, analyseres og evt. forbedres. Grunnen er at de kan være vanskelige å forstå, vanskelig å gjennomføre eller det er vanskelig å tolke resultatene. Dagens tester har utfordringer som gir grunnlag for å gjøre feil under testingen, vurdering av resultatene og dokumentasjon av resultatene.

Metoden for funksjons- og lekkasjetest av sikkerhetskritiske ventiler på Kårstø er vurdert i perioden januar til mai 2011. Det ble valgt ut 10 ventiler som ble analysert. Det fremkommer av observasjoner, samtaler, tester, analyser og erfaringsutveksling både internt og eksternt at en ikke har etablert beste praksis enda.

Metoden med bruk av cavity test og avlesning av trykkoppbygging pr. tidsenhet er vurdert til å ikke fungere tilfredsstillende. Det anbefales å opprette en egen stilling for testing av sikkerhetskritisk utstyr på Kårstø, og dedikert person som har ansvaret for totaliteten. Det anbefales også å videreutvikle arbeidet som er gjort tidligere og i form av denne rapporten, slik at det framkommer en løsning som ivaretar integriteten til de sikkerhetskritiske ventilene.

Det anbefales å bruke Aspen Process explorer etter at ESD bryteren er trykket i testen høsten 2011, sammen med testen av Coriolis måling. Da kan prosessingeniørene først overvåke en begrenset tidsperiode, før en tester med Coriolis måling og ordinær cavity test. Etterpå kan det analyseres om resultatet er at de samme ventilene "lekker". Det anbefales å opprette en spesifikk prosedyre for hver ventil, for å sikre systematisk gjennomgang av hvordan ventilen fungerer i forkant av hver lekkasjetest.

Metode for funksjonstesting er vurdert til å fungere tilfredsstillende. Det anbefales at dokumentasjonen av funksjonstesting og opplæring/oppfølging av de som tester utføres bedre.

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Title: **Positioning of Gas Detectors at Offshore Installations**

Status: OPEN

Abstract: The safety level at offshore installations is considerably influenced by in which degree undesired gas releases are detected. The primary functions of a gas detection system are to detect the presence of gas and inform other safety functions and systems if gas is presented.

Gas detectors are essential components in the gas detection system and their position are important in order for the gas detection system to ensure quick and reliable detection of released gas. The gas detector positions affect the functionality of the gas detection system, meaning the ability to detect released gas and initiate control actions in form of other safety functions and systems. In addition, the gas detector positions affect the reliability of the gas detection system, which is the ability of the system to perform its intended functions under different conditions over time.

This thesis studies different factors, which must be considered when selecting the best, suited positions for gas detectors at offshore installations where production of oil and gas takes place and evaluate their degree of impact on the functionality and reliability of the gas detection system. The different factors' influence on the risk level related to undesired gas releases are discussed as well.

In addition to a literature review gas dispersion simulations have been carried out using FLACS in order to study how different physical factors such as wind speed, wind direction, leak source, leak direction, leak rate, gas composition and the geometry of a given module influence the behavior of released gas, which again determine the best suited positions of the gas detectors.

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Title: **Framework for Successful Project Management: the Case of Maersk FPSO**

Status: OPEN

Abstract: Project management is a separate knowledge field with many published methods for success. In the oil and gas industry where costs are high, successful project management is very important to ensure successful project results and at the same time manage costs. Even though project management has been given more and more attention through the latest years, many companies still have some way to go. Maersk FPSO is an international company that is part of the A.P. Moller- Maersk group. They handle projects of all sizes and are relying on competent project managers to ensure cost effective and safe project performance. The company is dedicated to train their project managers and uses the most recognized tools in the industry. Still Maersk FPSO is missing some clear and good guidelines and procedures for conducting projects, especially smaller projects offshore.

The practical study that is presented in this thesis is based on two separate but identical projects, performed onboard the Maersk Inspirer. The first project was conducted without any guidelines, procedures and the second project was conducted according to a quick guide to project management that was created during this thesis.

The result of this thesis is the making of a framework for successful project management for Maersk FPSO. This framework has been created to align with the company management system and will be presented for implementation. In addition to the framework a quick guide based on the framework has been made to better suit the performance of smaller projects executed offshore.

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Title: **Optimization of Maintenance Performance for Offshore Production Facilities**

Status: OPEN

Abstract: New technologies are becoming advanced and complex for offshore production facilities. However, this advancement and complexity in technology creates a more complicated and time consuming forensic processes for finding causes of failure, or diagnostic processes to identify events that reduce performance. As a result, micro-sensors, efficient signaling, and communication technologies for collecting data efficiently, advanced software tools (such as fuzzy logic, neural networks, and simulation based optimization) have been developed, in parallel, to manage such complex assets. Given the nature and scale of ongoing changes on complexities, there are emerging concerns that increasing complexities, ill-defined interfaces, unforeseen events can easily lead to serious performance failures and major risks.

To avoid such undesirable circumstances, „just-in-time“ measures of performance to ensure fully functional is necessary. The increasing trend in complexity creates a motivation to develop an integrated maintenance management framework to get real-time information to solve problems quickly and hence to increase functional performance (help the asset to perform its required function effectively and efficiently while safeguarding life and the environment). Establishing “just-in-time” maintenance and repairs based on true machine condition maximizes critical asset useful life and eliminates premature replacement of functional components.

