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Abstract

IK Norway is a company that is supplying products and solutions for the pipe and pipelines for the oil and gas industry. This is a very conservative industry and IK is relying on good quality in their products and a good reputation to be able to compete. In 2008 IK was involved in an incident on SFA which increased the skepticism to these types of operations. To reassure the customer that their operations are safe IK is constantly trying to improve the processes to reduce risk and increase the quality. In this process they have identified the interface between the engineering department and their workshop as a source of potential risk factors. By improving this interface they believe that they can reduce the operational risk which will satisfy the customer, but also the financial risk by reducing the internal errors. On the basis of this the thesis will be an analysis of this interface to find improvement potential in regards to overall quality in IK's operation. This will be done by looking at a prior incident and the improvements that where made then, and compare them with a current project and their operation today. The thesis will then evaluate if the systems they are using today are working and if there should be made further improvements.

As a result IK has initiated this master thesis to find improvement potential in this interface, to avoid similar incidents to happen in the future. The thesis will look at relevant literature in project and interface management and it will evaluate IK's work process, communication, documentation, and their contribution to the interface. The thesis will also follow an ongoing project on Statfjord A to evaluate the performance of the improvements made after the incident, to see if they have the expected effect or if they need further improvements.

The thesis concludes that IK has had a major development since the accident in 2008 but there are still some improvements that can be made to better the interface and to reduce the coherent risk. The key factors that were used in the evaluation, proved to be relevant to the performance of the interface and the thesis provides 7 different suggestions for improving these factors. The largest improvement potential was identified within the work process where lack of definition was the main issue. The communication could also be improved by including the mechanics earlier in the project to reduce the probability of errors caused by misunderstanding and lack of information will be reduced.

Acknowledgements

This thesis marks the end of my master degree in Industrial Asset Management and two great years at the University of Stavanger. It has been a lot of hard work, but I have learned a lot.

At the OTD fare I stumbled upon IK's stand, where I talked to Eyrin Sanner, Christian Knutsen, and Pål Angell Bergh. I would like to thank them all for taking an interest in me and for communicating my need for a master thesis to the rest of their company.

I would like to express my great appreciation to my external supervisor at IK, Kjetil Aamodt for allowing me to come and write my thesis for him in his department, Pipe Intervention. He has helped me to find a very interesting subject for my thesis and has been very helpful and made sure that everything I needed during the thesis has been available for me. He has also been eager to comment and discuss relevant subjects and issues that emerged.

I would also like to thank the rest of the employees in Pipe Intervention, both in the engineering department and the workshop. They have been very patient and understanding even if I have disturbed them repeatedly with difficult questions. They have also been very friendly and provided a good working environment for me to write my thesis in.

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Ørjan Hofland Ohm

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Abbreviations

AMS	Antenor Management System
CEO	Chief Executive Officer
DNV	Det Norske Veritas

FAT	Factory Acceptance Test
FMEA	Failure Mode and Effects Analysis
FMECA	Failure Mode, Effects, and Criticality Analysis
FTA	Fault Tree Analysis
HAZID	Hazard Identification
HAZOP	Hazard and Operability Analysis
HR	Human Resources
HSE	Health, Safety, and Environment
ISO	International Organization for Standardization
IT	Information Technology
NOK	Norwegian Kroner
PI	Pipe Intervention
PIM	Project Interface Management
QAP	Quality Assurance Plan
SJA	Safe Job Analysis
SPOC	Single Point OF Contact

Table 1 - Abbreviations

Chapter 1
Introduction

This master thesis will look at the potential risk factors in the interface between engineering and workshop. IK is a company that is supplying products and solution for pipe and pipeline intervention for the oil and gas industry. They are relying on a good reputation and a high quality in their products and services to be able to compete in a pressed marked. To reassure the customer that they can deliver at this level IK is constantly trying to improve their operation and processes to reduce risk and increase the quality. In this process they have identified the interface between the engineering department and their workshop as potential risk factor. By improving this interface they believe that they can reduce the operational risk which will satisfy the customer, but also the financial risk by reducing the internal errors. On the basis of this the thesis will be an analysis of this interface to find improvement potential in regards to overall quality in IK's operation. This will be done by looking at a prior incident and the improvements that where made then, and compare them with a current project and their operation today. The thesis will then evaluate if the systems they are using today are working and if there should be made further improvements.

1.1 Background

As explained above IK is company that is supplying products and services for pipe and pipelines. The projects that IK are taking on are very often special cases that there are no standard solutions to. As a result a large part of the tools and equipment they are developing are specialized and customized for a specific project. This type of equipment is always related to uncertainty and risk. It is therefore vital for IK to take the necessary measures to reduce this risk as much as possible to avoid financial loss and injury to personnel. It is also important to reassure the customer that IK is delivering at a high level of quality. The customers are often reluctant to use new equipment that they aren't familiarized with and that has not been extensively tested. To achieve this, IK has implemented all the necessary requirements to be certified according to ISO 9000, which is a collection of standards that establishes and maintains a quality management system for the manufacturing and service industry. This is done to make sure that quality is present in all the steps of the project development and to reassure the clients that they have the necessary quality assurance measures needed to deliver high quality products.

Some of the projects that IK is taking on are also very urgent, because if something brakes on an oil rig the consequences can be catastrophic and it is very expensive to shut the plant down for a longer period of time. In these cases IK are contacted to find solution and quick fixes that enables the operators to start up the production as fast as possible. In these situations it can become very hectic and the risk of errors and miscommunication increases. Therefore it is important to have clearly defined interfaces and procedures to follow to make sure that the project is progressing as effectively and errorless as possible.

In 2008 IK was involved in an incident on the Norwegian continental shelf where the operators of IK's equipment did not have the proper understanding of how the equipment was functioning. The result was a hydrocarbon leakage that created skepticism in the industry towards buying these types of solutions. After this IK had to rebuild their reputation and changed the way they were operating by implementing new risk reducing measures and quality processes. After the incident IK identified several root causes, where the interface between their engineering department and the workshop was identified as one of them. IK therefore initiated this thesis to analyze this interface and find measures to improve their operation.

1.2 Main Objective

To increase their competitiveness in a quality and risk focused market; IK is trying to identify measures to reduce the probability of errors and misunderstandings in their operation. They have therefore identified the interface between the engineering department and the workshop as a source that has a large potential to reduce the risk level. On the background of this the following objective was defined:

- How can the interface between engineering and workshop be optimized in order to reduce the risk of errors and unwanted incidents in IK?

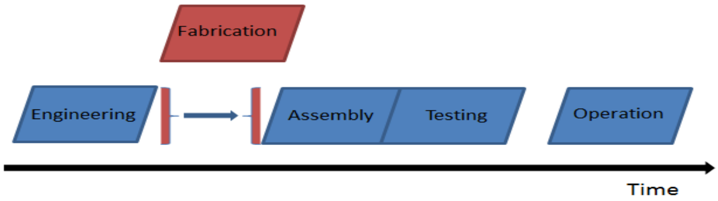

Figure 1 - Illustration of Interface

To be able to answer this question there will be identified concrete improvement measures which will result in a better and more effective interface to increase the quality of the project execution. The improvement measures will be targeting the Pipe Intervention department, but where there is possibility to generalize the measures they will be recommended for other departments as well.

To be able to find a solution to the main objective I have found it necessary to derive it into smaller secondary objectives:

- Create an understanding of critical factor in a project interface based on existing literature.
- Describe the company and define the interface between the engineering department and the workshop.
- Describe the 2008 incident to evaluate the compliance to the improvement measures established.
- Evaluate the current operation based on an ongoing project.

The secondary objectives will be accomplished by participating in IK's daily operation. This will ensure a good understanding of the company and good communication with the personnel in the engineering department and the workshop. Internal documents and processes will also be studied.

1.3 Methodology

The research strategy that has been chosen is an Abductive strategy. This means that there will be taken an objective approach to get an understanding of the problem and then use scientific theories to explain what is observed (Blaikie, 2000). The researcher will in the beginning of the project follow the company to learn their way of thinking, their work processes and risk management. When information is gathered and an understanding is achieved, the project will describe the social interactions and uncover the motives. Then technical explanations will be established and a theory will be developed on what changes can be made to get a positive impact on the risk management.

To be able to get an understanding of the performance in the interface between engineering and workshop, the beginning of the project was used to participate in the ongoing projects and to speak with people in the engineering department and in the workshop. Then there was made literature searches to collect relevant information from the library and in papers from online databases. The incident reports from the incident in 2008 were undergone as well as IK's quality system.

Because IK is a small company it was most suitable to use interviews as the method to identify the different points of view. This was done to get a better understanding of the opinions of the workers and it would enable the project to get some feedback on how the systems are working in practice.

There will be performed four interviews in this project.

- CEO of IK
  The CEO was interviewed because he is involved in all the changes in the quality system and has also a good understanding of IK's organization, strategies and goals.

- Department Manager of Pipe Intervention
  Department manager was interviewed because he is the leader of the projects and he is responsible for the results and schedules in the projects in Pipe intervention. He has a lot of experience in project management and played a big role in the improvement process after the incident in 2008.

- Supervisor Pipe Intervention
  The supervisor from Pipe Intervention was interview because he is the leader of the mechanics in the workshop and the person that has the most contact with the engineering department. He has a good understanding of the challenges in this interface.

During the project a lot of time will be used in the office and in the workshop to familiarize with the workers and the work process at the company. Other personnel will then also be consulted to better understand the working conditions and to get multiple opinions. But the main sources of information will be the aforementioned individuals.

1.4 Risks related to the thesis

There are several risk factors that can affect the outcome of this project. The risk factors might vary during the different life cycle stages off the project. In the table below the most likely risk factor are presented.

ID	Life cycle stage	Possible Risk Factors
1	All stages	I spend insufficient time on one or more stages
2		Keeping the schedule
3		Key information isn't in writing
4		Sickness
5		Personal matters prevents project progress
6		External supervisor lacks the proper knowledge to aid in the project
7		Internal supervisor unavailable
8	Organizing and preparing	The project is not properly defined (Lack of Constraints)
9		Collecting irrelevant data
10	Carrying out the work	Loss of data
11		Upper management or other key drivers show only mild interest in your project.
12		Changes in IK's operational procedures
13		Change of critical personnel

Table 2 - Potential Risk Factors

1.5 Limitations

This project is written as a master thesis for the University of Stavanger. This thesis is weighted with 30 study credits. The University of Stavanger states that a master thesis cannot be written in collaboration with other students, and that normal workload for a thesis is 30 hours per credit, which means that the expected workload of this project will be approximately 900 hours.

This project will describe risk factors, improvement potential and procedures that are common in project interfaces. It will then concentrate on the interface between the engineering department and the workshop to evaluate how this can be improved based on these theories. The project will also limit itself to the department of Pipe Intervention but may include references to other department within IK. This is because there are differences in the operations of the departments and it would be too comprehensive to evaluate all of them in this thesis. Other interfaces in the company, that could be optimized, will not be evaluated in this project due to the time limitations.

The following interfaces are not addressed in this project

- External interface between customer and IK
- External interface between sub-supplier and IK
- Internal interfaces towards Economics, IT, HR, or other sub departments

To evaluate the risk factors in interface between engineering and the workshop there has been chosen some key factors that this thesis will be focused on. These factors are:

1. Work process
2. Communication
3. Documentation

Further the project has decided to follow a project that Pipe Intervention is currently executing on behalf of Statoil regarding a cement plug. By following this project it will be easier to see if IK is following their work processes in practice and not just in theory. I will also make it easier to find concrete improvement measures.

There are currently no other projects that are being executed on this or similar topics in the company and because of this there is no risk for overlapping work.

1.6 Thesis Structure

The first part of the project will provide an introduction of the project. It provides a background for the project with information about the company that has initiated the project, why it has been initiated. It will also define the main objectives in the thesis and provide the necessary frames that the thesis will be working within. This part will also provide information on the structure of the thesis, and the methods used to execute this project. At the end of this chapter there will also be a short risk analysis for the possible risk factors that can influence the performance of the thesis.

In chapter two there will be a general introduction to relevant literature. This chapter will properly define how the interface is a part of, and affects the performance of the entire system or project. This information will later be used as a basis for evaluating the performance of IK's interface and the challenges related to it.

In the third chapter there will be a proper introduction of IK the company, the services they provide and products they make. One of the biggest challenges in IK's operations has been identified as the interface between the engineering department and the workshop. This interface will then be properly defined so that the thesis is able to identify all the factors that are affecting the performance. Then there will be presented a related case from 2008 that IK was involved in to illustrate the risk of not properly managing the projects and its effects. After this incidents there were made several improvements to the management process in IK to increase their overall quality and risk reducing measures.

In chapter five a current project will be evaluated to analyze the improvements IK made after the incident to see if they are able to comply with the systems and processes that were implemented. The thesis will also evaluate to what extent these measures are increasing the quality of the project. At the end of the thesis, recommendations will be made on how IK can improve their operation to reduce the risk factors in the interface between the engineering department and the workshop.

