NTNU – Trondheim
Norwegian University of
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Safety as succeeding under varying conditions

Contributing factors to successful operations

Astrid Thevik

Safety, Health and Environment
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Supervisor: Eirik Albrechtsen, IØT
Co-supervisor: Trygve Steiro, Safetec

Norwegian University of Science and Technology
Department of Industrial Economics and Technology Management

NTNU
Det skapende universitet

MASTERKONTRAKT
- uttak av masteroppgave

1. Studentens personalia

Etternavn, fornavn **Thevik, Astrid**	Fødselsdato **16. des 1990**
E-post **astrithe@stud.ntnu.no**	Telefon **92895390**

2. Studieopplysninger

Fakultet **Fakultet for samfunnsvitenskap og teknologiledelse**
Institutt **Institutt for industriell økonomi og teknologiledelse**
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Hovedveileder ved institutt **Førsteamanuensis Eirik Albrechtsen**	Medveileder(e) ved institutt
Ekstern bedrift/institusjon **Safetec**	Ekstern veileder ved bedrift/instutisjon **Trygve Steiro**
Merknader **1 uke ekstra p.g.a påske.**	

4. Underskrift

Student: Jeg erklærer herved at jeg har satt meg inn i gjeldende bestemmelser for mastergradsstudiet og at jeg oppfyller kravene for adgang til å påbegynne oppgaven, herunder eventuelle praksiskrav.

Partene er gjort kjent med avtalens vilkår, samt kapitlene i studiehåndboken om generelle regler og aktuell studieplan for masterstudiet.

Trondheim 11/4-14
Sted og dato

Astrid Thevik
Student

Hovedveileder

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Abstract

Background: Traditional safety thinking has been concerned with investigating accident causations in order to learn from these. It would be interesting to shift the focus towards learning from all the operations that go well in the same manner. After all, the successful operations constitute the great majority of all the operations

Objective: The main goal of this master thesis is to study what factors might contribute to successful operations in terms of safety. In relation to this it is also relevant to look into the definition successful operations.

Method: The empirical study comprises of 10 interviews with people who work on board a drilling rig currently operating in Norway. The informants who participated in the interviews hold different positions and come from different companies represented on board the rig. The thesis does also include a literature review upon related theories.

Results and conclusion: The findings in this study show that it can be difficult to characterise or define successful operations. The definition will be subjective; however there are some common features of successful operations. Maintaining the life and health of people are the number one priority. A successful operation should also result in the intended product even though it might take some more time than planned. A successful operation is created by many factors and conditions. This study identified 27 factors that might contribute to successful operations in terms of safety. It can be difficult to pin point exactly what factors that might create a successful operation. A lot of the theory focuses on informal factors related to humans and their actions, however the findings in this study implies that there must be both formal and informal factors present. It seems like these are both equally important.

Sammendrag

Bakgrunn: Tradisjonell sikkerhetstenkning har vært opptatt av å granske årsakene til ulykker for å lære fra disse. På samme måte vil det være interessant å flytte fokuset over til å lære fra alle de operasjonene som går bra. Vellykkede operasjoner utgjør jo faktisk størsteparten av alle arbeidsoperasjoner.

Mål: Hovedmålet for denne masteroppgaven er å undersøke hvilke faktorer som kan bidra til vellykkede operasjoner med tanke på sikkerhet. I den sammenheng er det også relevant å se på definisjonen av vellykkede operasjoner.

Metode: Den empiriske studien består av 10 intervjuer med personer som jobber på en borerigg som for tiden opererer i Norge. Informantene som deltok jobber i ulike stillinger og kommer fra ulike selskaper som er representert om bord på riggen. Denne masteroppgaven består også av en litteraturstudie av relaterte teorier.