This thesis focuses on developing an integrated maintenance management framework to establish „just-in-time“ maintenance and to ensure continuous improvements based on maintenance domain experts as well as operational and historic data. To do this, true degradation of components must be identified. True level of degradation often cannot be inferred by the mere trending of condition indicator level (CBM), because condition indicator levels are modulated under the influence of the diverse operating context. Besides, the maintenance domain expert does not have a precise knowledge about the correlation of the diverse operating context and level of degradation for a given level of condition indicator on specific equipment. Efforts have been made in here to identify the true degradation pattern of a component by analyzing these vagueness and imprecise knowledge.

Key words: effective and efficient maintenance strategy, ‘just-in-time’ maintenance, condition based maintenance, P-F interval.

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Title: **Condition Monitoring of Electrical Machines**

Status: OPEN

Abstract The use of condition monitoring technology as part of an asset management strategy for industrial plant is gaining acceptance as a means of driving maintenance costs down. Knowledge about the real state of an asset or machine can help to optimize the maintenance for that asset. The use of condition monitoring technology should normally lead to reduced maintenance outlays and reduction in the amount of unplanned downtime

Electrical machines are commonplace in industry from generators, electric motors and all other sorts of electrically driven machines. The use of electrically driven machines is one of the key factors that have led to the rapid industrial growth of present day.

This master thesis is aimed at studying the means by which the actual condition of electrical machines used in industry is determined and how this condition monitoring data is applied to the maintenance program for such equipment.

This thesis addresses three aspects of common failures of rotating electrical equipment, namely:

- Failure modes
- Available technology to address these failure modes
- Data collection techniques

Emphasis is placed on the use of equipment that can predict machine condition by measuring electrical parameters such as voltages, currents, insulation resistance, etc.

The analysis will be conducted based on information from industry and real condition data for machinery that is in operation where available.

Some case studies, which show the cost savings that are obtained through the application of condition monitoring, have also been presented.

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Title: **Present and Future Technical Integrity Management Practices for Integrated Operations**

Status: OPEN

Abstract The first part of this thesis will map the requirements and best practices for performing criticality classification, maintenance and inspection analyses leading to the establishment of preventive maintenance and inspection programs. Over the last decade or so the recognition of IO has brought increasing use of information and communication technology to the NCS making it possible to transfer vast amounts of real time data through high speed fiber cables between off- and onshore installations.

This has led to increasing use of condition monitoring technology giving operators the possibility to detect degradations at an earlier stage. Emerging from this technology is the development of integrated information systems like the TIMS maintenance portal; a web-based decision support portal for managers, planners and decision makers giving access to a wide range of maintenance related information from multiple sources. The TIMS maintenance portal will be introduced and further exemplified in a case study of a water injection system, proposing a way to use real-time and offline technical condition data for visualizing the technical condition of the WI system in the TIMS maintenance portal interface.

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Title: **Choosing Technical Solution Based on Engineering Service Company**

Status: OPEN

Abstract This master thesis is aimed to understand, analyse, assess and recommend a possible system analysis program performing Reliability, Availability and Maintainability (RAM).

Th analysis program is supposed to:

Help company's engineers at their early design phase to assess the challenge of dealing with a plant construction (put in together logistic and staff availability, Contractor Company, reduce redundancy, etc.)

Help company's operators to enhance their maintenance strategy by dealing with criticality of system or component, repair time delay, spare parts optimization, etc.

Alongside enhancement of maintenance, the analysis is also providing better decision and strategy within the organization industry.

Reliability, Availability and Maintainability applied in an operating system are a cost effective and efficient strategy used by many industries (Barringer 1997). Barringer (1997) define RAM as "components of effectiveness equation". Effective RAM program tool is needed to answer the company demands. Therefore, throughout the research, different programs will be assessed and the result will be to choose, based on the research, a comprehensive program prior to the demand of the company.

A coherent methodology to understand the applications behind the program will be adopt, as these applications help detect failures or improve an unreliable system or propose preventive action. This will serve as a base to identify suitable program, which fulfill most or all of the criteria the company requires, and recommend it accordingly.

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Title: **Criticality-based Improvement of Maintenance Practices in GEM Projects: Issues, Challenges, and Recommendations**

Status: **CONFIDENTIAL**

Abstract There are different methodologies applied in the maintenance world such as preventive, corrective, predictive, and other. These methods and others aim to provide maintenance programs to increase the uptime, reliability, and availability of the equipment at any plant.

Various numbers of analyses could be found such as Life Cycle Cost, Safety Integrity Level, Risk Based inspection, FMECA, RCM and so on. Some of these analyses use the criticality analysis to assign every unit with a criticality level.

Through this work, a discussion of a suitable practice is going to be developed aiming to enhance the existing practices of maintenance. This is done due to the reason that the existing practice is not considering the criticality analyses in the planning of preventive maintenance programs.

The idea behind the thesis is to suggest enhanced maintenance procedures of the existing ones. The suggestions should be based on the Z-008 recommendations. Other international standards and known practices in addition to manufacturer recommendations and CMMS packages are also used to support the results. The focus is given to criticality classification and how it will affect the maintenance programs. Some work will be spend to explain other related factors that could be involved in the maintenance program or the enhancement such as CMMS, RCM, RBI (as apart of the DNV RP-G-101 standard) and inventory.

The effects of this method on the inventory, its strengths and weaknesses, and other relevant issues are going to be discussed as possible. Implementation process of the improvements is going to be formed in order to ease the process of applying the method into the existing practices.

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Title: **Human Factors, Technical and Organizational Issues in Onshore Operation Center: Challenges, Best Practices, and Recommendations**

Status: OPEN

Abstract The master thesis intends to identify Human factors that include human characteristics, mistakes, working conditions, and changes in human performances, and to identify Technical challenges that include operational delays, technical limitations, standards and cost-affect, and to identify Organizational challenges that include work-flow delays, decision making errors and hierarchy levels. Discuss and define the above challenges and limitations with oil and gas operator's onshore operation center personnel.