Chapter 2

Literature Review

In this chapter existing literature will be presented. The first subject will be system engineering as IK is designing complete systems for their customers, from idea to implementation. This thesis will not look at this whole process but it is important that the interface management is contributing to the performance of the system. The second subject will be human factors. In most systems one of the most unreliable components are the humans and it is therefore vital that these are taken into consideration as early in the design process as possible, because this will have a considerable influence of the performance of the system. In the end we will look at interface management which is one of the main concerns in systems engineering because the main task of the system engineer is to make sure that all the different parts are interacting as efficiently as possible to make the complete system better.

2.1 System Engineering

According to Kossiakoff, Sweet, Seymour and Biemer (2011) there has been an explosive growth in technology, after the World War 2, which made it possible to increase the capabilities of existing systems as well as making it possible to create new and more advanced systems. These where larger and took advantage of several different disciplines. This also made it more difficult to manage these projects, and the risk of having unexpected interactions between the components in the system made it more difficult to predict the performance and the outcomes. As a result System engineering was developed as a necessary measure to be able to handle these challenges.

When looking at system engineering the first thing that needs to be defined is the system. There are many different ways to define a system. The American department of Defense (2001) published a book where they described a system as "an integrated composite of people, products, and processes that provide a capability to satisfy a stated need or objective". This implies that there might be a large amount of parts that interact with each other in order to perform a specific function. These parts might have complex and intricate relationships which can be difficult to identify and this makes it very difficult to predict the performance of the system. Chapanis (1996) states that one of the aspects of systems that is disagreed upon, is if the human is a part of the system. The human can either be outside the system and providing input or it can be inside and participate as an integrated part of the system. Kossiakoff, Sweet, Seymour and Biemer (2011) believes that the human component should be excluded from the system, because defining it as something that has been engineered is more applicable to the term of system engineering. According to Chapanis (1996) it is common to include the human in the system when talking about human factors. This is in my opinion the right thing to do, because the human is a big part of the system and has a considerable impact on the systems performance. The human capabilities and limitations should therefore be taken into consideration when the system is designed.

The purpose of system engineering is to help manage the engineering of large and complex systems (Kossiakoff, Sweet, Seymour, and Biemer, 2011). This is a very simplistic way of looking at system engineering and there are several aspects that are not captured. Chapanis (1996) emphasizes that systems are designed to meet a human need and system engineering is the process of evaluating and understanding the needs that the system is meant to satisfy. System engineering focuses on the system as a whole and the system engineer will take a step back and look at the function of the system and the external factors like how the system is interacting with the environment.

The system engineer bridges the traditional engineering disciplines (Kossiakoff, Sweet, Seymour, and Biemer, 2011). This means that the different parts of the system might be designed by different people that might have little or no understanding of the function or physical properties of the other parts in the system. From an engineering point of view it is easy to only think about the technical solutions but Rhodes and Hastings (2004) explains that system engineering also has to take into consideration the human, social, and industrial context. This can often lead to interference between the parts and this is the system engineer's job to avoid. A system engineer can be compared with a conductor of an orchestra. The conductor has the overview of the whole orchestra and can hear the sounds from all the instruments, and how they interact. The person that plays the violin might only be able to hear the instruments that are closest to him because they are playing so loud. This makes it difficult for him to know if his contribution is adding value to the system as a whole. It is therefore important to have a conductor that can guide all the participants in the system, so that it performs as well as possible. The system engineer will not only manage the communication between the components of the system but he will also participate in the conceptual development of the system, and in this way make sure that the system is satisfying the customer needs.

An important part of system engineering is standardization. Lamb and Rhodes (2007) explains that standardizing a process is a way of breaking large and complex systems into smaller pieces and specify who needs information and how is it distributed. They also state that system thinking is best learned by experience, which means that the engineers with less experience have a disadvantage. To accommodate this standardization is a good tool as it guides them through the necessary steps to enforce and develop system thinking. Standardization makes it possible to identify the best practice and make that the standard procedure, which results in a more effective operation. Lamb and Rhodes (2007) explain that opponents to standardization will state that standardization kills flexibility and creativity. This may be the case, but in my opinion this can be avoided by making sure that the standardized processes doesn't dictate how the steps should be solved, but rather define what steps needs to be taken. The benefits of standardization are according to Lamb and Rhodes (2007) a consistent design without variations and opportunities for different interpretations. Standardization will also promote learning, as best practices and previous mistakes are recorded and implemented in the standard to make sure that the operation becomes as effective as possible in the future.

One of the main processes in system engineering is the risk management. Kossiakoff, Sweet, Seymour, and Biemer (2011) explain that in system engineering it is vital to balance the risk with the use of new technology. New technology is necessary because it enables the system to satisfy needs that hasn't been possible in the past, and it might also be necessary to avoid the competitors from outperforming your company by making better and more advanced products. The use of new technology also introduces more risk into the system and therefore it is important to find a balance of new technology and proven components. The risk which is introduced by new technology can be controlled by development and testing.

According to the American department of defense (2001) it is common in systems engineering to look at the complete life cycle of the system. This means that System engineering is an exercise that follows the project from the identification of customer needs, through the entire life cycle of the system, to the decommissioning. This is a very large subject which stretches way outside the limits of this thesis. The thesis will therefore be limited to the design and operational phase and how to reduce the risk of product failures or human errors.

2.2 Human Factors in System Engineering

According to Jones (1995) the most important component of any business is the human, but at the same times its main weakness. The humans are very flexible and are able to make rational decisions in situations where they are not familiar. Jones (1995) states that even in the most advanced and automated systems there is still a need for a human component to make decisions or to supervise. On the other hand the human is also the most unreliable component of the system and is most likely to make mistakes.

The international ergonomics association (n.d) defines Human factors as "the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance". This is a relatively complicated definition, but Chapanis (1996) has a slightly simpler on. He defines human factors engineering as "the application of human factors information to the design of tools, machines, systems, tasks, jobs, and environments for safe, comfortable and effective human use". This means that knowledge about human strengths and limitations are taken into consideration when the designing systems containing people, equipment, and their environment. As a result we can design systems that inflict less stress on the operators and reduce the probability of them making mistakes.

Jones (1995) explains that there are two main ways that humans can contribute to risk, which are "active errors" and "Latent errors". Active errors are errors that can be observed instantly, which means that the system is operated based on constant feedback from the operator to control the system. Examples of this could be when you are driving a car and press the gas pedal instead of the breaks. This will make the car speed up instead of slowing down and you will get an immediate feedback that you have pressed the wrong pedal. In worst case this could result in an accident if you hit the car in front of you. The other type of error is "Latent errors". These types of errors will not be as easy to discover as the results are not visible to the operator immediately. An example of this could be if the operator at an oil plant is using the wrong kind of corrosion inhibitor. This will not be discovered until the pipes are inspected and the corrosion has started to tear on the pipe walls, or if the pipe starts to leak. According to Jones (1995) this type of error is also more commonly made by managerial personnel, as the consequences of their decisions will not be evident until later when the result can be measured.

To avoid this the systems are designed to make sure that humans are not allowed to make mistakes or compensate for the mistakes, however Jones (1995) reminds us that the system designers can only design against the error modes that they are aware of. The easiest errors for the designer to anticipate are the active errors; because the errors are immediate they will most likely occur during the testing of the system. The system is defenseless gains the errors that the designer didn't know of. These are in most cases the latent failures that might be highly unlikely and dependent on a chain of events to be initiated. Jones (1995) says that "Well defined problems yield well defined solutions. The trouble is that accidents are caused by an interlocking web of mostly latent errors". Each latent error might not be able to make the system fail on its own, but when a series of latent errors is combined it can have unwanted effects. In order to identify these risks at an early stage of the project there are several tools that can be used. Chapanis (1996) mentions Fault tree analyses and FMEA as good methods for this task.

Fault Tree Analysis (FTA)

A fault tree is a logical diagram which gives an overview of the events and relationships that could lead to an unwanted event. Aven (1991) says that a Fault tree analysis is used to identify

all the possible combinations of events that could lead to a system failure. By doing this the engineers can implement measures that reduces the probability of these events to happen or completely design them out of the system. Fault tree analysis is a top down approach which means that it identifies all the top/unwanted events that can happen and then works its way down by looking at all the possible events that can trigger this incident. The fault tree is not limited to the components in the system but can also include human errors and external loads. This is a common method to use in incident investigations where an unwanted event has occurred and the root causes needs to be identified.
Chapanis (1996) explains that the product of the fault tree analyses is the root causes of an unwanted event and the probability that this chain of events will happen. This will help the designer in prioritizing the criticality of the events by identifying redundancy in the system and the probability that each event will happen. As a result the resources can be used more effectively by concentrating on reducing the probability of the chain of event that will have the most impact on the overall risk of system failure.

Failure Modes and Effects Analysis (FMEA)

A Failure modes and effects analysis (FMEA) is a design tool for looking at all the possible system, subsystem and components to identify failure modes and their effects. In some cases the analysis can be extended to include a criticality analysis (FMECA). Chapanis (1996) describes failure modes and effects analysis as a method for identifying how the failure of one or more components and their probability would affect the performance of the system. The FMEA is usually performed in the beginning of the project to make sure that it is possible to use the information of the analysis to reduce the risk of failure, but it should also be a dynamic document that is updated through the design process. The main purpose of doing a FMEA is early identification of critical failure modes so they can be eliminated before it becomes too late or expensive to correct it. FMEA provides a documented method for choosing a concept for your system that has the highest probability of success.

The analysis is performed by identifying all the possible ways that the components in the system could fail. Chapanis (1996) explains that in the case of human factor these errors often occur in the interaction between the system and the operator. Therefore it is important to identify all the errors could be made by interacting with either the system or subsystems. Then these errors are assigned probabilities and consequences. In the end you would have a list of vital interactions that could potentially damage your system or subsystems. These can be taken into consideration when the system is designed by completely removing the interaction, or by reducing the probability of them occurring. According to Chapanis (1996) it is almost impossible to predict all the types of errors that the human can introduce into the system, and it is therefore very difficult to design against them. However the procedure will usually be very effective at identifying a number of errors and eliminates error inducing features in the system.

Leveson (2002) reminds us that such event-based models can be misleading as they omit accidents that don't involve component failure at all. In some cases the component can have undesirable behavior in relation to the overall system even if it satisfies all of the components requirements. This is important to keep in mind when performing the risk analysis but the event-based models are still very good at identifying and reducing the risk factors that are caused by component failure.

Jones explained (1990) the purpose of the risk management is to deal with calculated risk to gain an engineering oversight. By using adequately time and resources in the beginning of the project to properly define the challenges and risks, it is possible to properly define the requirements and to implement solutions that will compensate for or remove issues at an early stage. But as explained earlier the complete life cycle of the system has to be taken into consideration to be able to discover the potential issues that might create problems in the long run. Chapanis (1996) explains that this is also important to look at the human interactions that are made throughout the lifetime of the system and that people are interacting with a system in three different ways. These are as designer, users, and maintainers, which all have an inherent possibility of introducing both active and latent mistakes into the system. Ideally the same person would perform all of these tasks, because then he would have a proper understanding of how the system works and how it should be operated and maintained. This is often not the case and the different tasks are executed by separate people. This requires proper training of the personnel that interacts with the system, to make sure that they have the necessary understanding of the operations they are performing and that they are familiar with the consequences. It also demands good communication and documentation which ensures the flow of information to all participants.

2.3 Project Interface Management (PIM)

Morris (1989) believes that the system approach is by far the most pervasive method to manage larger projects. He also states that system thinking emphasizes the importance of viewing the system as a whole and that system thinking has proven that projects should be administrated as an organization. As a result it is vital to manage the project interfaces. The reason for this is that interface management will identify the subsystems that needs to be managed, the interfaces between them that requires attention, and the way these interfaces should be managed successfully.

Wu, Wang, Shu and Zhang (2009) explain that the main goal of interface management is to improve the efficiency of product development or innovation. This is a very relevant way of looking at it in this thesis, but a more general definition is stated by Berger and Kelly (2005). They describe interface management as a method for ensuring that the communication and operation in a project are as timely and effective as possible. This includes both oral and written communication between all the participants of the project. Because of the human factor is a significant part of the communication, this is one of the biggest sources of misunderstandings and lack of information and requires careful management and coordination.

According to Morris (1989) the main interfaces in a project can be found between the different life cycles of the project. He explains that there are four main life cycle stages which are the Prefeasibility/feasibility stage, the design stage, the manufacturing/assembly stage and the operational stage. At each side of these stages the project differs dramatically in objective, operation and scale. This also means that the operation is very different and has different needs of management. In this thesis we will look specifically on the interface between the design stage and the manufacturing/ assembly stage.

Morris (1989) states that interface management is not a well-documented theory and that it is more a way of looking at project management and the implementations measures are mostly illustrative. Berger and Kelly (2005) on the other hand have a little more specific approach. They explain that the first step in interface management is to make clear and concise job descriptions. After this the next step is to evaluate the interfaces to see if they are performing satisfactory, or if there is unexploited improvement potential. The last step is to establish standard protocols for critical communications. This will bridge the gaps and challenges that are uncovered in step two. This removes the uncertainty around the limitations of the different roles, and who is responsible for the required processes. This also clarifies the chain of command which makes it easier for the employees to know who to consult when decisions need to be made.

Chapter 3

IK – The Company

IK was established in 1987 and is a niche supplier of solutions, products and services for subsea, pipe and pipelines, focusing on the worldwide oil and gas industry. IK comprise of the following departments; Subsea, Field Service, Pipe Intervention, Torque and Calibration, and Pigging Products and Service.