Resultat og konklusjon: Funnene i denne studien viser at det kan være vanskelig å karakterisere eller definere vellykkede operasjoner. Definisjonen vil være subjektiv, men det er noen fellestrekk ved vellykkede operasjoner. Å ta vare på menneskers liv og helse er førsteprioritet. En vellykket operasjon bør også resultere i det ønskede produktet selv om det kanskje tar litt lengre tid enn planlagt. En vellykket operasjon blir skapt av flere faktorer og forhold. Denne studien identifiserte 27 faktorer som kan bidra til vellykkede operasjoner med tanke på sikkerhet. Det kan være vanskelig å peke på nøyaktig hvilke faktorer som er involvert. Mye av teorien fokuserer på uformelle faktorer knyttet til mennesker og deres handlinger, men funnene i denne studien tyder på at det må være både formelle og uformelle faktorer tilstede. Det ser ut som disse spiller en like stor rolle.

Preface

This master thesis was written during the final semester of the Masters' degree program in Health, Safety and Environment, at the department of Industrial economics and technology management at the Norwegian University of Science and Technology (NTNU). The thesis was written in relation to the research project "Learning from Successful Operations", which is a collaboration between SINTEF, NTNU, NTNU Social Science and Safetec.

I would like to thank my external supervisor Trygve Steiro, Senior Safety Advisor at Safetec and my teaching supervisor Eirik Albrechtsen, Associate professor at my institute at NTNU. I am truly grateful for all the help and support throughout this semester.

Last but not least I would like to thank the research team working with "Learning from Successful Operations" and all the informants who participated in the empirical study.

Astrid Thevik

Trondheim 05 June 2014

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1 Introduction

In the autumn semester 2013 I was choosing a topic for a project in the course TIØ 4521 HMS Fordypningsprosjekt. The choice fell upon "successful operations in terms of safety". The project formed the basis for this master thesis and served as a preparation for this study. Successful operations and the factors leading to these caught my interest because it represents a new way of safety thinking. In traditional safety thinking, the focus is on the things that go wrong, such as accident investigations, in order to learn and prevent similar things from happening again. Safety is thereby defined by the lack of safety. Accident investigations and the study of factors that lead to failure are widely used. Things that go wrong draw a lot of attention both from the organisation, authorities, media and the public. Such events are often very visible, and in combination with negative consequences, it is no wonder they have such a big focus in our everyday life. However one can agree that accidents and failed operations make up a very small part of all the operations which are performed in an organisation. Most of the time operations tend to go well. If there is so much to learn from the small proportion resulting in accidents and unwanted events, then there must be a large potential for learning from the opposite side as well. This new way of thinking shifts the focus toward all the things that goes right in order to understand normal operations and everyday performance. We use our knowledge about accident causations and contributing factors to accidents in order to prevent it from happening again. By gaining knowledge about the contributing factors which lead to success we can learn from successful operations as well.
There have so far been published few studies on learning from successful operations and the factors that lead to success. However organisational learning is a widely studied field.

> *The interest around the term organisational learning is built on the idea that continuous changes and tougher competition require the ability to be innovative and develop competence in order to succeed*
> (Petroluemstilsynet, 2013)

Today the development of new ideas and technology are increasing in speed, and thereby also the need for learning and adapting. Learning from successful operations can help companies in the oil and gas industry to decrease the level of risk and thereby enhance safety in their operations.

1.1 Drilling operations

Drilling operations are interesting field of study when it comes to successful operations because of their complexity, association with high risk activities and the number of actors involved. Drilling operations have many stakeholders, all the way from the operator who will profit from the findings of oil and gas to the fishermen whose livelihood will suffer in the case of pollution. Accidents in the offshore oil and gas industry have the potential for severe consequences and it is in everyone's interest to ensure successful operations in terms of safety.