The goal is to identify factors, issues, and challenges that can make onshore operations more safe and successful. Interaction and meetings are reviewed in order to better understanding the complex system operation at onshore CR. Integrated operation (IO) knowledge was introduced, which includes the onshore operations, network upgrades, and sophisticated automated system implementation and latest integrations techniques. At last, some conclusions concerning the challenges involved, limitations discussed earlier, best practices and some recommendations were presented to improve the business and production performances.

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Title: **Study of Equipment Degradation Mechanisms: Maintenance Optimization Through Condition Monitoring Using P-F Curves**

Status: OPEN

Abstract Condition Based Maintenance (CBM) is maintenance based on Condition Monitoring (CM). The two requisites for CBM is CM and procedures for how to perform the maintenance based on the CM data. CM data is the information acquired through condition monitoring. This master thesis is aiming to aid in the understanding of both CM and how/when to respond to the CM data.

Maintenance is an old discipline that has been subject for an accelerating development over the last decades. While one since preindustrial time has maintained houses and boats based on the subjective understanding of what is needed, the highly technological industries of today needs an objective foundation for planned or predictive maintenance. By gathering CM data and cross referencing it with actual failures one can get a warning on when the failure are expected to occur. This can enable maintenance staff to take action to prevent unexpected failure.

However, the development and implementation of a CBM program on advance, complex and integrated offshore installation is a challenge. It involves that the companies develop solutions to manage the large amount of data, develop a detailed understanding of failure mechanisms. Organize diagnose/prognosis equipment condition, and expedite just in time actions. Those industrial parties who do take part in this development will have a competitive advantage. In industries with high complexity like the offshore oil industry will the advantage be greater than in less complex industries with fever secondary failures and less expensive downtime.

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Title: **Effective Use of E-learning Tool for Organizational Competence Development and Knowledge Management**

Status: **CONFIDENTIAL**

Abstract The main objective of this research is to identify the possible gaps and improvements of E-learning module that implemented in Skretting company. The literature review was done to understand the meanings of competence and knowledge management aspects but also to clarify terms, elements, and challenges of E-learning tool in general. A case study was implemented based on data collection through Skretting management interview and personnel questionnaire from different countries where Skretting has its production assets. The management interview was conducted to three managers from different Skretting departments where all of them have expressed their own professional opinions regarding Skretting training strategy. The questionnaire was aimed to identify the quality of the main three elements (technical design, content design and learning process) of E-learning module based on personnel opinions. All received results from the interview and questionnaire were discussed in details in this master thesis. Recommendations as a deliverable part of the research are presented at the end of the thesis where the main aim is to improve the effectiveness of E-learning module that can be used to train Skretting production personnel. The full versions of the interview and questionnaire illustrated in appendixes A and B at the end of the thesis work.

Keywords: Knowledge Management, Competence Level, E-learning Tool, questionnaire, interview, Content Design, Learning Process, Technical Design

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Title: **Developing of Screening Software Tool for Evaluation of Pipeline Lateral Buckling**

Status: **CONFIDENTIAL**

Abstract During its lifetime a pipeline is subjected to an increase in internal pressure and temperature from its as-installed condition. These loads cause the pipeline to expand at its “free” end, and induce stresses and forces in the pipe wall. If the pipeline is not allowed to expand, this will result in buckling if the magnitude of the loads is large enough, to overcome external restraining forces.

The scope of this thesis is to develop a *Screening Software Tool for Evaluation of Pipeline Lateral Buckling*; a tool for evaluation of pipeline integrity based on survey results. The main purpose of the software is the identification and evaluation of locations that have undergone lateral buckling. This is done by first of all creating a software tool that can import text files; files such as the design route, as-laid data and survey data. With this information the software is able to print all three pipeline routes, and a visual comparison between design/as-laid and the survey route can be performed. Further, the lateral offset between design/as-laid and the survey route is plotted in order to get a better overview on locations that may have undergone global lateral buckling. From this plot the user can select a section for further investigation. The survey data is the data set to be analyzed, it is not fully accurate; noise often occurs and needs to be reduced/ eliminated. Noise reduction is done by smoothing the data set. After this smoothing is carried out and the user feels the smoothed curve is realistic; this part of the work is finalized.

With this smoothed curve the screening tool can now calculate the curvature, and multiplying it with the bending stiffness of the pipe; the result is the bending moment. This is not a fully accurate result, but it gives a good indication on where the pipeline might be operating under a high degree of utilization, and that a better and more thorough FE- analysis should be run.

The verification work on this screening tool has been applied in the program SIMLA, where self-established routes have been tested with the Lateral Buckling Screening Software.

The Lateral Buckling Screening Software (LBSS) has shown to be a good tool for the evaluation of pipeline lateral buckling. It has developed into an easy and effective tool for import of data files. And it contains a great smoothing function that makes the results realistic and sufficient to obtain a good estimate for further curvature calculations.

The LBSS has its limitations when calculating the bending moment; it only takes the horizontal position into consideration. So any effect from an uneven seabed or upheaval buckling is not included, this is why the LBSS will always give lower stress results than a FE- analysis software.