Figure 2 - IK-Norway main office in Forus, Stavanger

Their main office is located in Forus, outside Stavanger, where they have an engineering office, workshop, storage facilities and a calibration laboratory. IK also have a manufacturing facility in Newton Aycliffe (IK-UK) where they produce pigging products and plugging tools, and a department in Saudi Arabia (IK-Saudi) which is currently under incorporation.

This project is initiated by the department of Pipe Intervention (PI) which is located in Forus. PI is making customized solutions for operation and lifetime extension on hot and cold systems in the offshore industry. Typical operations are:

- Pipe intervention services
- Hot tap services
- Line stopping services
- Delivery of repair and tie-in clamps
- Cutting and machining services
- Freeze plugging

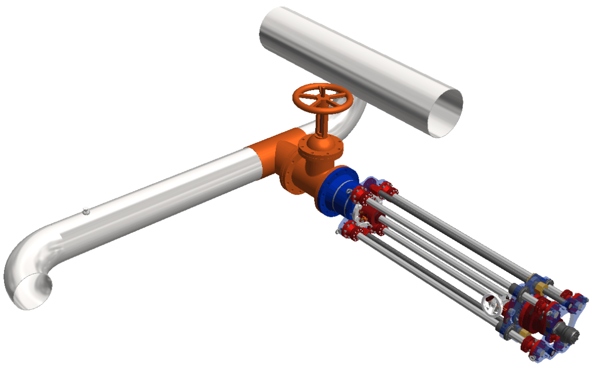

Figure 3 - Illustration of a hot tapping procedure

The main purpose of these operations or services is to create solutions to problems on offshore or onshore installation which might cause an unplanned shutdown of the operation. The main alternative to IK's services is to shut down the plant and make a proper repair to the system. This is more time consuming and therefor very expensive. IK can supply a very quick solution that will keep the operation running until the next planned shutdown.

Their biggest market is on the aging offshore installation on the Norwegian continental shelf, where the oil rigs are long outliving their initial design life. Life extension is very challenging but is very beneficial to the operators. It is therefore an increasing demand for the types of services that IK provides.

1.2 IK's Challenges

IK is a relatively small company which has found a niche in the oil and gas industry with a high demand. As a result they are expanding rapidly and constantly needs to improve their management to accommodate the challenges that come with. Because of this it is vital that IK continuously improve themselves, to make sure that they constantly are in control of their risks.

To be able to compete in the oil and gas industry it is vital to have a good reputation in regards to health, safety and environment (HSE). This is the main issue that the oil companies are concerned about in addition to the costs. This means that IK needs to convince the customers that they have the required tools to be able to execute a project at a high level of quality, at a high speed, and to a low price. To be able to do this IK must have an effective project management and reduce the number of mistakes in their operation. This can be clearly reflected in IK's company values, which are shown in the table below.

One of the biggest contributors to increased cost and inability to meet deadlines are errors which cause corrections and rework. According to Chapanis (1996) this is most often caused by human errors, because it's not easy for one person to understand something that is designed or explained by someone else. This is why this thesis has been initiated to reduce the risk in the interface between the engineering department and the workshop. As shown in the table below this thesis will support several of IK's values and help them execute their projects in a way that will support their overall goals.

IK Values	
Customer in focus	
Quality and Safety inherent in products and operation	X
Efficiency & result driven from design to execution	X
Highest ethical standards, values & integrity	
Courageous and Hands-on	
Openness in communication	X

Table 3 - Thesis relations to IK values

- The project is supporting IK's goal of having quality and safety inherent in all products and operations, by making sure that there is good communication between the engineer that designs the products and procedures and the mechanics that builds, tests and operates them.
- The project is supporting IK's goal of being efficient and result driven from design to execution, by directing attention to possible issues that can reduce efficiency and result in redesign. It is much more cost and time effective if you only have to do things once.
- The project is supporting IK's goal of openness in communication because it is addressing the communication and interaction between several interfaces in the project.

1.3 Engineering – Workshop Interface

IK has established that the interface between engineering and workshop is the most critical to their operation. By improving this interface they believe that they can significantly contribute to reducing their overall risk. This is not a big interface in the sense that there are many contributors, but it's a significant interface because the project is managed very differently on both sides. Pipe Intervention only has 8 employees which are distributed on the following roles.

Title	**Number**
Department manager	1
Project Manager	1
Project Engineer	3
Supervisor	2
Mechanics	1
Total	**8**

Table 4 - PI Employees

At this point I will not describe the complete work load of the employees but I will try to establish their main contribution to the workflow in a specific project.

Department manager

The department manager is the owner of the project. He has lots of contacts in the industry and works as the departments face outwards. He is often the one that is initially contacted by the customer to evaluate the problem and decide if it is possible to find a solution.

Within the project the department manager mainly function as an engineering specialist. He is the brain behind the big projects and develops the concepts and solutions for the problems.

This is done in collaboration with the project engineers as well, but it is the department manager that makes the final decisions. He will follow the projects to the end but is only working on concepts, problem solving and testing. The detail design is left for the project engineers.

Project Manager

The project manager has responsibility for progress of the project and to make sure that the stated goals are accomplished. He needs to make sure that the needs of the client are met and at the same time manage the cost, time, scope and quality of the project.

He is also controlling the workload of each of the workers in the project. He assigns projects and tasks to both the project engineers and the mechanics in the workshop. This makes him one of the biggest contributors to the interface between engineering and workshop.

Project Engineers

The project engineer's main responsibility is to make the detailed design. They will also participate in the development of the concept itself but it has to be approved by the department manager. When the concept is chosen then project engineer will create the design or the solutions that is required for the concept to work.

The project engineer will mostly communicate with the department leader about technical solutions and the project manager about time schedules, costs and other administrative subjects.

Supervisor

The Supervisor is the customers main contact point when a project is being executed offshore. It is he who leads the job and is responsible for making sure that procedures are followed and that tasks executed correctly. Onshore there is in practice less difference between the supervisor and the mechanics.

Mechanics

The mechanic performs regular tasks in the workshop, like putting together assemblies and creating test rigs. He also performs necessary machining, to make small parts, or to modify a part that doesn’t have the correct dimensions.

1.3.1 Organizational Interface

If you look at the Pipe Interventions from a strictly human resources point of view the structure of the department would look like the figure below. As we can see the department leader is on top. He is the owner of all the projects and is responsible for the human resources, and the project manager is subject to the department leader.

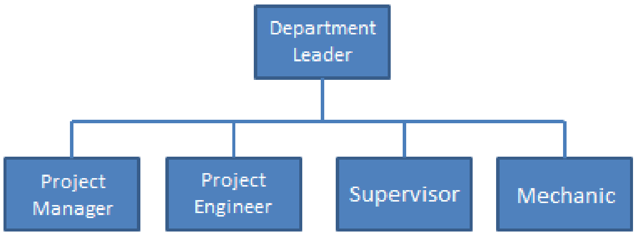

Figure 4 - Organizational Structure

This image changes if we go into a specific project. Within the project the department manager works like an engineering specialist, and are a resource which is managed by the project manager. The hierarchy will then look more like the figure bellow.

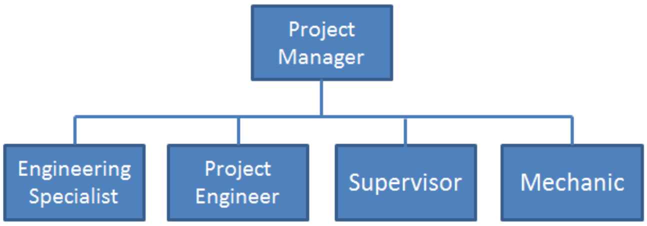

Figure 5 - Project Structure

For this thesis I will use the hierarchy within the project as a reference because this is the one that is most relevant when evaluating the interface between engineering and workshop.

Communication

One of the main advantages with a small department is that it is very easy to communicate together. The reduced distances make it easier to walk over and talk to a coworker, which will reduce the threshold for retrieving information. The close cooperation also allows the employees to get to know each other on a personal level. This reduces the risk of misunderstanding each other and makes the communication flow better.

There is one minor restriction of communication. This is the interface between the engineering department and the workshop. The workshop is located very close to the engineering office, which makes this less of an issue than for other companies. The quality of this communication will also vary with the specific employees who are communicating. Because the department is so small, communication is made between all the participants in the project, but in the figure bellow I have illustrated the main communication channels.

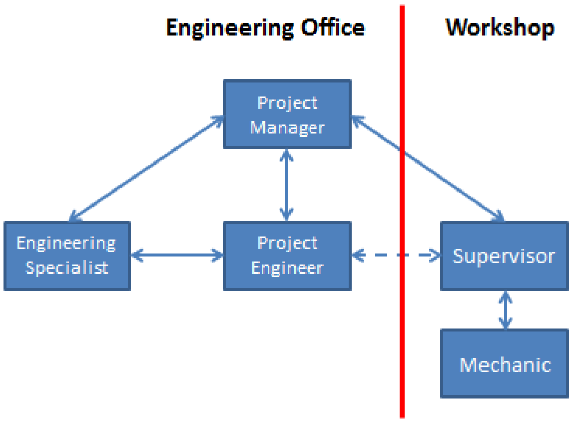

Figure 6 - Interface between workshop and engineering

- The department leader is functioning as the engineering specialist within the project. Most of his communication will be between him and the project engineers or the project manager.
- The project engineer is mostly communicating with the department leader and the project manager, but also has some communication with the supervisor. This is shown in a dotted line because the amount of communication might vary with the projects and the specific personnel involved.
- The Project manager is the center point of the information flow. He communicates with all the participants in the project to make sure that they are performing the right tasks, at the right time, and have the proper information.
- The supervisor will in most cases communicate with the project manager which provides him with tasks and schedules. There will be some communication with the project engineers as well but this is a less formal communication channel.
- The mechanics will in most cases communicate with the supervisor but in some smaller projects he will adopt the role as supervisor. He will then go through the same information channels as the supervisor.

1.3.2 Scope of Interface

One of the main advantages of IK is their flexibility. They are able to take on a large specter of projects, from small routine operations to large complex project where completely new equipment needs to be developed. This also means that the number of participants in the project, and the project process varies.

In IK they have roughly divide the projects into two:

- Small Projects
  The small projects are routine operations that IK has performed several times and that requires minimal of design and modification. These projects have a cost less than 1.000.000 NOK.
- Large projects
  The large projects are much more comprehensive and require more documentation and analysis. These projects typically cost more than 1.000.000 NOK.

After the incident in 2008 there was a big change in how IK managed their projects. The biggest difference was that they implemented a project management system to assure a high level of quality in the projects (Appendix B). This project management process has been through several revisions and has become very comprehensive.

This process works very well with the larger projects with a big budget. In these projects they have the proper resources to complete the amount of documentation and analysis required in their management system called Antenor Management System (AMS), which will be described later in the thesis. This is important because these projects have the highest risk for the company, with regards to both revenue and reputation.

IK also has a lot of small standard procedures which they have done several times and are considered almost routine operations. In most cases there will be made some small customization for each project, but not to the extent that it's considered a new design. The smaller projects with smaller budgets and timelines can't complete the whole AMS process, because it is too extensive. These types of cost can't be justified to the customer; hence some of the steps in the project process will be omitted.

1.3.3 Documentation Interface

IK has also very clear guidelines for what documentation the projects require. The AMS system defines the requirements for documentation and at what point in the project these documents should be made. The AMS also links to the location of the templates that should be used for this purpose. These templates include all the headlines and information about what content should be filled in and where. This makes it very simple for the engineers that are working on the project to find the proper document and to fill in the necessary documentation.

By using this system the quality of the documentation increases and there are made less mistakes. The information will have the same format every time which makes it easier for the employees to find the information they need, because it is in the same place every time. This will also reduce the time used to find information and will also make it easier for the person who is revising the document. Another advantage of using these templates is that you ensure that all the necessary documentation is created and that nothing is forgotten. If the documents were to be made from scratch every time, there would be a high probability that something was forgotten, neglected or deemed unnecessary. As a result the risk of mistakes and incidents would drastically increase.

IK has also made another step to ensure the quality in their documentation, by making sure that all issued documents are properly reviewed. This will ensure quality of the document and provide credibility with the customer. Every document or drawing that is created by a project engineer, needs to be peer reviewed by a qualified person that works within a relevant field before it can be approved for release. The approval for release is a formal way of ensuring that the document has been reviewed and the person that has reviewed has the required expertise to do so. It is ideally done by a third person, however in PI which is a small department, this is not always possible and the documents can be released by the creator of the document after he has made sure that it has been reviewed.

1.3.4 Risk related to interface

Compliance Risk

In the oil and gas industry almost every activity and product development is governed by rules and regulations. The company needs to follow the required standards in order to be allowed to bring their equipment offshore and to perform their operations. Nonconformance from violation of rules and regulations, mandatory practices or internal policies might result in loss of income, fines, payment of damage, and voiding of contract.

IK is certified according to the ISO 9001 standards which mean that they have implemented the necessary measure to ensure a certain level of quality. If the requirements in this standards would change IK would have to make changes to their operation which potentially could require a lot off resources to implement.