The findings at Ekofisk in 1969 represented a flying start for the Norwegian petroleum industry, closely followed by other large fields like Statfjord (1974), Gullfaks (1978) and Oseberg (1979). Only last year, 59 new explorations wells were drilled on the Norwegian continental shelf, resulting in 20 new findings (Olje- og energidepartementet, 2014). This illustrates the extent of the drilling activities. 59 explorations wells were drilled, all consisting of a large number of sub operations that was performed without any major accidents.

Drilling of a well can be performed with several different techniques and by many different offshore installations or types of drilling rigs. However the basic drilling system will overall be the same. Very simply explained a hole is drilled in the ground by a rotating drill bit. Torque is transferred from a power source through a drill string. The use of a drilling fluid that is pumped down the drill string help transport the cuttings which are a product of the drilling up to the surface. The drilling fluid will also function as lubricate and cool the bit. In order to control the pressure one can adjust the weight of the drilling fluid. In addition there is a blowout preventer (BOP) which can seal off the well if there is a "well kick" that upsets the balance of the system (Jahn et al., 2008). Even though it all sounds quite straight forward there are a large number of things which have to be considered during the drilling of a well. We're talking about highly flammable substances under pressure. Not only are we drilling a hole in the ground, but the ground in question is placed up to several hundred meters under the ocean surface, which can cause challenges related to currents and weather conditions. There are several different actors involved in the drilling from different companies. One can define these operations as quite complex with many different components affecting each other and large amounts of energy involved. A drilling installation is a relatively small area where disturbances will spread rapidly through the system. Both the complexity and the tight coupling could be recognised from Perrow's theory of normal accidents.

Based on Normal Accident Theory (NAT) organisations with complex interactions and tight couplings, cannot succeed in the long run since these two characteristics combined will inevitably lead to major accidents (Perrow, 1984). Examples of this type of organisations are nuclear power plants, the aviation industry and also the oil and gas industry. Even though accidents do happened from time to time, we do know that these organisations are also able

to function well and carry out successful operations in the great majority of their operational time. This raises the questions: how is this possible when considering NAT? How can such organisations succeed? The theory of High Reliability Organisations (HRO) may provide some answer to this. HRO states that it is in fact possible to avoid accidents if the organisation is well designed and managed (LaPorte & Consolini, 1991). HRO focuses on things that go right despite of disturbances, through preparedness, foresight and flexibility (Rosness et al., 2010).

1.2 Deepwater Horizon

In the interview guide the Deepwater Horizon accident was used as an example of a major accident (see appendix A). This was used to try highlighting the contrast between a major accident and successful operations and as a way of placing the topic of the interview into a well-known context. All of the informants were familiar with the Deepwater Horizon accident. The following description is mainly based on Tinmannsvik et al. (2011).
On the evening of 20th April 2010 there was a blow out on the mobile offshore drilling rig Deepwater Horizon. The rig was preparing to leave the Macondo well in the Gulf of Mexico. This blow out resulted in explosions and fire, after which the rig sank two days later. 11 people died in the accident. The rig was going to place a cement plug in the well. During this operation the BOP was left open and therefore the only barrier to the reservoir was a cement plug at the bottom of the well. The drilling fluid was replaced with sea water, and during this operation there were several indications that something were wrong, however nothing was done to close in the well. No one noticed the well kick before drilling fluid started to pour out on the drill floor. By this point the blowout was so far along that gas was already spreading through the installation. This lead to multiple explosions and fire on board and the installation sank after two days. The oil leakage from the well was not stopped until 87 days after the accident (Tinmannsvik et al., 2011). Accident investigations have revealed that this accident was a result of many factors at the same time. So far there have been no blow outs with such severe consequences in Norway, however there have been events that possibly could have led to a similar outcome have they not been averted. One example is the blowout on Snorre A in 2004 (Schiefloe & Vikland, 2005). Considering this and the fact that Deepwater Horizon accident happened as late as 2010, prevention of major accidents and what factors that contribute to this is a highly relevant topic.