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Title: **Repair Methods for Damaged Pipeline Beyond Diving Depth**

Status: **CONFIDENTIAL**

Abstract Mechanical damage of a subsea pipeline is found as one of the most severe concern in management of pipeline integrity. The need to reach and bring the hydrocarbons from the fields located in deep and ultra-deep waters, imposes the need to improve the technologies and techniques in order to repair any unacceptable damage in pipeline. The main objective of this work is to investigate various methods for repairing a subsea pipeline that has been damaged and that is below diving depth. The investigation covers the methods that are applicable for three different water depths of 150, 350 and 1350 meters, two different pipe sizes of 12 and 28 inches and two different length of lines: 5 km (e.g. in-field pipeline) and 500 km (e.g. export pipeline). Since the cause and severity of damage determines the necessity and type of required repair, it is significant to study different scenarios of damage: dent, crack (field joint) and corrosion. For this purpose, the studies and investigations that have been performed so far will be reviewed. Welding sleeves and mechanical couplings provide the main solutions for major damages. High pressure and structural clamps are also repair tools for minor damages. Remote welding concept is under development for deep waters .The repair challenges have been discussed and some ideas are concluded. The idea of Angled-clamp that is presented in this project can be developed for the damaged angled pipes and for spool connection where alignment is hard to achieve.

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Title: **Risk Based Inspection: Developing Empirical Formula to Calculate Inspection Coverage**

Status: **CONFIDENTIAL**

Abstract The Risk Based Inspection (RBI) method prioritizes the process equipment, by calculating separate likelihood and consequence values for each piece of equipment. The combination of likelihood and consequence can be evaluated in a variety of ways to indicate critical equipment for action. Using the tools of Risk Based Inspection, it has been confirmed that equipment can be operated safely for a period of time, if inspections closely monitor the condition to eliminate uncertainties inherent in predicting the damage rates such as corrosion and erosion. The developing RBI tool for the Oil and Gas industry show promise as being effective and practical for decision making regarding equipment inspection (Conley and Reynolds, 1997). A Risk-based inspection approach helps in designing an alternative strategy to minimize the risk resulting from failures. Adapting a risk-based maintenance strategy is essential in developing cost-effective maintenance policies (Bertolono et al., 2009).

On the Norwegian Continental Shelf (NCS), some of the production and process facilities are reaching to the end of their design life and need of inspection activities is more critical. Stricter environmental and safety regulations and barriers coupled with inspection, emphasizing on cost reductions have been forcing the industry to use development inspection techniques and materials (Santos and Hajri, 2000). These return to the question: how much is the inspection coverage?

In this study, the Technical Condition (TC) of a sub-system in a production and process facility is evaluated based on findings and historical data. Wall thicknesses of piping components inherently decrease due to degradation mechanisms such as corrosion and erosion. The minimum wall thickness is defined based on the standards and regulations. Based on the TC, reports are made for future inspection purposes as well as to present to the asset owner (Operator Company). The report recommends number of inspection that has to be carried out annually based on the TC.

Based on the remaining design life of the process facility, finding rate, criticality of the system, materials specification changes, degradation rate, unexpected degradation behaviors and the experience of the inspection planners, the thesis suggests an empirical model for inspection coverage by using risk based inspection strategy and previous inspection data to be used on an aged platform. The thesis also discusses about developing an inspection model as well as validating it based on past inspection data.

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Title: **Development of an assessment procedure for environmental consequence in RBI analysis**

Status: **CONFIDENTIAL**

Abstract Even with the recent developments in renewable energy, oil & gas are still our most important energy source today. This will also be the case in the foreseeable future, but new demands are constantly being forced on the industry. The need for hydrocarbons is recognized, but they are expected to be produced with minimal risk to operating personnel, company economy and the environment. The latter is the subject in this thesis, which aims to propose a new procedure to assess environmental consequence of failure within the discipline of risk-based inspection. Risk-Based Inspection (RBI) is a formal approach developed to aid in the assessment of risk connected to the static equipment on a process plant, and to assign inspection intervals which give a good balance between safety, practicality and economy. The risk for each module is calculated using the probability of failure (PoF) and the consequence of failure (CoF). These two factors are combined to give a risk rating, which is then used to set an appropriate inspection interval for the module or component in question.

The consequence part of RBI is typically divided into three main categories: safety, cost and environment. Safety consequence is concerned with the possible injuries or fatalities in the case of an accident, while cost consequence covers the material damages, loss of production and reputation damage. The last category describes the consequence if the surrounding environment is exposed to spills or emissions.

The study presented in this thesis is partly based on existing literature, but the previous work in this area has proved to be limited. The environmental consequence has mostly been based on cost for clean-up, fines and penalties. The reason for this limited approach is probably the huge number of factors which could affect the environmental consequence from a spill. Detailed models exist, but they are too comprehensive to be applied in a practical RBI context.

In this thesis, factors influencing the environmental consequence of failure (E-CoF) are first identified and discussed. A procedure is then presented to assess the various factors and combine them into an E-CoF rating. The procedure is presented in the form of flowcharts, and a guide is provided to show the calculation of each contributing factor. As quantitative calculations are not always possible for RBI purposes, several methods for evaluation are presented for some of the factors.

The cost term has been left out of the E-CoF analysis, as it is difficult to compare cost to environmental harm. However, as costs are important, a separate procedure has been prepared for estimating the costs involved with a liquid hydrocarbon release. A matrix is also provided to allow combination of E-CoF and cost into a common consequence rating.

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Title: **Development of a work process for condition monitoring management of topside static mechanical equipment**

Status: OPEN

Abstract Degradation and fatigue of static equipment is common in the offshore industry. The combination of saltwater, temperature, and humidity can significantly reduce the integrity of static process equipment, and thereby increase the possibility of failure. Condition monitoring and inspection of oil and gas production facilities are regularly performed to maximize availability, but the vast amount of data and imperfect results may be difficult to interpret.