There is also a risk of the company not following their own management process and neglect vital steps in the procedures. This could be caused by lack of understanding, changes in management or recklessness. To avoid this routine checks are necessary, to continuously ascertain that the company is in compliance with the standard.

Financial Risk

Financial risk is a very wide term, which includes several types of risk associated with financial loss. This is type of risk is probably one of the biggest concerns for a company, because it's the economical results that creates the foundation that the company stands on. If the company is not able to generate the required revenues the company becomes insolvent. There are several ways the engineering-workshop interface can contribute to financial risk.

If mistakes are made due to poor communication, design, or work processes this can lead to significant losses in both time and money. These errors are often not discovered until the equipment is tested and at this point it is very difficult to make changes to the project. The parts that are not working needs to be redesigned, manufactured, assembled and then tested again. This will make a big impact on the time schedule and it will increase the cost because new parts need to be manufactured. By having good project interfaces the probability of errors can be reduced and the financial loss be minimized. When designing new equipment with limited experience and knowledge it is not possible to remove the risk completely and there will always be some uncertainty.

Operational Risk

The operational risk is probably the risk that the customer is most concerned about because that comes into play when the IK's equipment is interacting with their equipment. Therefore it is important that the operation of the equipment is properly defined and tested before it's taken offshore. If something goes wrong when the operation is performed it's vital that the operator knows what to do and how to handle it. He must understand how the equipment works allowing him to know why the equipment is behaving as it is. He should also be taught what to do if something does go wrong.

The key factors relation to risk

In order to counterweight the risk factors that has been identified in IK's operation, it's important to ensure high quality in their operation. In this thesis I will evaluate the three key factors; work process, communication and documentation to see how they contribute to the quality of the operation and how they can be improved to reduce the risk of errors and unwanted incident in the interface between the engineering department and the workshop.

Figure 7 - Balancing risk and quality

Chapter 4

2008 Incident

In 2008 IK was involved in an incident on the Statfjord A platform, where hydrocarbons leaked out into one of the legs and created an explosive atmosphere. This was a severe incident that could have had very high consequences and both Statoil and the petroleum authority have created an incident report. This accident has to some extend damaged IK's reputation and created some skepticism in the industry to the use of hot taping operations.

According to Statoil's investigation report (2008) the accident was triggered in conjunction with a project that Statoil initiated in 2004 where they planned to remove some redundant pipes in the utility shaft on the Statfjord A platform. These pipes where located in the utility shaft approximately 61m above the sea bottom.

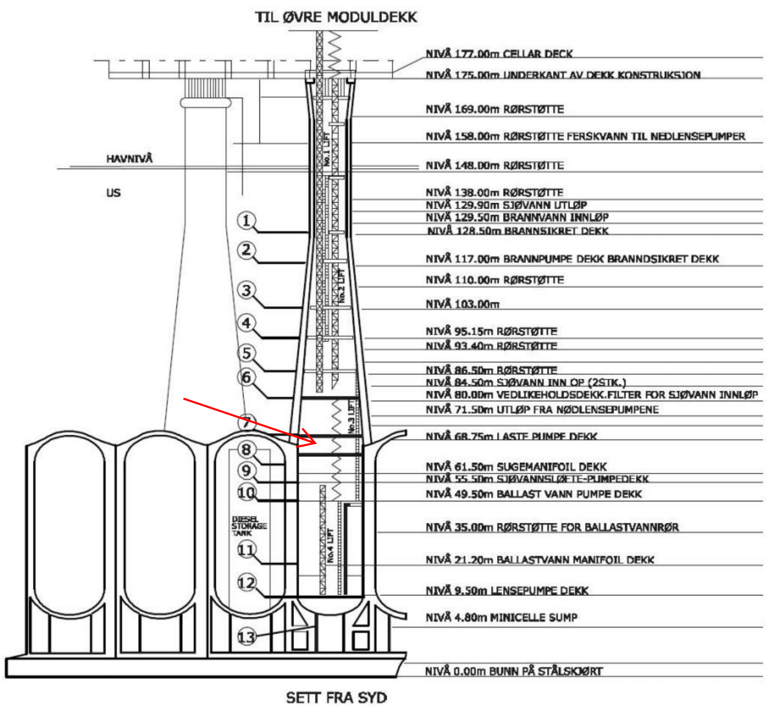

Figure 8 – SFA, location of the leak in the utility shaft

The pipes that where going to be removed were part of a system that was used to pump sludge form the oil /water contact in the ballast tanks. The sludge-lines where in direct contact with the storage tanks and was tied in to an open drain manifold. These pipes were never used but as long as the pipes were filled with hydrocarbons they presented a potential risk of leakage due to constant deterioration from corrosion. Statoil decided to remove these pipes in order to reduce the risk and to minimize maintenance. The picture below is taken from Statoil's investigation report and shows, in red, the open drain manifold that needed to be removed. To avoid stagnant hydrocarbons in the remaining pipe it was decided to cut it at the location of the stapled red line in the picture below.

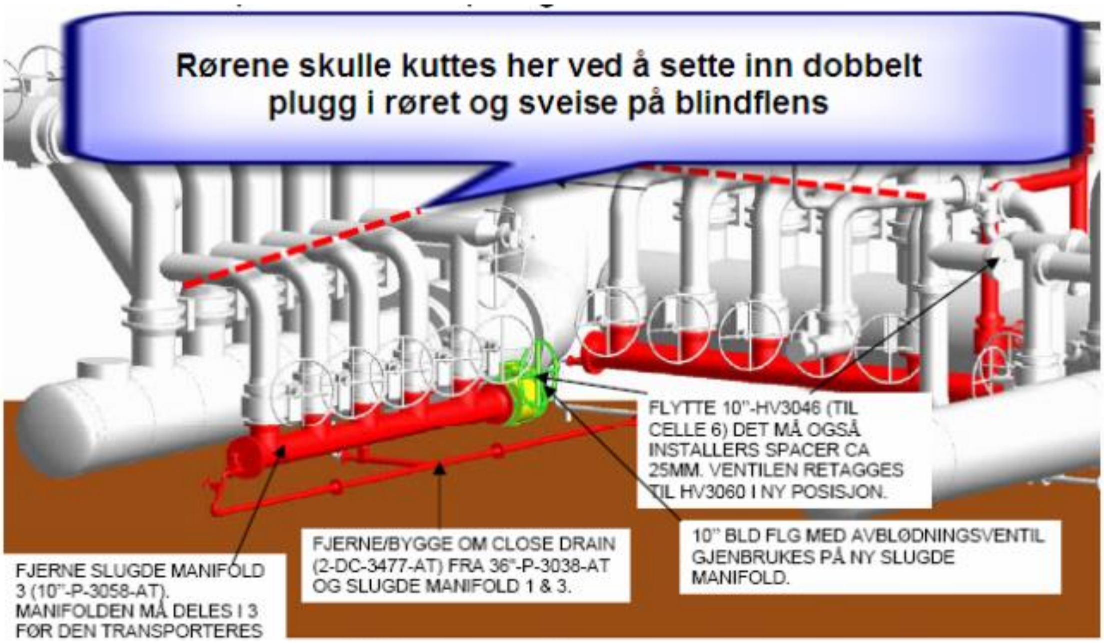

Figure 9 - Illustration of where the piping were going to be cut

Statoil hired Aker Solutions ASA to be the supplier for this project with all its responsibilities. In the summer of 2004 Aker created a study for conducting removal of the sludge manifold and associated equipment (Førland et al. 2008). In this solution a freeze plug is mentioned as a possible solution but this is denied by Statoil. It is then decided that hot tapping is the best alternative for this job.

IK was then contacted to create a study of a possible solution for hot tapping and removing the sludge manifold. This study was completed and submitted 20.02.2006 and it was decided that IK will perform the operation and an order was placed 13.03.2006 (Førland et al. 2008).

To be able to remove as much of the pipe as possible it was decided that IK was going to drill though the 90 degree bent to be able to place the plug as close to the vertical pipe as they could, which is illustrated in the picture below to the left. Because the pipes where going to be cut in a 90 degree bend, there was a risk that the saw could jam if it wasn't completely centered. To solve this IK designed two saw-supports that where screwed into the hot-tapping clamp to make sure that the saw stayed centered. This saw-support is shown in the picture below to the right.

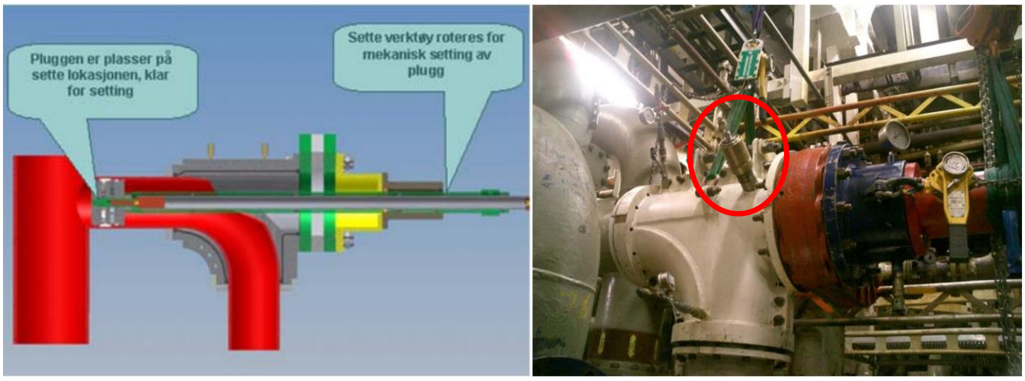

Figure 10 - The hot tapping clamp with saw-supports marked in red

The project was executed in several phases and manifold 2 were removed in 2006 (Jacobsen et al. 2008). The work was halted due to some technical issues which caused some leakage trough the seal around the saws axel. This was fixed and manifold 1 and 3 were removed in a shutdown in 2007. The resisting piping was planned to be removed in 2008 (Jacobsen et al. 2008).

The incident happened 24.05.2008, when IK had drilled trough on of the pipes and they retracted the saw and removed the cut part (Førland et al. 2008). The next procedure was to insert a brush that would grind the inside of the pipe to make sure that there was a clean and smooth surface where the plug was going to sit. This brush was slightly bigger than the hole that was cut and the operator decided to retract the saw-supports to make sure that they were not damaged when the brush passed. During the brushing procedure one of the saw-supports came loose and hydrocarbons were allowed to flow freely through the 2" hole. There were made attempts to reinstall the saw-support, but they were not successful and the shaft had to be evacuated.

During the incident 156 m^3 of oil leaked out into the utility shaft on Statfjord A (Førland et al. 2008). The hydrocarbons vaporized and created a highly explosive atmosphere in the shaft. Approximately $70m^3$ of oil was pumped into the sea (Jacobsen et al. 2008). The petroleum authority concluded that under marginally different circumstances the consequences could have been fatal.

Statoil's report of the incident states that the initiating causes were there weren't any barriers that prevented the operator from screwing the saw supports too far out. IK's operators on the shift was not aware of the hazard of screwing the saw-supports too far out and there was not established routines on how to reduce the leakage if something went wrong.

4.1 The petroleum authority has identified the following root causes in their report:

- **Unclear responsibilities and inadequate compliance to their own management systems.** There was and inadequate control of the risk factors that were present in the project, because the participants were not able to follow their own systems for managing responsibilities.

- **Inadequate risk assessment in the early stages of the planning.**
  It the beginning of the project it was not properly identified that that there was potential for very large consequences in the operation. As a result this was also neglected during the risk analysis later in the project.

- **Inadequate use of knowledge about the technical conditions of the plant**
  During the planning of the operation and risk analysis the knowledge of weaknesses in technical barriers were neglected. There were also no routines for ensuring that this was executed.

- **Inadequate management of competence**
  There were no requirements that ensured that the personnel or leaders had the proper competency in relation to the plants environment and risk factors. There were also no routines for ensuring that the personnel met the requirements of proper competency.

- **Inadequate transfer of experience from previous jobs and incidents**
  All relevant personnel that participated in this project have experience from similar incidents. The lessons learned in these incidents were not sufficiently considered during the planning and execution of the project on Statfjord A.

- **Inadequate technical development of method**
  The equipment that was used was not quality assured by the members of the project and it wasn’t developed according to the relevant requirements and routines. As a consequence the vulnerabilities inherent in the design weren't identified and the proper barriers towards the hydrocarbons weren’t implemented.

- **Inadequate detail planning and approval of the job**
  The detail planning was not properly executed and the precondition of lowering the pressure in the system prior to the operation was neglected. There was not established any mitigating measures since this hadn’t been taken into consideration during the

planning of the project. The work permit was not in compliance with the actual work that was planned.

- **Inadequate training of executing personnel**
  Parts of the personnel from all of the participating companies that were directly involved with the execution of the project did not have the proper training in risk factors and the use of the equipment.

- **Inadequate knowledge of Statoil's managing documents**
  Personnel from all of the participating companies had a lack of understanding and knowledge about Statoil's governing documents. The personnel's knowledge about these documents was not verified prior to the operation.

These points are taken from the report "Gransking av hendelse Hydrokarbonlekkasje I utstyrsskaftet på Statfjord A 24.5.2008" (Jacobsen et al, 2008).

As a result of this investigation the petroleum authorities issues a warning to IK which states that:

"IK is required to identify and execute measures to improve their management of activities, including compliance with applicable requirements for development and qualification of equipment and procedures, securing the necessary competence of personnel and identification and management of risk in execution of assignments.