1.3 Scope and limitations

The scope of this thesis is to do an empirical study to explore what factors can contribute to successful operations in terms of safety in drilling operations in the Norwegian petroleum industry. In this context it will also be necessary to look at people's perception of successful operations. The goal is to try to define successful operations in terms of safety.

Research questions:

The objective for this thesis is to look at what factors can contribute to successful operations in terms of safety

The three research questions below are formulated on the basis the problem description in the master contract.

1) What are successful operations in terms of safety?

2) What factors can contribute to successful operations in terms of safety?

3) Give recommendations for further work

Figure 1 presents the structure of this master thesis. Chapter two is based on a literature review on the topics related to successful operations. This chapter will shed light on some relevant theories and previous research. Chapter three presents the methods utilised in this study and the case. In chapter four results and analysis are directly tied to the main discussion. Chapter five consists of a summarising discussion and chapter six presents the conclusion.

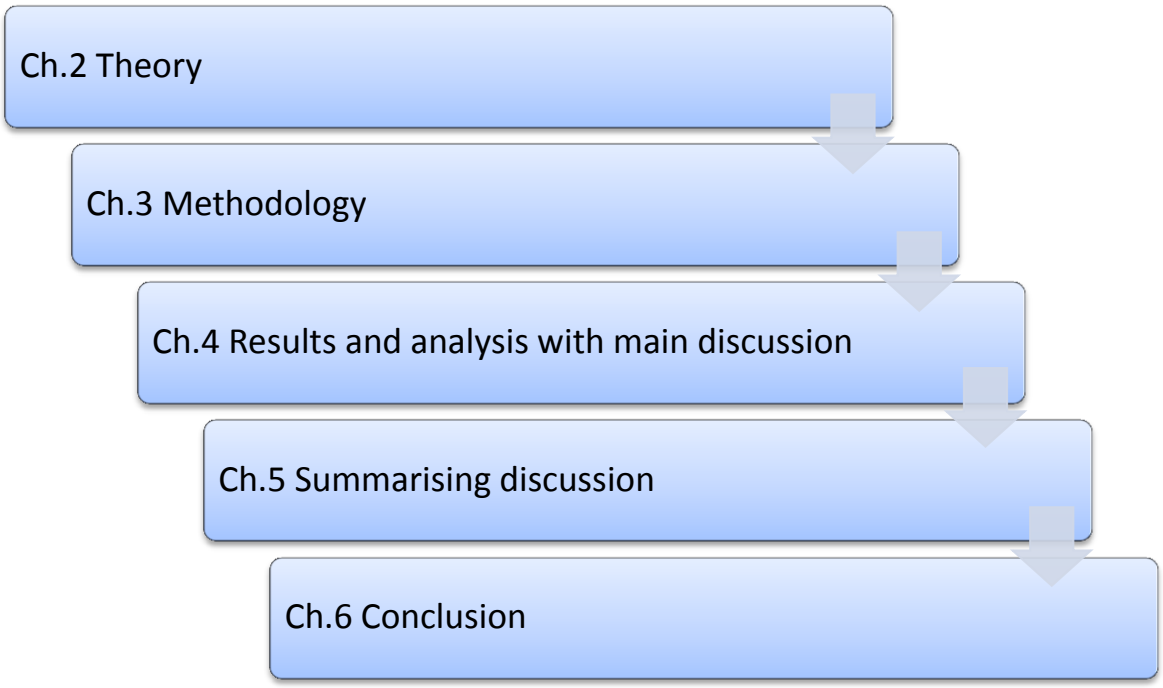

Figure 1: The structure of the master thesis

Limitations

Due to the time and resources available the study is limited to a single case which consists of a mobile drilling rig operating in Norway and the drilling operations on board this rig. The collection of data was conducted by interviews. The main focus of the study is on major accidents and organisational accidents, not on individual accidents and risk.