Inspections on static process equipment are usually planned and executed based on risk-based principles, where risk is defined as a combination of consequence of failure (CoF) and probability of failure (PoF). This technique is called Risk-Based Inspection (RBI) planning. The inspection plans are based on the risk-evaluation and degradation rate calculated using base parameter values (e.g. flow rate, production, temperature, pressure). However, the values are static which gives a narrow view of the process since fluctuations of parameters are common at such production facilities.

Condition monitoring (CM) is a technique where the process condition is monitored either continuously or periodically. This technique monitors process parameters (e.g. temperature, pressure, flow rate, etc.) and feeds the user/onshore engineer with data regarding the equipment. The data collected may then be used to ascertain the possible rate of degradation mechanisms, which in turn can be used to calculate PoF, CoF and eventually risk.

A condition management system integrates the condition monitoring and risk-based inspection. The collection of live process parameters is integrated dynamically with the RBI analysis, optimizing the decision-making for inspection and maintenance planning of topside static mechanical equipment.

This thesis presents a work process for how a condition management system could be designed. It will give guidance on how information and data should be assessed and integrated to give the user/onshore engineer useful and effective support.

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Title: **Drilling spare parts: identifying and evaluating critical parameters**

Status: OPEN

Abstract Spare parts for drill rigs are a complicated and important task to be handled. The operations are run on tight schedules and costs are based on the number of days to complete the operations. There are strict regulations concerning the safety while running operations offshore, since consequences for both the personnel involved and the environment can be severe. To avoid having to stop the drilling operations it is very important to have a functioning system to provide spare parts if a component breaks down or need maintenance. To further complicate the handling and logistics of spare parts, a drill rig will be located at several different locations during its life time, compared to a fixed production rig, which may spend decades at one location producing hydrocarbons from an oil or gas field.

A set of parameters that affect the importance of spare parts have been set up to explain the need for spare parts, with a basis on drill rigs and their complications with being moved from one location to another. The usage rates of which parts are used, replaced or maintained play an important role and needs extensive monitoring and analysis to have a good estimate of the expected life time of a given component, part or system. Rules, regulations and criticality of equipment affect the safety of the drill rig, personnel and the environment. There need to be detailed analyses and planning of consequences, safety systems and the availability of such critical parts. Storing and transport of spare parts to offshore drill rigs will have affect on the logistics for spare parts.

Finally costs will always be an important factor in decision-making. The costs of having a drill rig wait for several days and the consequences of a serious accident while drilling are of such magnitude that expensive equipment, advanced monitoring, redundant systems and other safety measures may often be worthwhile. Because of the large numbers of different parts on a drill rig, the spare parts are categorized into high, medium and low criticality groups, where computerized programs and modeling has great potentials in simplifying the logistics and reducing costly over- and under stocking. Such computerized program should involve as many as possible factors and set of data available to establish a good model for the need for spare parts. The system needs to provide simple and understandable data, with possibilities for both offshore and onshore personnel to update, control and gain information on current stock, deliveries, part history and other relevant statistics.

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Title: **Case study of condition monitoring of a pipe handling system**

Status: OPEN

Abstract Condition monitoring is gaining more and more popularity in the modern industry, this also include the oil and gas industry. The basics of condition monitoring are to monitor the wanted machine or system with different sensors that gather data of the condition. The different data can be vibration, temperature, flow, sound etc. and is collected analyzed by software and personnel to establish the condition. Form this data failure development can be discovered and actions can be done to repair the failure. This is condition based maintenance and the principal is to do maintenance when it needed and fitting for the operation and should reduce maintenance and unplanned downtime.

The goal of this thesis was to investigate the possibilities of condition monitoring of one of the machines in the pipe handling system on platform Eldfisk Alpha and if it is economical profitable to implement it. The platform was built in 1979 and in 1998 it significantly upgraded including a new pipe handling system.

Different condition monitoring technologies is described. Review of how the pipe handling system works and included machines. In the pipe handling system the star racker is chosen and failure history is analyzed to identify condition monitoring techniques that are suitable for the identified failures, also rules and regulation that apply for the star racker is reviewed. A cost analysis is also done.

The data gathered is from literature in condition monitoring, internal procedures, maintenance program and databases. Conversations and discussions with Archer and original equipment manufacturer personnel have also contributed.

The thesis concludes with that implementing condition monitoring should not be implemented on the old machine. But if the pipe handling system is going to be recertified and planned to be operated in 20 years more. Without doubt new equipment with condition monitoring should be bought and condition based maintenance established.

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Title: **Drilling rig maintenance: an analytical study of the classification, treatment, data quality of equipment failures and related downtime**

Status: **CONFIDENTIAL**

Abstract The aim of this thesis is to improve the way failures caused by insufficient maintenance are being managed and reported on drilling rigs and thereby reducing the overall downtime and related cost for the rigs.

By looking into the quality of reports for critical and non-critical failures, identifying the potential consequences of non-critical failures and identifying downtime trends and possible reasons for these we will try to make suggestions on how to improve the maintenance management.

The downtime caused by insufficient maintenance was found to be low compared to other causes, with 3rd party suppliers being the cause of a large percentage of the downtime.

After introducing first line maintenance in 2006 there is a significant decrease in the number of downtime events. The downtime is however not decreasing with the reduction of events; this is most likely because the downtime is dominated by large single events. These large single downtime events have not been reduced as successfully as the smaller with the introduction of first line maintenance. Further studies of these large downtime events should be done in order to better prevent them from occurring again in the future.

Most of the downtime was found to be caused by a small selection of equipment groups, with the main contributor being the Rotary table, top drive and associated equipment group.

Using planned downtime has shown to reduce not only the unplanned downtime, but also the overall downtime of the rig.