IK must have complied with these requirements within 01.12.2008. The authorities must be notified when these corrections have been made."

The complete warning can be seen in appendix A

4.2 In Statoil's incident report the root causes related to IK's role in the project are:

- **IK didn't follow rules/procedures/ and good work practice**
  IK was responsible for the design verification and the safety evaluation of the equipment, in accordance to ISO9001 and the machinery regulations. IK is certified according to the ISO9001, which means that the company has an internal procedure IK-P5.1 "Procedure for Design". It is not possible to find any documentation of this procedure being followed when this equipment was developed.

During the verification of the equipment all the tests were focused on the functional part of the equipment and its ability to saw through the pipe and to set the plug. There was not executed any test to verify the equipment's reliability as a barrier. There has not been conducted any FMECA (Failure mode, Effect and Criticality Analysis) or similar review of the possible failure sources, in relation to technical or human errors during operation of the equipment.

- **Requirements and expectations for work execution were not communicated.**
  IK failed to train their operators with regards to the risk of operating the saw-support. The risk was also not described in the operational procedure. This is probably because of the lack of failure identification in the design and development of the hot-tapping tool.

  The training of the personnel was only based on the presence of the personnel during the FAT (Factory acceptance test). Parts of the operation were also excluded from the FAT. Because there was no rust on the test pipes, there was argued that there was no need to brush the inside of the pipe in order to get a good seal around the plug. The operator was therefore not properly trained in this brushing procedure.

These points are taken from the investigation report "Granskingsrapport Oljelekkasje I utstyrskaft på Statfjord A 24.5.08" (Førland et al, 2008).

4.3 Improvements after the incident

After the incident IK was required to make some changes to their operations to reduce the risk factors, but also to improve their reputation and reassure the customers that this would not happen again.

The most important thing that IK changed after the incident was their attitude towards risk. Until 2008 IK was a very small player in the industry and did whatever the customer told them to, without asking questions. The customers were the ones with the money and the knowledge about the system, and if they said it was ok then IK accepted it. After the incident IK realized that they needed to take responsibility for their own operation and start to set demands to the customer. These demands were made to ensure that the operation of IK's equipment becomes as safe as possible and if the customer is not following these demands, IK will refuse to complete the operation.

Instead of hiding the risks they started to present them for the customer. They also explain what measures they have taken to reduce these risks and how the customer could contribute to reducing the risks. If the customer fails to meet these risk reducing measures and the consequences would affect the safety IK would not perform the operation. If there are consequences to the operators equipment, IK would warn the customer that they can do the operation, as long as the operator are familiar with the consequences and are willing to take the risk of the potential damage.

This change in attitude is probably the change that has had the most impact on the risk related to IK's operation, but this is intangible and very difficult to measure. IK also made some tangible changes to their operation by implementing a management system, familiarize themselves with relevant standards, and improve the training of their operators.

Management System

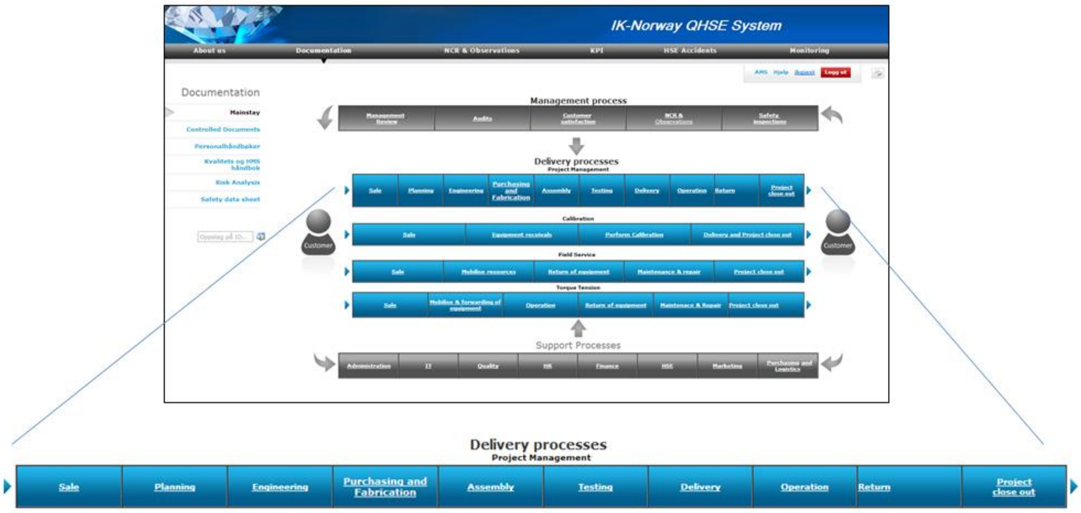

Figure 11 - Illustration of the web based management system (AMS)

As a result IK implemented a web based, process oriented, quality system called Antenor Management System (AMS). This system increased the availability of procedures and the consistency in the management process. It also provided a step by step manual for the work flow in the project, which ensures that all the vital parts of the project is executed properly, and in the same way every time. The roles and responsibilities of all the participants in the project are clearly defined and it provides the necessary templates for the documentation that needs to be completed. The picture above shows the mainstay of the system, where the process for project management is enlarged. A larger excerpt from this system can be seen in appendix B.

Knowledge of Standards

Before the incident IK was not very concerned about following all the standards that are used in the oil and gas industry. The reason was that the equipment they were using was only temporary and not a part of the installation. Therefore they argued that it was not necessary that all their equipment should be subject to these restrictions. After 2008 this has changed and IK has familiarized themselves with all the standards that are relevant to equipment used on the Norwegian continental shelf. All their equipment shall today meet these requirements or higher, and goes through a qualification process.

Operation and training of personnel

IK has also changed the way their operators are trained. After the incident all the operators has to be present during the assembly of the equipment and the testing. This is to ensure that they have the proper understanding of the equipment they are operating and that they have done one or more test runs of the equipment before they are offshore. This will make them familiar of potential issues they can encounter when they are offshore, and how to handle them. If the personnel that perform the test are not able to go offshore the test will have to be repeated with the personnel that will replace the former.

The operation will also be planned in such a way that the part of the operation that involves the highest risk will be executed during the day shift. This will ensure that the operators have good working conditions and can access necessary personnel from both operator and from the engineers onshore.

If something happens offshore and the customer wants to change the operation of IK's equipment, then the engineers onshore need to be consulted. This procedure is meant to protect the personnel offshore from being overrun by powerful people from the operator. This is a very common situation where the operators want to change something, even if the operational procedure has been agreed upon upfront. To avoid that IK's operators are pushed to make these kinds of changes, they have to get approval from the engineers onshore, which makes the process a little bit more formal and difficult for the operator to push through their shortcuts.

Chapter 5
Results and Analysis

There is no doubt that IK has come a long way since the incident in 2008 and that the focus on health safety and environment has improved significantly. After speaking to the representative from DNV, who were performing the yearly revision of the ISO 9001 standard, was impressed with the improvements they had made. But there is always room for improvement and that is something IK is very committed to.

5.1 Statfjord A permanent concrete plug

During this thesis I have followed a project which was initiated by Statoil. This project is a concept study to verify a method for installing an 18" concrete permanent barrier for a ballast water pipe on Statfjord A. The requirements from Statoil were that they wanted to concrete fill an 18" pipe, which is concrete-lined and connected to one of the storage tanks. The plug must be reinforced with iron bars and there has to be a 2" bypass to allow some communication with the tank. If IK can find a solution and confirm that it works, then Statoil will buy a couple of these plugs to keep in storage in case they need them.

To solve this IK designed a long articulated train carrying three hoses internally. Two of these hoses were used to drain water, while the third one was used as a bypass. At the end of the bypass hose there is an inflation plug. The main function of this plug was to create a barrier against the storage tank to make sure that the concrete are not pouring into the tank. The concept and test rig is illustrated in the picture.

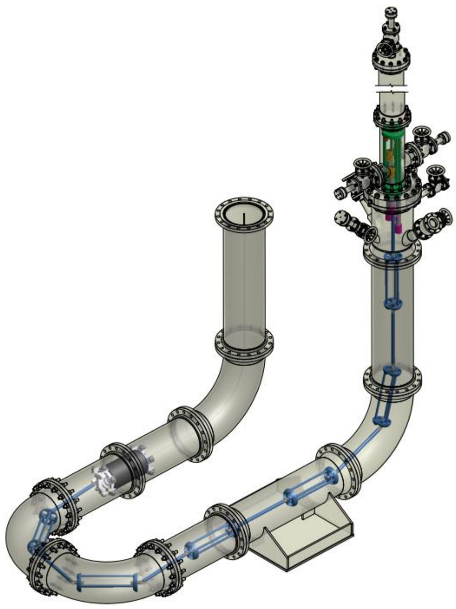

Figure 12 - Illustration of the concept created for the concrete plug on SFA

5.1.1 AMS

After the incident in 2008 IK implemented the Antenor Management System (AMS). This is supposed to be a guide for all the steps that need to be made during the project process and who is responsible for the execution. This system is very comprehensive and well suited for larger projects that have a lot of resources and a long time horizon. To evaluate this system I have used the current project for the concrete plug, and traced the project through the project management process to see if PI was working in compliance with their documented procedures.

When following the concrete plug project it become evident that the steps in this process hadn't been properly completed. During the planning phase their management systems clearly states that there shall be created a quality assurance plan (QAP) and it is referred to the proper template. This document is created and the proper template has been used, but the document has not been completed. Several steps in the QAP have been neglected or poorly defined. One of the most critical steps, which are the risk register, has also been skipped. During the project there has been made changes to the concept, but the document has not been updated. The result is that some of the information which is provided in the QAP is not relevant.

In the AMS there is stated that in the planning phase of the project there will be identified the necessary risk assessments. As explained earlier IK has three main risk assessments:

1. Risk register
2. Obligatory SJA
3. (HAZOP, HAZID, FMECA)

None of these three steps had been completed when the project had reached the test phase. The risk register was neglected in the QAP and it only refers to a separate HAZID report, but there has not been executed a separate HAZID report because this is usually done in cooperation with the customer during the planning of the operation. As this project will only prove a concept and not be executed offshore, at this stage, the customer has not required a HAZID meeting, and therefore this has not been executed. In this project there will only be done a FAT and the customer is not involved in the execution. This means that there has not been done any documented risk assessment as the project reaches its end.

5.2 Work Process

When the employees are addressed with these issues they are all giving the same answer. As explained earlier IK has a common understanding that the smaller projects that are based on known technology does not require the same amount of documentation and that they are to some extent allowed to deviate from the process in AMS. This is also verified by the CEO of the company. My first concern with this is that there is no clear definition to what separates the two types of projects, in fact there is not defined anywhere that there are two types of projects. This is just a common agreement which should have been implemented in the AMS. There should also be a proper definition on what separates these two, like to what extent there will be used new technology, the timeline of the project and the potential risk related to it.

The project for the concrete plug on Statfjord A is a concept study which involves a lot of new technology and operational procedures. This would be a perfect example of a project that could have taken the full advantage of the AMS system, but this was not properly specified when the project started. When confronted with this concern the employees also agree that this would probably be an ideal project to use the AMS procedure, but it had been forgotten or neglected. It seems that since most of PI's projects are small and with little new technology they have familiarized themselves with the shorter version of the project management process, which is also the most convenient.

On the smaller projects that involve known procedures and technology the processes seems to work very well. The required documentation, hazard identification and communication are present. Before the job is completed pro-ops meetings are conducted where the complete operation of the job, checklists, hazards and so on are thoroughly repeated with the operators that are going offshore. This ensures that all questions can be answered and everything is documented so there is no doubt afterwards to what was agreed upon. The execution is very professional and they are in control of all parts of the procedure.

However, my second concern is the fact that this shorter version of the AMS process is not defined anywhere. It is based on thinking that some parts can be excluded and it is up to the management to make a qualified decision on what parts this is. This is not a good philosophy because the parts that are skipped might differ for each project and in some cases vital information can be neglected. It is also difficult to check if the proper content is created when you don't know what documentation is required. Even if this seems to work well in practice it can be difficult for new or inexperienced employees to keep up with what's happening. Some of the employees in PI are relatively new and not that familiar with the processes. It is evident that they are very uncertain in how to proceed and are highly reliant of the more experienced workers to supply tasks for them. Therefore the management needs to be very alert and follow-up the project progress to make sure that nothing is neglected. If this process had been standardized it would be much simpler for the project engineers to know what needed to be done and execute the proper tasks. This would give them a stronger sense of ownership in the project, which most likely would increase the dedication and will to do a good job. It would also reduce the amount of time and attention needed by the management.

5.3 Communication

Good communication and information flow is vital for a project to be executed effectively and without errors. This can be a challenge in larger projects with many participants, where it can be difficult to make sure that all the participants has received the proper information and that they have understood it. Since Pipe Intervention is such a small department this is not a big problem. In this project there were incidents where the project engineers got different messages from the project manager and the department manager, however since the department is so small the miscommunication was rapidly discovered and corrected.