1.4 The research project "Learning from Successful Operations"

This master thesis is a part of the project "Learning from Successful Operations". The project is a collaboration between SINTEF, NTNU, NTNU Samfunnsforskning AS and Safetec. The research team does also cooperate internationally with the professors Andrew Hale and Erik Hollnagel. The scope for this project is a wish to prevent major accidents through knowledge about why accidents do not happen. The goal is to develop methods and tools which the industry can use to analyse and learn from successful operations.

This study is a part of a larger research project involving experienced researchers and the empirical work will be used further in this project. This has been a great support in the writing of the thesis. Even so, the writing of this thesis is an independent work which I have conducted by myself.

2 Theory

This chapter presents theories and research related to successful operations and why and how operations go well. The theory is meant to shed light on the findings in chapter 4.

2.1 Complexity and tight couplings

According to Normal Accident Theory (NAT), a system can be defined by its degree of tight coupling and complexity. Tight coupling is characterised by a low degree of redundancy which leaves little room for improvisation. Disturbance in one part of the system will directly affect the other parts, and the disturbance will spread fast throughout the system. A system with high complexity and complex interactions can behave in a way that can be difficult for people to understand or foresee. Unexpected or new interactions could suddenly occur. Complex interactions results in loss of a complete overview of the system (Perrow, 1984). Perrow (1984) has described some strategies to control systems with different degrees of tight coupling and complex interactions. An overview of the strategies is displayed in table 1. A system with a high degree of complexity can be controlled by decentralisation of the organisation. This is because such systems will include tasks that are difficult to standardise, non-routine tasks. Such tasks are best handled by the sharp end of the organisation. In a tightly coupled system, disruptions will spread rapidly; this will require a fast and well-coordinated response. Therefore tightly coupled systems are most effectively controlled by centralisation. When it comes to systems who are both high in complexity and tightly coupled, the strategy become more complicated. Ideally one should both decentralise to control complexity and centralise to control tight couplings. However, this is not possible to do simultaneously. Therefore, Perrow (1984) argues that this type of systems cannot be effectively controlled, and will inevitably lead to accidents.

Table 1: Strategies to handle coupling and complexity (Perrow 1984)

	Linear interactions	**Complex interactions**
Tight coupling	Centralise to control the tight coupling	Centralise to control the tight coupling, but *do also* decentralise to control complex interactions
Loose coupling	Centralise or decentralise will both be effective	Decentralise to control complex interactions

NAT tells us that tight couplings and complex interactions leads to higher risk, and that it will be impossible to avoid accidents in such systems. Figure 2 illustrates the relationship between tight coupling, complexity and increasing risk. NAT do also tell us that it is not possible to prepare for the unimaginable (Perrow, 1984).

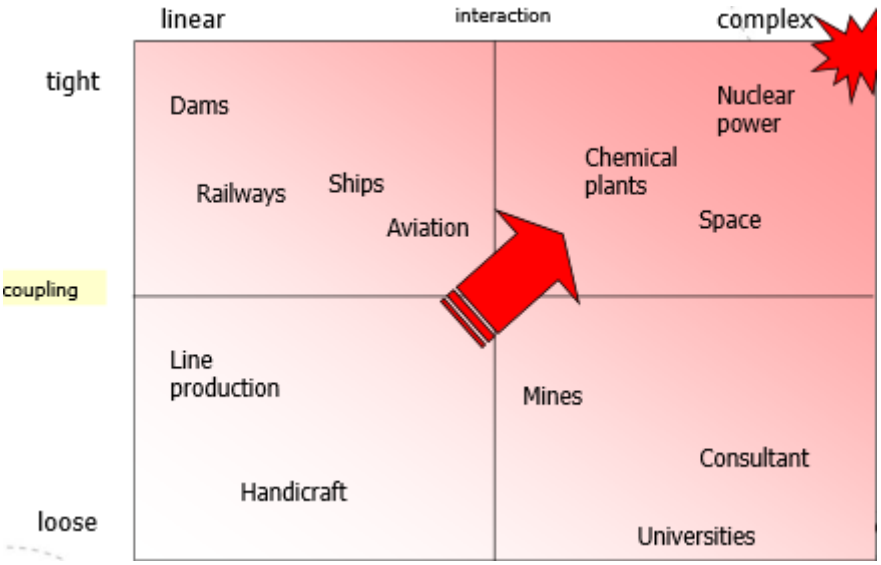

Figure 2: The relationship between coupling, complex interactions and increasing risk level. (Perrow, 1999)