When studying the effect of major overhauls on two different rigs we found that it preserved a very low downtime and need for maintenance for one rig and significantly lowered both for the other rig.

The quality of the reports was studied against existing guidelines and requirements as well as the requirements during the work of this thesis. Two of the databases were found to contain data of good quality, while the third in large parts not only failed to meet the requirements in this thesis, but also the existing internal requirements of NADL. To use the databases to find any hidden downtime was found to be difficult, if not impossible. A different set of criteria's in the reports has been proposed in this thesis in order to make this possible. To increase the overall quality of the reports it was found that improved communication between receiver and sender most likely would give good results.

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Title: **Use of condition monitoring and remote support to improve maintenance planning in order to reduce the downtime**

Status: **CONFIDENTIAL**

Abstract Correct use of condition monitoring and remote support can be used to plan the maintenance in an effective and efficient way. This can result in less downtime, less schedule-based maintenance and less reactive maintenance. Eni Norge, which is the operator on the Goliat production facility, will equip the platform with monitoring systems that will measure the needed parameters to know the integrity of the machine or equipment.

This thesis will focus on condition monitoring and the use of remote support in order to reduce the downtime with better-planned maintenance on the topside of the production facility. Different methods to monitor the different equipment will be examined, and so will the integrated operation system, which will enable remote support.

As a new player on the Norwegian Continental Shelf, Eni Norge has a golden opportunity to succeed with the Goliat project as operators. The Goliat field will be the first field where Eni Norge is the operator, and as they turn over a new leaf with this project without influences from other players, extended use of condition monitoring and integrated operations can tribute to the success of the project. The thesis concludes with that there has to be a driving force within the company to utilize the monitoring systems. There are lots of other important work tasks regarding remote support and condition monitoring that has to be done within the company before and after the production has started.

The monitoring is often given a lower priority when the same persons have other duty of assignments, and this could lead to maintaining in the traditional maintenance regime. If this is the case, the invested monitoring systems are superfluous. It is best to have an own discipline regarding condition monitoring as it is often shown that the condition monitoring is given a lower priority among other work tasks. An own discipline regarding condition monitoring is recommended for Eni Norge, even if it is an expense for the company.

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Title: Unngå storulykker – Fokus på kritisk utstyr

Status: OPEN

Abstract Mye har skjedd siden den første oljen ble funnet da “Colonel Drake” boret en letebrønn utenfor byen Titusville, Pennsylvania i 1859. Vi har opplevd mye og blitt mer kunnskapsrike. Mange ulykker, flere av disse store, har vært relatert til det sorte gullet. Ulykkene har dannet en grobunn for økte sikkerhetsrutiner, og ut fra nullfilosofien er enhver ulykke en ulykke for mye.

Statoil har vært kritisert i media den siste tiden, mest sannsynlig for de står i posisjon til å bli det. Innad i selskapet står sikkerheten sterkt. Kontinuerlig fokus på å unngå ulykker, eller hendelser i det hele tatt. Det vises igjen i systemene og programmene som brukes, rapportene som er tilgjengelige, og nye tiltak som stadig blir innført, med en hensikt, å øke sikkerheten.

Snorre A er brukt som case, noe som gjenspeiler store deler av rapporten. Funksjonene som skal bidra til at en hendelse ikke utvikler seg til en storulykke, blir betegnet som utvalgt sikkerhetskritiske. Utvalgt sikkerhetskritisk er ikke det samme som sikkerhetskritisk. Det er bare en liten del av de sikkerhetskritiske, som er definert som de viktigste sikkerhetsbarrierene på installasjonen. Alt utvalgt sikkerhetskritisk utstyr har skjulte feil og må testes jevnlig. Oversikt over hvilket utstyr som er utvalgt sikkerhetskritisk, testene som er utført og resultatet av disse testene kan finnes i A10 rapporten.

Etterslepet er et stort problem med hensyn til sikker og effektiv drift, og vi har flere rapporter som kan fortelle oss hvor stort det er. CMR (Critical maintenance report) er en daglig rapport som gir status på hvilke kritiske planer som ligger på etterslep den aktuelle dagen. MiS (Målstyring i Statoil) er arena for flere rapporter.

Det er flere årsaker til etterslep; slurv, mangel på folk, sengeplass og problematikken med at flere arbeidere har hele Nordsjøen som arbeidsplass, som gjør at en i prinsippet kan havne på forskjellige installasjoner på hver tur. Dette forsøker en selvsagt å unngå, men resultatet av å være ny på hver tur, er mye lavere effektivitet.

Statoil fokuserer kontinuerlig på sikkerhet, og det blir hele tiden innført nye tiltak som kan bidra positivt til en sikrere arbeidsdag. Det er sett på forskjellige tiltak som er innført. Den nye driftsmodellen er tatt i bruk, A standard er et handlingsmønster som presenterer oss når vi er på vårt beste. Målet er at jobben alltid skal være A standard og det er trent på å handle korrekt i aktuelle situasjoner. Ut fra tilgjengelige rapporter tolkes det om disse har hatt en positiv virkning på sikkerheten.

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Title: **Engineering Methodology for Selecting Condition Based Maintenance**

Status: OPEN

Abstract During the last decade, condition based maintenance and condition monitoring have experienced a growing area of application. Along with the introduction of Integrated Operations (IO) in the Norwegian oil and gas industry, new opportunities in maintenance management emerged and IO became an important driving force for increased use of condition-based maintenance. Although CBM has a wide area of application, it will not be suitable for all equipment types in a process plant. CBM has to be feasible and cost-effective in order to be the preferred maintenance type. The main objective for this master thesis has therefore been to create a methodology for selecting equipment suitable for CBM during the project phase. The methodology is focusing on describing the work process to ensure a qualified and documented specification of equipment/systems suited for CBM, as part of the maintenance engineering. Although condition monitoring instruments can be installed on almost every piece of equipment, this thesis will focus on where CBM actually can create value.