When the information is passed orally, from one person to another, the information will change because it is not communicated in the exact same way every time. The last person to receive the information might not perceive it in the same way as the distributer intended. This is especially true when the personnel that are communicating are speaking different languages. IK has a very high fraction of personnel that speaks foreign languages and as a result all the written and a large part of the oral communication is done in English. This can potentially be a source of misunderstanding, but this is not experienced as a problem as all the participants are speaking English well and are used to communicate with each other.

5.3.1 SPOC Single point of contact

After talking to the employees it became evident that most of the information flows through the project manager. He is the main distributer of information and is also the main link between the engineering department and the workshop. He keeps track of all the projects, the schedules, and the tasks that need to be done. This makes it easier for the mechanics to know who to turn to if there is something that needs to be taken care of. If the information is flowing through several channels then it is more likely that it isn't reaching all the recipients that are dependent on it. This is not a big problem in PI as it's such a small department that it's easy for the project manager to keep track of the projects and distribute the information properly. However if the department is growing this can become an issue and it might be wise to be aware of the importance of a single point of contact.

5.3.2 Cooperation between engineering and workshop

There also seems to be an agreement in the fact that there are different ways of thinking in the engineering department and in the mechanical department. One is not necessarily better than the other only different. In the engineering department there might be more theoretical thinking and risk assessment while the mechanics thinks more practical. This difference can be a source of great frustration in some cases, if the interface between them is direct without any overlay. If the mechanic receives a system that needs to be assembled that he has never seen before, he might not understand why it has been designed the way it has. This will also create resentment towards the engineering department, because they have little understanding of the design process.

If something goes wrong in the workshop and the equipment is not functioning as it was supposed to, it's the mechanics that has to find a solution to the problem. At this point it is vital that the engineers are participating in finding a solution and not just disregard the project as soon as it has been handed over to the workshop. This can be very frustrating for the mechanics because they are the once that have to work overtime to get the system to work even if they haven't participated in the design or even think it is a good solution. This was something that was observed in one of the other departments in IK but has not been that evident in the PI department. This is probably dependent on the people involved, who all have different ways of working.

This difference in thinking might not only be a bad thing if you are able to exploit it correctly. Having different perspectives and ways of thinking can also be a great advantage. By including the mechanics earlier in the design process they are more likely to understand the design choices being made. They can also contribute with ideas and feedback on how the design can be improved so they don’t run into issues in the workshop which could have been avoided if it had been discovered earlier in the design phase. This has not been the case in the PI department as the mechanics have little or no contact with the engineers during the design phase. After talking to the mechanics in the workshop it became evident that they are not satisfied with how the projects are managed and the level they are involved in the projects. They get a weekly update on what projects are starting, but their participation stops there. They are not involved, or consulted in any part of the design and development stages of the project. They are not involved in the project until the parts have been ordered and are starting to arrive at the workshop. Then it is their job to assemble them and test the solution before it is brought offshore for operation. There are many principles that work on paper that just don’t work as well in practice. This is something that might be difficult for the engineers to see and that the mechanics has a lot of experience in. When they are not included in the design phase there might arise issues where parts are not working as well when the concept is tested in practice. This will result in a lot of work that has to be redone and the project becomes delayed. This could have been avoided if the mechanics had been involved sooner.

It was also evident that the mechanics did not feel any ownership in the projects they are working on. They have not been able to express their opinions or concern about the project and is only set to assemble the parts and expected to fix any mistakes made by the engineers. There was quite a bit of frustration and they were eager to point out all the things that they thought where poorly designed, instead of being proud of the system they were building. As a result I noticed that there is a lack of willingness to make the solutions work. There is used more energy in talking about how the solution should have been, instead of making the current solution work. If it does not work right away, the general attitude is that they knew it wouldn’t work and they disregard it as a failure at the first sign of problems, instead of trying to tweak it to make it work despite the drawbacks.

The downside of including mechanics in the design process is that there might be disagreement on how the problem should be solved, which will increase the resentment and reduce the willingness to cooperate to make the design work. It is therefore important that this is managed in a good way to make sure that the two departments are contributing in a way that makes all of the participant take ownership in the project and striving to make it perform as optimal as possible.

5.3.3 Communication with customer offshore

When talking to the mechanics in the workshop they expressed a major concern about the communication with the customer. It is the mechanics that goes offshore to execute the operations and if something goes wrong, is not working, or is poorly planned it is the mechanics that gets the heat from the client. This might be a hard pill to swallow, especially since they have had no say in the development and the planning of the solution.

The engineers also agrees that this is a challenge and worries that the mechanics will have to answer for mistakes made by the people onshore without having the proper understanding of the reasoning behind it. They also worry that the customer might pressure IK's mechanics to deviate from the predetermined procedure to take shortcuts that would benefit them.

As a safety precaution IK has implemented a standard that if the customer has any questions or wants to change any of the operational procedures while offshore, this has to be forwarded onshore to the project manager. By redirecting the question onshore it becomes more formal, and the customer is less likely to want to go through the process, unless it is very important. This will also enable IK to go through the required processes to make a prudent response, which is reasonable without increasing the risk.

5.4 Documentation

The documentation is probably one of the issues that PI has the biggest improvement potential according to the department manager. As described above in the chapter about work process, there have been several steps in the concrete plug that has been poorly executed, but this seems to be a bigger issue on the larger projects than the smaller once. On the smaller projects the documentation is good and there have been developed proper operation procedures and checklists. The representative from DNV, which where revising IK for compliance with ISO9000, where also impressed with the fact that the necessary drawings and documentation was established even on projects that was very urgent. The biggest challenge seems to lay with the bigger projects and my main concern was the fact that there has not been performed any risk analysis.

5.4.1 Risk Analysis

On the smaller project the test and operational procedures are well known. The operators have executed them several times and the equipment has gone through several rounds of improvements. Because of this PI knows what the potential dangers are with operating this equipment and are very thorough when communicating this in the HAZID meetings with the customer, allowing the proper precautions to be made. In my opinion there should be made a formal risk analysis for the different procedures and the equipment they are operating. This will ensure that all failure modes are evaluated and it makes it easier for new operators to read this document to see which potential risks he is facing. A good example of this is the incident in 2008 where the operator unscrewed the saw-support to far. If there had been performed a FMECA or a similar risk analysis, it would probably have been detected that this could happen. Then the operator would have been aware of the risk or in the best case designers could have made stoppers that prevented this from being possible at all. Another advantage is to be able to tell the customer that there has been performed a risk analysis on the equipment, which might make them more confident in the solution. The operations that PI is performing are related to high risk, with big consequences and therefore it is still some skepticism in the marked even if the methods are well proven. By being able to show that a proper risk analysis has been performed, it can become easier to sell the solution to the customer.

On the larger projects where new technology is developed it is even more important to complete a proper risk analysis. In the case of the Statfjord concrete plug the risk analysis has been neglected. When confronted with this the general answer is that the risk is usually discussed during the HAZID with the customer. This will uncover any operational hazards and conflicts, but in this project there will not be any HAZID because the project is only going to be developed at this stage, and the HAZID will probably not be performed until the equipment is going to be used. But during the testing it became evident that there are several issues that need to be corrected in the design and in the operational process. This caused a lot of wasted money and time in materials and manufacturing, and as a result only parts of the operation can be displayed to the customer during the FAT. There is no guaranty that performing a risk analysis could have avoided these issues, because there is always uncertainty in prototyping new equipment, but it could most likely have avoided some of them.

The risk analysis also has great impact on the interface between the designers and the operators. The risk analysis will shed light on all the possible ways that the operator can generate wrong input into the system. When this is identified the necessary steps can be taken to ensure that the operator is aware of these issues, or the system can be designed to compensate for the errors made by the operator. The incident in 2008 is a perfect example of this.

5.4.2 Document Quality

One of my observations was that most of the concept design, risk assessment, testing procedures and overall project development are super managed by the specialist engineer/department manager. The decisions he makes and the concepts that he develops is then passed on to the project engineers. Then it is the project engineer's job to create the proper documentation. The result is that the project engineers are only getting fractions of information and it becomes difficult for them see the bigger picture and understand all the argumentation for the different decision. As a result the documentation becomes fragmented, because the project engineer hasn’t completed the steps himself. He also doesn’t know what steps in the project process has been completed and will therefore rely on others to assign tasks to him. The project engineer lacks the proper ownership of the project and if he doesn’t have any tasks he will simply wait until he is assigned a new on. There is also a lack of verification that the project process is being followed. It is mainly the project manager that is responsible for this task but there is not any specific approval for the completion of the documentation.

5.5 Uncertainties

There are several factors that contribute to the uncertainties in this analysis. One of the main issues is that there is such a large difference in the projects that is performed at IK that it is difficult to evaluate to what extent the same issues are present in all types of projects. An issue that arises in one project might not come up in another. This means that this thesis might not be able to pick up weaknesses that weren't present in the project that was evaluated, or the issues that was pointed out was a one-time incident and is not representative for the normal operation.

Another source of uncertainty is that the project has been executed mainly by inexperienced personnel. IK has grown a lot during the last couple years and as a result they have hired a number of new employees. The main project engineer on the project that this thesis has followed has not been working in IK very long and this was the first project that he has been responsible for. This means that the execution of this project might differentiate from the norm. The advantage of this is that it is a good opportunity to see if the system is able compensate for the lack of experience and function as a guideline to ensure good quality.

Chapter 6
Recommended Solutions

According to Morris (1989) the main interfaces in a project can be found between the different life cycles of the project, and in this chapter there will be made some recommendations for how IK can improve the interface between the engineering department and the workshop to eliminate unnecessary risk factors. These recommendations will then tried to be rooted in existing literature, even if Morris (1989) states that interface management is not a well-documented theory.

Chapanis (1996) explains that human interactions are made with the system throughout its lifetime and that all these interactions provide a potential for introducing errors into the system. There are mainly three types of people that interact with the system and these are the designers, the operators and the maintainers. In this thesis we are looking at the interface between the designer and the operators which represent two different parts of the systems lifecycle. As a result the types of mistakes on the different sides of the interface are often slightly different. On the engineering side of the interface the mistakes are often "latent errors", which Jones (1995) explains is most commonly done by managerial personnel. This means that the errors are not identified until later in the lifecycle. On the other side of the interface the errors are mostly "active", which means that instant feedback will inform the operators if they have made a mistake.

6.1 Work Process

After the incident in 2008, one of the major improvements that were made was to implement the AMS quality system. This is a very good system that ensures that the necessary steps are taken to maintain a high level of quality and risk management. Implementation of new systems is rarely received with enthusiasm since it often requires the employees to change established procedures. Despite this, it seems like the employees at IK have had a great understanding that this type of system was needed and has tried to take as much advantage of it as possible. Even if this system is working well there is still room for improvements and as Berger and Kelly (2005) states; the first step in interface management is to make clear and concise job descriptions.

6.1.1 Define large and small projects

As explained earlier there is a common understanding that IK has different types of projects that require different types of management and documentation. This is not specified in their management system, which means that there is not a proper way of deciding what type of documentation and management the project require. These projects should be properly defined in order to make sure that there are no confusion or personal opinions on how to proceed.

As early as possible in the project, there should be included a step for making a conscious decision on what type of project it is going to be and there has to be some predefined requirements that needs to be met in order for the project to be qualified as one of the types of project. This will make the process more efficient and there is no confusion to what project process to follow. This type of standardization would greatly benefit the work. As Lamb and Rhodes (2007) states; the standardization of work processes will promote consistent design practices and reduce variability and ambiguity. This will have a positive impact on the interface between the engineer and mechanics because it makes it easier for the mechanics to predict what type of input they will get. As a result it makes it easier for them to plan their work and find the information they need. Another important issue with not having properly defined work processes that Lamb and Rhodes (2007) emphasize is that new employees must make the same mistakes that the more experienced workers have done before them. This means that the company is not learning and evolving as the new employees keep making the same mistakes as the company has done before. This is very critical in the oil and gas industry as making mistakes are not taken lightly when done once, but if the same mistake is done twice then it could seriously damage the company's reputation.

6.1.2 Define what can be skipped in small projects

The AMS system also provides a good representation of the steps needed to complete the projects in a proper manner. Since there is an agreement in IK that not all projects require the same level of documentation and management there is a high probability of confusion and inconsistency. The AMS should include some information of which steps where mandatory for the different types of project. If this is left for each project manager to decide, it is likely that you will have as many different project procedures as you have project managers in the company. This is because humans interpret risk different, and what seems necessary for one person might not be as important for another. This is why this process should be standardized.

There are a couple of ways to implement this. You can make completely new work process for the smaller projects with all its steps, responsibilities and documentation. This solution is very time consuming and require some work to be implemented. This solution will make it very clear how to proceed in the project and leaves little room for mistakes. Another solution would be to properly mark the current project process with the steps that are mandatory in all the projects. This is probably the simplest solution as it only requires small modifications, though it leaves some possibilities for misreading the procedure.

6.1.3 Implement routines for checking compliance with AMS

To make sure that all the necessary steps in the AMS process are completed it would be wise incorporate procedures for checking that the necessary steps are completed before you are allowed to proceed to the next phase of the project. This is a measure that is implemented in other management systems where each step in the process has to be properly closed before the next step can be initiated. This will ensure consistency in the projects and eliminate the personal interpretations of what is necessary and reduce the errors introduced in the management of the project.