A drilling rig would be placed in the upper right corner with a high degree of complexity and tight coupled systems.

2.2 Resilience

Traditional safety thinking is based on learning from failure and thereby preventing similar failures from happening in the future. The focus is on why and how things go wrong. Safety is described as freedom from risk (Hollnagel et al., 2011). Since safety is an abstract phenomena and very hard to measure, it is usually measured in-directly through the things that go wrong. It is widely common to assess the level of safety in an organisation by the use of indicators that measure failure. Examples of such indicators could be Fatal accident rate (FAR), Lost time injury rate (LTI-rate) or Severe incident frequency (SIF). This traditional view of safety has also been called “Safety-I”. In the recent years the focus has started to shift towards another type of safety thinking, “Safety-II”. Safety-II has been defined as the ability to succeed under varying conditions. The goal of Safety-II is to learn from normal operations and the things that go right every day (Hollnagel et al., 2011). One could say that Safety-II is equal to Resilience which will be presented later in this thesis. Figure 3 illustrates Safety-I versus Safety-II or Resilience.

In traditional safety thinking one has a tendency to overlook or maybe even take for granted all the operations that go right. One thing that causes this can be habituation. Much like when we put on clothes in the morning and after a while our body doesn't feel that we're wearing them, because the neurons "get used to" the stimulus. The human brain does also "get used to" the exposure to all the things that go right since these are in large majority compared to the things that go wrong (Hollnagel et al., 2011).

Figure 3: Safety-I vs. Safety-II or Resilience (Hollnagel, 2013b)

Successful operations and resilience are closely related, it is therefore interesting to look at resilience and resilience engineering in order to understand the processes behind successful operations. According to Hollnagel et al. (2006), the focus of resilience engineering is to help people cope with complexity when under pressure, in order to achieve success. Resilience has been defined as:

> "*The intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions*" (Hollnagel et al., 2011 p. xxxvi)

Resilience engineering resembles HRO in many ways. Redundancy, reconfiguration and adaption are central aspects. The difference might be that in resilience engineering these are more fundamental aspects, like a normal state, when for HRO this first comes present under exceptional conditions (Rosness et al., 2010). Another difference could be that resilience engineering is more directed towards management, whereas HRO is about the organisational aspects.

Resilience consists of four basic aspects or abilities of a system, illustrated by figure 4. These four abilities can be established and managed in different ways depending on the nature of the system, but a resilient system must contain at least some of each (Hollnagel et al., 2011).

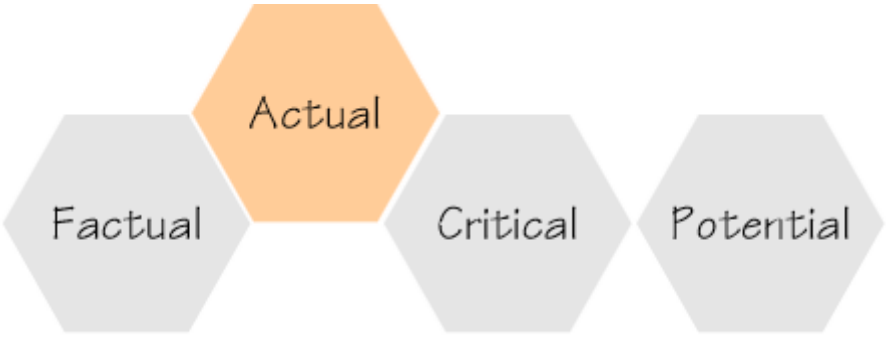

Figure 4: The four pillars of Resilience (Hollnagel et al. 2011)

A system must know how to respond to events, both regularities and irregularities. This response could be something the system has prepared for in advance, but it is also about change and adjustment of its normal function as disturbances occur. The ability to respond in the correct way and to know what to do could also be called the "ability to address the actual" (Hollnagel et al., 2011).