Introducing condition based maintenance leads to new challenges within maintenance engineering. Both opportunities and challenges with CBM have been discussed. CBM offers potential benefits such as increased system reliability and availability, more cost-effective and a reduced number of maintenance actions. The potential challenges are technical complexity, organizational changes, responsibilities, competence, requirement for outsourcing and maintenance planning.

The success of CBM relies on multiple factors from design of sensors to the end-user's work process. The use of condition monitoring will require focus with regards to the interaction between human, technology and organisation. In order to establish a methodology, decision criteria for selecting CBM have therefore been reviewed. The primary criteria that have been discussed are that CBM should be feasible, beneficial and cost effective. These criteria create a basis for the methodology.

The methodology is designed to provide input to both the maintenance program and the equipment/system design. The timing of performing the specification methodology has therefore been discussed. The analysis should be performed early enough to provide input for detail design and late enough to ensure proper data for performing the methodology. At an early stage of a project traditional methods such as RCM have been regarded as too demanding. A simplified, but still a qualified and documented methodology has therefore been developed. The methodology involves processes like data collection, criticality screening, technical feasibility and cost-benefit evaluation.

CBM puts more responsibility on the vendors to deliver support documents such as FMECA and to propose technical solutions for condition monitoring, including a proposal for condition based maintenance program. A short description of the operational implementation of CBM is also presented, but is not emphasized. Here, the challenges of planning maintenance actions will be an important issue. Other implementation issues such as vendor involvement and service agreements have also been briefly described.

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Title: **Development of a procedure for making inspection plans for corroding oil and gas pipings**

Status: OPEN

Abstract The degradation of topsides process piping on an offshore platform carrying oil and gas can result in undesirable events like bursts and leakages. In order to manage the challenges arising from such failures, the piping is regularly inspected using different types of Non Destructive Testing (NDT) methods. Since this piping has different configurations and is often located in places that are difficult to access, the associated costs of these activities are quite high. To support the decision-making on the development of an effective and efficient inspection program, Risk-Based Inspection (RBI) analysis is often used. Based on the recommendations of the RBI analysis, the inspection is carried out and the results of the inspection are then reinvested into the inspection management program to update the analysis.

This thesis presents a methodology based on Bayesian updating to formally ensure that experience and knowledge are used in a systematic way, when deciding how much needs to be inspected in order to be convinced that the corrosion group of components does not contain any significant corrosion. It is expected that the implementation of the methodology will improve the inspection management by providing a systematic tool to incorporate the inspection results, provide traceability and reveal critical assumptions. This thesis will also present a method for how to evaluate and communicate different uncertainty factors.

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Title: **A further development of the extended risk based inspection methodology – guidelines and performance**

Status: OPEN

Abstract Risk Based Inspection (RBI) is a much used method for planning inspection intervals in the oil and gas industry. The RBI method has over the recent years proved to show fruitful results with regards to proactive risk measures and continues to show results of increased safety, more reliable and predictable systems and a more economical routine for maintenance and inspection activities. However, some weaknesses in the method have been discovered; the method lacks a clear definition of risk and avoids assessing the uncertainties in calculations, data and judgements which potentially can lead to unwanted consequences. In order to assess this weakness, the ERBI method was developed by Selvik, Scarf et al. (2010).

The basic idea behind the method is that uncertainties are communicated to the management through an extended uncertainty evaluation which integrates the results from the risk analysis and the uncertainty analysis. This thesis presents and discusses the ERBI methodology and provides an enhanced description of how to perform the ERBI method. The methodology is taken a step further; from a theoretical framework to a recommendation of practice. The recommended practice enhances some of the basic ideas of the ERBI methodology and maximises the benefits by using the method. The additional assessments of uncertainty and sensitivity in the ERBI methodology produce some increase in the time needed to perform the process, as well as resources required. The purpose of the thesis is to show that with an effective method of performing the ERBI, the increase of resources can be minimal – without compromising on the safety.

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Title: **Opportunistic maintenance models: Review and discussion with a special focus on the treatment of uncertainty**

Status: OPEN

Abstract In this thesis, we review and discuss the area of opportunistic maintenance models. We want to examine if the existing models can be useful as decision-support to maintenance management, and focus especially on the treatment of uncertainty in the models.

A short introduction to opportunistic maintenance models has been given, and we have reviewed the treatment of uncertainty in existing models. Based on this review we have concluded that many assumptions and simplifications are taken in these models. Hence, they are not directly useful as decision-support without further assessment of the uncertainty related to these assumptions and simplifications. We present a method for assessing the uncertainty factors and rank their importance. With the information given by this assessment, we believe that the maintenance management has a better premise to use these models as decision-support.

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Title: **Strategivalg i produksjonsbedrifter: Trender i Nord-Europa**

Status: OPEN

Abstract: Hensikten med denne oppgaven er å se på ulike strategiske valg i produksjonsbedrifter i Nord-Europa hvor jeg ser på ulike trender i disse strategivalgene. Jeg har fokusert på emnene konkurransestrategi, valg av leverandører, valg av belønningssystemer, bruk av team og antall organisasjonsnivåer og kontrollspenn.