6.2 Communication

Since the Pipe Intervention department is so small the communication is very good between the engineering department and the mechanics. Especially in the testing phase as the engineers are spending a lot of time in the workshop to aid the mechanics and to make sure that everything is going as planned. The communication is also very good in the operational stage of the project even if the engineers are not always present. There are well established procedures that all questions and changes requested by the customer is going to be forwarded to the engineers onshore to relive the operators from the pressure form the client and to make sure that there are made well considered answers from the people that is most familiar with the design of the equipment and procedures. As a result the communication across the interface is working very well but there is still some potential for improvement that could reduce the risk even further.

6.2.1 Involve mechanics earlier

One of the main concerns that were expressed by the mechanics was that they were not involved in the project early enough. They often experienced that the things that were designed in the engineering department wasn't functioning as the engineers intended. As a result they got a lot of extra work to modify and to make that part fit together. This was something that the guys in the workshop believed could be minimized if they had been involved in the process earlier.

It is also important for the operator to have a good understanding of the equipment he is going to operate. Chapanis (1996) explains that designers try to design the systems with good intentions with regards to the operability and ergonomics, but in many cases they are not successful because they don't only have to design the system to withstand regular use, but also misuse and unintended use. Chapanis (1996) says that there are five different elements that need to be taken into consideration when designing a system. These five elements are: Personnel selection, personnel training, machine design, job design and environmental design.

IK is most often designing equipment that is only going to be used by one or two operators. This means that it is not effective to use the time and resources that is needed to make the equipment user friendly enough to be operated by a large selection of people. They have the advantage that they only need to make the equipment fit a small number of people which they are well aware of the abilities and limitations of. According to Chapanis (1996) people are adaptable to operate poorly designed equipment, but it would most likely result in more extensive training and stress on the operators. In order to avoid this, Sanders and McCormic (1992) explains that the identification of the user needs is best done through observation and interviews, so by involving the operators in the design process as early as possible it makes sure that the design of the equipment is making sense to the people that are operating it. It will also give the operator a better understanding of the equipment that they operating which reduces the risk of human errors.

The supervisor in the workshop suggested that they could have a meeting when the design was finished, but before it was sent for production. This is something I agree on as the engineers are still in control of the general concept of the project, but they can still make the necessary changes if there is discovered any issues or deviations by the mechanics.

6.2.2 Poorly defined roles can become a challenge at growth

Since the PI department is such a small department the employees has to take on several roles in order to be able to get everything done. This works well as long as the number of participants in the project or in the department is relatively small but it can be challenging if the department grows further. Berger and Kelly (2005) explain that the first step in interface management is to make clear and concise job descriptions, this is especially true if the participants are having several roles in the project. In the PI department the department leader also functions as the engineering specialist, and the project engineers might function as supervisors and so on. This can be challenging and creates a very complex structure with intricate communication channels. Berger and Kelly (2005) then state that there needs to be establish standard protocols for critical communications. This will bridge the gaps and challenges that are uncovered. It removes the uncertainty around the limitations of the different roles, and who is responsible for the required processes. This also clarifies the chain of command which makes it easier for the employees to know who to consult when decisions need to be made. This mixture of roles is not something that seems to be a problem in the projects today, but it might become a problem in the future as the department is growing. It is therefore important to be aware of this, so the necessary steps can be taken before it becomes a real problem.

6.3 Documentation

The documentation in PI is of varying quality. The documents that is most directly affecting the interface between the engineering department and the workshop is the technical documents like drawings and test procedures. These documents have a very high quality and are also the documents that there are spent the most amount of time on.

The part of the documentation that is more indirectly affecting the interface between the engineering department and the workshop is not at the same level of quality. One of the parts of the documentation that has been neglected is the risk analysis. The risk evaluation has been completed to some extent but only verbally or in the engineering specialists head. This is not a very systematic way of doing it and it can be a challenge for the other participants in the project because they don’t understand or know what risk evaluation has been done.

6.3.1 Risk Analysis on smaller projects

On the smaller projects most of the equipment and risks are well known and the operator has long experience in operating them. There are also performed pre-ops meetings before every operation to repeat the common risk factors and other operational issues. As a result the risk is minimal, but it could still have been beneficial to create a risk analysis for the equipment. By completing a risk assessment like the FMECA for all of the standard equipment that PI has developed they could makes sure that no risk enhancing elements are neglected and it makes it easier for new operators to read and familiarize themselves with the equipment and the potential dangers of operating it. It can also be an advantage in a sales situation as it would help to reassure a skeptical client that the necessary risk assessments have been executed.

6.3.2 Risk Analysis on larger projects

On the larger projects where new technologies are being developed it should be mandatory to perform a risk analysis. According to Kossiakoff, Sweet, Seymour, and Biemer (2011) the risk assessment is one of the main processes in system engineering and it is vital when trying to balance the risk with the use of new technology. The AMS states that the use of risk analysis should be applied, but it is the project manager who decides to what extent. If the difference in project types are more clearly defined then it would be easier to set a requirement that a risk analysis should be executed if the project is of a certain type.

Chapanis (1996) mentions Fault Tree Analyses and FMEA as good methods for this task. These types of risk assessments would enable the designer to discover problems in the design in an early phase of the project. If these mistakes are passed further down the chain, they can have very big consequences for the company. By sending faulty equipment to manufacturing it will cost a lot of money to correct afterwards and it will most likely affect the schedule.

As Jones (1995) explains the errors that are made in the design phase can either be "active" or "latent". The "active" errors are the most common and the easiest to discover as these will have a direct effect on the function of the system. This could be design issues that makes it impossible or difficult to make the different parts of the system fit together, or the system might simply not work. The mechanics in PI have expressed some frustration that there are simple mistakes that has been done in the design phase that creates a lot of problems for them, which could have been avoided if they had been discovered before the parts arrived at the workshop. An example of this is the Statfjord A concrete plug where the locking mechanism of the plugging train simply didn’t fit its housing because the surface finish was too coarse. Luckily the mechanics was able to modify it so it fit, or else they would have to buy a new one. This type of rework costs a lot of money and takes a lot of extra time which can affect the schedule, which is not well received by the customer.

The "latent" errors are more difficult to discover because the system might not fail because of it. This means that the system is able to functions but there might be certain circumstances that might trigger an error, or it might only function when compensating measures are applied to make it work. This is a very big risk because even if the error is discovered it is often decided that it is too expensive to correct it, since the system is functioning. As a result the equipment is operated with weaknesses that have a high probability of making the system fail if the operator is unaware of it, or neglects it. A good example of this is the incident in 2008, were there was a weakness in the saw-supports, as it was possible to completely unscrew them. The operator unscrewed the saw-supports to make sure that the brush could pass them when it was inserted in the pipe. This was a logical thing to do, but it had not been done during the FAT. As a result this potential error was not discovered until it failed during operation. If a risk analysis had been completed this would probably have been identified as a potential issue and the proper measures could have been implemented. This could have been done by implementing a procedure for how far it would be safe to unscrew the saw supports before they failed, but the most ideal solution would be to design some stoppers which made unscrewing them impossible. Today these saw supports have been designed out completely and other measures for centering the saw has been implemented.

Chapter 7

Discussion

7.1 Main Goals

After the incident in 2008 IK identified the interface between the engineering department and the workshop as one of the areas with the biggest improvement potential in regards to reducing the risk of unwanted incidents. As a result this thesis was initiated to evaluate this interface based on the following three key factors:

- Work Process
- Communication
- Documentation

The thesis was initially going to be a general study for all the departments in IK, but after some research it became evident that it would be comprehensive as there were large differences in the operation. Thus the thesis was limited to concentrate on the Pipe Intervention department. Even if the study has been focused on only one department some of the recommended improvements are related to IK's governing documents and would affect all the other departments as well.

7.1.1 What did I do?

To be able to properly evaluate the interface between the interface between the engineering department and the workshop based on the three factors an Abductive strategy was chosen. As Blaikie (2000) explains, this means that the analyst needs to take and objective approach, by following the company to learn their way of thinking, before a technical explanation is established based on existing literature and established methods. This is a strategy that is a bit challenging as it takes a lot of time to learn and fully understand the operational procedures, and map all the channels of information and communication that exists within the company.

To be able to evaluate the work process in IK the first part of the project was used to participate in ongoing projects to see how the employees are cooperating and communicating. This also presented the opportunity to get to know the employees in both the engineering department and in the workshop. Relevant personnel was also interviewed to identify what they experienced as challenging in relation to the interface and what was going well. This was considered the most suitable way of retrieving the information as the number of employees is so small.

7.1.2 What did I find out?

After the incident in 2008, IK's reputation was impaired and a little skepticism was introduced in the marked for operating on live pipes. As a result IK had to make some drastic changes in order to ensure the customers that they were able to operate safely and took the necessary precautions to improve themselves and to learn from their mistakes. As a result the operation has improved a lot since then and today they have a very quality and safety minded operation, where they are constantly trying to improve themselves. To be able to accomplish this, the most important thing is to learn from your mistakes. Lamb and Rhodes (2007) explain that by standardizing best practice, you can avoid the same mistakes from happening again. This is why IK has implemented their management system (AMS) to make sure that the necessary steps are taken in the project to avoid making the same mistakes again. However, in IK there is a common understanding that some of the steps in the operational procedure can be neglected on the smaller projects. This is a very serious issue as you are bypassing the measures that are implemented to make sure that you are not making any errors. This is the same thing as happened in the Chernobyl accident in 1986. Von Glinow and Mohrman(1990) explains that the engineers working in Chernobyl removed all the safety systems to do some tests on the generators, to see how low they could be run and still provide power for the cores cooling system. During this test the operators lost control of the core, and since all the safety systems were deactivated, it resulted in a large explosion with major airborne release of radioactive material. Therefore it is vital that the safety systems are not bypassed without the proper understanding of consequences and therefore the quality process needs to be properly defined for all the different scenarios in IK's operation.

Another key factor for avoiding operational errors is to ensure good communication throughout the project. Berger and Kelly (2005) explain that ensuring communication across the interfaces in a project is vital for timely and effective operation as it minimizes the number of mistakes that causes waste of time and money in the sense of rework. According to Morris (1989) the main interfaces in a project can be found between the different life cycles of the project. This complies with the conclusions IK has drawn that their most critical interface is between the engineering department and the workshop. As this thesis has discovered there are two types of errors that can occur in this interface. The first type is when all the parts are manufactured and assembled correctly but the system is not functioning as well as expected, or not at all. This is a common situation when building prototypes as it is impossible to overcome all the uncertainty that is related to a project, when there is little or no prior knowledge on the subject. Kossiakoff, Sweet, Seymour, and Biemer (2011) tell us that system engineering is vital in balancing risk of uncertainty and the use of new technology. A common way of handling these types of risks are according to Chapanis (1996) to use tools like FMEA or FTA. This is also supported by Jones (1995) statement that a "Well defined problem yields a well-defined solution".

The other type of error that was observed was errors where the actual manufacturing or assembly wasn’t performed as the designer intended. This means that the drawing for the manufacturer was wrong or the mechanics have assembled them in the wrong order. As a result the parts often need to be modified, reassembled, or completely remanufactured. This takes a lot of time and cost a lot of money, which affects the bottom line of the project and the customer's satisfaction. These mistakes are very easy to discover as their effects are immediate, but they are more difficult to prevent. The supervisor at IK believes that by involving them earlier in the project some of these issues could be discovered earlier, since they have a slightly different point of view and are more likely to discover errors that might become a challenge during the assembly and operation of the equipment.

7.2 Further Research

In the oil and gas industry it is very important to keep improving the risk management. This thesis only cover a small part of the potential improvement potential that exist in in the company for reducing risk and further research that supports this would always be encouraged.

To be little more specific, further research to improve the risk management in IK could include:

- Similar studies that cover the risk factors in the interface between engineering and workshop in other departments
- It would also be beneficial to see what effects the implementation of the recommended improvements would have over time.

Because of time limitations and significant difference in operation between the departments, this thesis only evaluated the interface between the engineering department and the workshop in the Pipe Intervention department. There are probably similar issues in the other departments as well, which would be beneficial for the company to highlight.

After implementation of the improvements suggested in this thesis it would be very rewarding to see the effects over time. This is something that is very difficult to measure, but it could provide valuable information on the improvements in risk reduction.

7.3 Challenges

According to Morris (1989), interface management isn't a very well documented theory and that it is mostly a way of looking at project management. This made this thesis a little bit challenging as there was not any good literature on how to evaluate or implement interface management. This meant that in the beginning of the project there were used a lot of time trying to find the best suited way to evaluate this interface and what factors where the most relevant to look at. The basis of the thesis had to be supported by other similar subjects that were concerned with project management and human interactions and to see what had the biggest impact on the interface. As a result the literature study became very general and not very specific for the subject of the thesis, but it covered general concepts that are relevant in all parts of project management, but that could be used to support the issues that were discovered as a challenge in the thesis.

The thesis has chosen to follow a larger project taken on by the Pipe Intervention department, which was to create a concept for a concrete plug in the ballast water lines in the utility shaft at Statfjord A. This project is a relatively large project compared to the projects that are usually taken on by the department. Thus the execution of the project might not be representative for the daily operation in the department. However, it also presents a great opportunity to test the quality system to see if it manages to maintain the quality of the execution even if this is not a common working situation for the employees.