Problemstillingene jeg har arbeidet ut fra er:

- Hvilke trender finnes i valg av konkurransestrategi?
- Hvilke hender finnes i valg av leverandører?
- Hvilke trender finnes i valg av belønningssystemer?
- Hvilke trender finnes i bruk av teamarbeid?
- Hvilke trender finnes i antall organisasjonsnivi & kontrollspenn?

For å undersøke trendene har jeg tatt utgangspunkt i en internasjonal produksjonsstrategi studie, IMSS, som har blitt utført fire ganger i tidsrommet 1992 til 2005. Jeg har sett på hvordan de har rangert konkurranseparametre og hvilke kriterier som prioriteres ved valg av leverandører. Videre har jeg sett på bruken av insentivlønn vs. fastlønn, broken av teamarbeid og om produksjonsbedriftene følger trenden om flat organisasjonsstruktur.

Jeg har sett at produksjonsbedriftene prioriterer produktdesign og kvalitet, leveringspålitelighet og tilpasningskvalitet i sin konkurransestrategi. Videre har jeg sett at bedriftene prioriterer kriteriene kvalitet, leveringsdyktighet og lavest pris når de skal velge leverandører. Jeg har sett at i det stort sett har vært en økning i bruk av insentivlønn, og at bedriftene velger å bruke flere typer insentivlønn samtidig. Nesten alle produksjonsbedriftene bruker team, og det er nesten like stor bruk av team i samme funksjonsområde som team på tvers av funksjonsområdene. Til slutt så jeg at de fleste bedriftene hadde en flat organisasjonsstruktur.

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Title: **Inter-Agent Communication In Multi-Agent Systems**

Status: OPEN

Abstract: The oil and gas industry experience an increased dependency on IT and particular software based capabilities to achieve its business objectives. Core business processes such as exploration, well construction, production optimization and operations are all fueled by software and information technology. In coming years we will see that software will fill more and more advanced features, including central control functions in autonomous and collaborative robots and it is believed that agent technology may be of use in this scenario.

The primary reason for this is the practical benefit from goal oriented systems is a simplification of the human-machine interface. A goal oriented system is able to communicate and react to events in its environment in context of their goals. This is the primary driver for autonomous systems: simplifying and securing operation of machines in an unstructured / highly dynamic environment.

Inter-agent communication is an important aspect of agent software, as it helps in the process of decision-making, be it an individual decision or even group decision-making. It also enables agents to share its beliefs and desires among each other. In this thesis I will look at possible models for collaboration and coordination of autonomous robots, and how this can be addressed through the use of software agents. To do this a multi-agent solution for controlling Lego Mindstorms robots has been developed in cooperation with Rune Johansen.

The solution is based on three Lego robots operation on a line-based grid. One robot is set to explore the grid, finding object, and sharing this information (beliefs) with a second robot that is responsible for collecting and delivering these objects to a robot that sorts these object according to color. The solution enables investigation in relation to intelligent software agents combined with autonomous robot systems, such as inter-agent communication and coordination.

The agent system is developed using the Prometheus methodology for the design and the JACK Intelligent Agents framework for the implementation. Regular Java is used combined with the LeJos - Java For Mindstorms framework to implement the robot side of the system.

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Title: **Human Robot Interaction in Multi-Agent Systems**

Status: OPEN

Abstract: The oil and gas industry experience an increased dependency on IT and particular software based capabilities to achieve its business objectives. Core business processes such as exploration, well construction, production optimization and operations are all fueled by software and information technology. In coming years we will see that software will do more and more advanced features, including central control functions in autonomous and collaborative robots and it is believed that agent technology may be of use in this scenario.

The practical benefit from goal oriented systems is a simplification of the human-machine interface. A goal oriented system is able to communicate and react to events in its environment in context of their goals. This is the primary driver for autonomous systems: Simplifying and securing operation of machines in an unstructured / highly dynamic environment. Human Robot Interaction (HRI) is an important area in development of autonomous robot systems where an operator is present.

The design and solution for the HRI will be crucial to the systems performance and robustness. An operator can be relieved of stress as well as have his focus directed to important and critical information at any given time. In this thesis I will look at how intelligent agents can be used to implement a system for controlling autonomous robots and how this can provide a good solution for HRI challenges.

To achieve this a multi-agent solution controlling Lego Mindstorms robots has been developed in cooperation with Eirik Nordbø. The solution is based on three Lego robots operating on a line-based grid. One robot is set to explore the grid, finding objects, and sharing this information (beliefs) with a second robot which is responsible for collecting and delivering these objects to a robot in charge of sorting them according to color. This solution enables investigation of several challenges in relation to intelligent software agents combined with autonomous robot/machine systems, such as human robot interaction and inter-agent communication/coordination.

The agent system is developed using the Prometheus methodology for the design and the JACK Intelligent Agents framework for the implementation. Regular Java is used combined with the LeJos - Java For Mindstorms framework to implement the robot side of the system.

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Title: **Benefits of using StreamInsight and Fuzzy Logic with PI System to Make Industrial Alarm System**

Status: OPEN

Abstract: Pumps and their associated systems are essential in oil and gas facilities for the efficient transportation of fluids. Monitoring and controlling an ESP pump is vital and essential in management of ESP. Reliable and efficient alarm system with low-latency and real-time monitoring, helps operators to assess pump performance, avoid malfunction and result in increase in product and decrease in cost. One of the objectives of this thesis is to make an alarm system which will be used for monitoring an ESP pump implemented for Talisman Energy Company using OSIsoft PI ACE. The same target has been achieved by developing an application using different technology namely StreamInsight which is a complex event processing engine. The results and performance of these two technologies are discussed and compared. Also a fuzzy logic solution is proposed to add functionality to alarm system and improve the pump life time and performance.

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