At the beginning of this thesis this was going to be a general study of the Pipe Intervention, where the results then would be applied to all of the departments. This proved to be a bigger challenge than first expected, since the different departments are very different in types of projects, size and structure of departments. As a result most of the recommendations will be specific to the Pipe Intervention department, but the improvement of the Antenor management system would be beneficial to the whole company.

Chapter 8
Conclusion

The thesis has evaluated IK's interface between the engineering department and the workshop based on all the key factors that was described in the beginning of the thesis. The thesis concludes that IK has had major improvements in their operations regarding risk and safety since the incident in 2008. The measures that were implemented afterwards has been very effective and taken the operation to a whole new level. The biggest improvement has probably been the change in mentality as IK has gone from a small company that didn't dear to challenge the client and to think that everything is probably going to be fine, to a company that sets requirement for the clients and that demands nothing short of the lowest risk possible.

The thesis has evaluated the interface based on three key factors: Work process, communication and documentation and has found improvement potential within all three. The biggest improvement potential is probably within their work process. The thesis suggests that the work process within IK's quality system could be improved by properly defining the different alternatives the project managers have, and the decisions that needs to be made. The thesis also suggests that IK could benefit from including the mechanics earlier in the projects and to standardizing the use of risk analysis, to make sure that this is prioritized and performed in a professional manner.

All of the measures that has been suggested are relatively easy to implement and will have a positive impact on IK's operation. They will reduce the operational risk of accident that could lead to injuries, environmental damages and loss of reputation, which supports IK's ambition of having quality and safety inherent in production and operation. The suggestions will also reduce the risk of errors in the project phase, which will reduce the cost of rework and waste of time, which supports IK's goal of being efficient and result driven from design to execution.

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Appendix

Appendix A – Warning from the petroleum authorities

PETROLEUMSTILSYNET

Industrikonsult AS
Postboks 8018 Posteterminalen
4068 Stavanger

Vår saksbehandler
Hanne Etterlid

Deres ref.	Vår ref. (bes oppgitt ved svar)	Dato
	Ptil 2008/674/HE/SRJ/LJD/ID	25.9.2008

Oversendelse av rapport etter granskning av hendelse i utstyrsskaft på Statfjord A 24.5.2008 - med varsel om pålegg

Vedlagt følger rapport etter vår gransking av hendelsen på Statfjord A den 24.5.2008.

Granskningen påviste brudd på regelverket knyttet til Industrikonsult AS (IK) sitt ansvarsområde, se kapittel 9.3 i rapporten.

Vi varsler med bakgrunn i disse avvikene følgende pålegg:

Med hjemmel i styringsforskriftens § 3 om styring av helse, miljø og sikkerhet og rammeforskriftens § 5 om ansvar etter denne forskrift første ledd, jf. rammeforskriften § 58 om enkeltvedtak, pålegges Industrikonsult AS å identifisere og gjennomføre tiltak for å forbedre sin styring av aktiviteter, inkludert etterlevelse av gjeldende krav til utvikling og kvalifisering av utstyr og metoder, sikring av nødvendig kompetanse hos ledende og utførende personell og identifisering og håndtering av risiko forbundet med gjennomføring av oppdrag.

Frist for å etterkomme pålegget settes til 1.12.2008. Vi skal ha melding når pålegget er etterkommet.

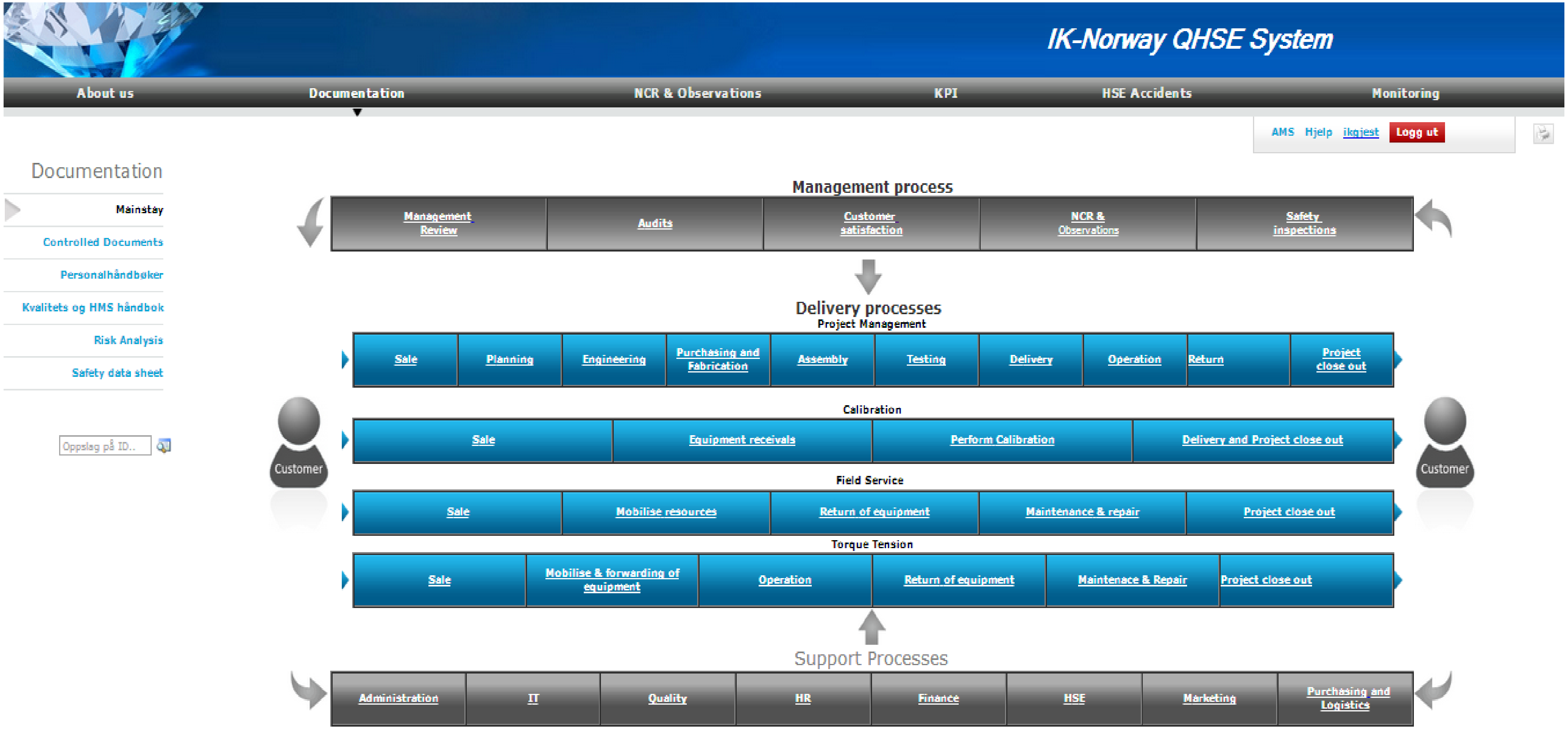
Vi ber om en redegjørelse innen 1.12.2008 om hvordan dere eventuelt har samarbeidet med andre involverte aktører i det gjennomførte forbedringsarbeidet.

Eventuelle kommentarer til varslet må være oss i hende innen 8.10.2008.

Vi ber også om at brevet og rapporten blir gjort kjent for de tillitsvalgte, deriblant verneombudene.

Professor Olav Hanssens vei 10, Boks 599, 4003 Stavanger, telefon: 51 87 60 50, telefaks: 51 87 60 80, E-post: postboks@ptil.no, internett: www.ptil.no

Appendix B – Antenor Management System



ENGINEERING

NB - Notifyed BodyDM - Departement Mngr.; EM - Engineering Mngr.; PE - Project Engineer; SUPV - Supervisor; PO - Procurement Officer; HSEQ - HSEQ Officer;

No	Activity	Responsible							
		NB	PM	EM	PE	SUPV	PO	HSEQ	
	Planning ➡				ST				◇ RISK ⓘ HSE
1.0 HSE	Start engineering and develop documents		⬚	⬚	▽				IK Document Template User Manual IK Document Template MRB IK Document Template Life Cyckle Information
2.0	Develop consept design		⬚	⬚	▽	⬚			-
3.0	Design Review Go through project specifics. Ref #12 Planning Process		▽	⬚	⬚	⬚			Design procedure PEI projects to be approved by IK/PEI contact person
4.0 HSE	Perform risk analysis as defined in planning		▽	⬚	⬚	⬚		⬚	Risk Analysis
5.0	Detail engineering				▽				Design procedure PEI projects to be approved by IK/PEI contact person
6.0	Design Review (IDC)	◆	⬚	⬚	▽	⬚			Design procedure PEI projects to be approved by IK/PEI contact person
7.0	Fabrication and Assembly Review		⬚	⬚	▽	⬚			
8.0	Approval of engineering documents.	◆	▽	⬚	⬚				Document Control
9.0 HSE	Develop Workshop Request Sheet (WRS)		⬚	⬚	▽				WRS (including, assembly, test, FAT, SIT)
10.0 RISK	Check if any changes from original sow		▽		⬚				Change control. Issue variation order request (VOR) Project Manager Report Use customer template for VOR / IK VOR
11.0	Develop basis for Purchase Orders (PO/Contract) and procurement list.		⬚		▽		⬚		General purchasing conditions PO Request Form According to relevant project specifications Assess need for back to back contract. Define documentation ref. MRB.
12.0 RISK	Approval of procurement list		▽						Authority matrix
			END						Purchasing and fabrication ➡

PURCHASING AND FABRICATION

NMP - Manager Projects; PM - Project Manager; PE - Project Engineer; LOG - Logistics; SUPV - Supervisor; PO - Procurement Officer; NB - Notifyed Body

No	Activity	Responsible						Comments
		NB	PM	PE	LOG	SUPV	PO	
	Engineering							
1.0	Identify suppliers and submit ITT. Receive, assess supplier.		⬚	⬚			▽	Supplier list
2.0	Select supplier, Contract form and purchasing strategy.		▽	⬚			⬚	Purchase Procedure Update NAV and AMS accordingly
3.0	Issue PO in Navision or back to back contraacat/Standard Contracts		⬚	⬚	⬚		▽	Authority matrix General purchasing conditions LOG to be informed about extent and planned delivery date.
4.0	Follow-up: Ref. Test and Inspection Plan	◆	⬚	▽	⬚		⬚	
5.0	Goods receival, sign packing list including QC and verify PO		⬚	▽	⬚	⬚	⬚	Procedure for goods receival
6.0	Check fabrication documentation		⬚	▽			⬚	
7.0	Accept goods when it is in accordance with PO and receive in NAV		⬚	▽	⬚		⬚	
								Assembly

Assembly

PM - Project Mngr.; PE - Project Eng.;
TECH - Technician; MW - Mngr. Workshop; NB - Notifyed Body

No	Activity	Responsible						
		NB	PM	PE	TECH	MW		Comments
	Purchasing and fabrication							
1.0	PM send Workshop Request Sheet (WRS) to MW							**Note:** WRS Including Assembly Instruction Handover in person and electronic
2.0	Define personnel and tools							
3.0	Assembly Kick Off							
4.0	Perform assembly according to Assembly Instructions							Toolbox talk Perform SJA if necessary OLF SJA
5.0	Note changes on drawings and forward to MW for return to PE							
6.0	Perform QC activity according to Test and Inspection Plan							
7.0	Component Functional Testing							Toolbox talk Perform SJA if necessary OLF SJA
8.0	Accept according to defined requirements							Ref. TIP
								Testing

TESTING

PM - Project Mngr.; PE - Project Engineering; SUPV - Supervisor; TECH - Technician;WM- Dept. Mngr Workshop; NB - Notifyed Body

		Responsible						
No	Activity	NB	PM	PE	SUPV	TECH	WM	Comments
	Fabrication & assembly						ST	RISK ◇ ⓘ HSE
1.0	Prepare and submit WRS and/or CTR for qualification testing		▽	⬚			⬚	Notified body to be noticed if required
2.0	Receive WRS and/or CTR for qualifictaion testing						▽	DMW start resource planning and check that proper documentation is available.
3.0 HSE	Perform Safe Job Analysis if required.		▽	⬚	⬚	⬚	⬚	OLF SJA
4.0	Perform Qualification Test	◆	▽	⬚	⬚	⬚	⬚	Documented and marked. (CE) IK Pressure Test procedure Samsvarserklæring (CE)
5.0	Prepare and submit WRS and/or CTR for PRE-FAT/FAT according to Test and Inspection Plan		▽	⬚			⬚	
6.0	Receive WRS and/or CTR for PRE-FAT/FAT and identify resources needed to perform		⬚	⬚			▽	The operations procedure forms the basis for FAT. Testrig and adaptations to be described.
7.0	Perform SJA and PRE-FAT		▽	⬚	⬚	⬚		Ensure the test is accordance with procedure
8.0	Notify client		▽					
9.0 HSE	Perform Safe Job Analysis with client		▽	⬚	⬚	⬚		OLF SJA
10.0 RISK	Perform FAT according to Test and Inspection Plan		▽	⬚	⬚	⬚		
11.0	Accept/reject		▽					Ref. punchlist
12.0	Issue Certificate of compliance	◆	▽					MRB Manufacuring Record Book
			END					Delivery