The ability to monitor ongoing events and the development in such events is called "the ability to address the critical" (Hollnagel et al., 2011). The system must be able to monitor ongoing developments in its surroundings and consider if these developments are a possible threat. Another important aspect is that the system needs to monitor internal developments as well as external (Hollnagel et al., 2011).

The "potential" is about anticipating the future. The system must know what to expect of potential disturbances, threats, changes and opportunities, and the consequences of these. In this way the system can try to prepare for such future events (Hollnagel et al., 2011).
The last, but not least, is the "factual". Systems must learn from past events and draw experience from this. Resilience seeks to learn just as much from success as from the failures (Hollnagel et al., 2011).

In resilience the focus has changed from looking at all the things that go wrong and the cause of failure, to studying things that actually go right. It aims to understand the causes behind success and thereby use this information to further increase success and thus prevent failure. Resilience consider both failure and success to be driven by a common fundamental process, and one can therefore get a better understanding of failure by looking at success (Hollnagel et al., 2011).

Hollnagel et al. (2006) has described several characteristics of individuals, groups and organisations that are experiencing success and successful operations. Among these are the ability to recognise and adapt when experiencing disturbances, variations and surprises. This ability is important especially in new situations that the system is not originally designed to handle (Hollnagel et al., 2006). To recognise disruptions and adapt to these seem to be central aspects of resilience. If one shall draw parallels to the four pillars, this would fall in under the ability to monitor or to address the critical, and the ability to respond or address the actual. In order to respond and adapt to disruptions and changes one must be able to recognise and identify ongoing developments. Systems that have the ability to anticipate potential disruptions before they occur will have a great advantage in that they can plan and prepare the response in advance. Nevertheless it is often impossible to foresee every little twist and turn in the situation, and therefore it will be important to be flexible and able to change strategies fast. The opportunity and ability to improvise could also be helpful when dealing with unexpected turn of events.

2.3 Compliance

Hale & Borys (2011) has described two paradigms related to compliance to rules and procedures. Paradigm 1 stated that rules are an essential foundation in order to create safety and that failure to comply with rules is a common cause for accidents. This can further be described a top-down approach to safety management (Hale & Borys, 2011) On the other hand there is Paradigm 2, which is bottom-up orientated and focuses of rules in practice. This approach allows “breaking” of the rules and states that this is in fact essential to create safety. Rules and procedures shall only sever as guidance. Paradigm 2 considers “breaking” of rules as a way of adaption in order to handle complexity and unexpected events (Hale & Borys, 2011).

2.4 Drift and Efficiency-thoroughness trade-off

2.4.1 Rasmussen's model of drift

Rasmussen's model of drift tells us that people is constantly operating within certain boundaries. Figure 5 presents three bondaries: the boundary of what is financially acceptable, the boundary of unacceptable workload, and the boundary of acceptable risk. Crossing the boundary of acceptable risk may lead to an accident or failure. According to Rasmussen (1997), both the effort to avoid unacceptable workload and to minimise financial costs can steer the operation or activities towards the boundary of acceptable risk(safety). In resilience, the goal is to be able to steer the activities close to this boundary, but never make a crossing, at least not an irreversible one. Use of the word "steering" is a good analogy to something dynamic, like a steering a ship. This highlights the fact that resilience is not a static characteristic of an organisation, but a continuously dynamic process (Hollnagel et al., 2006).

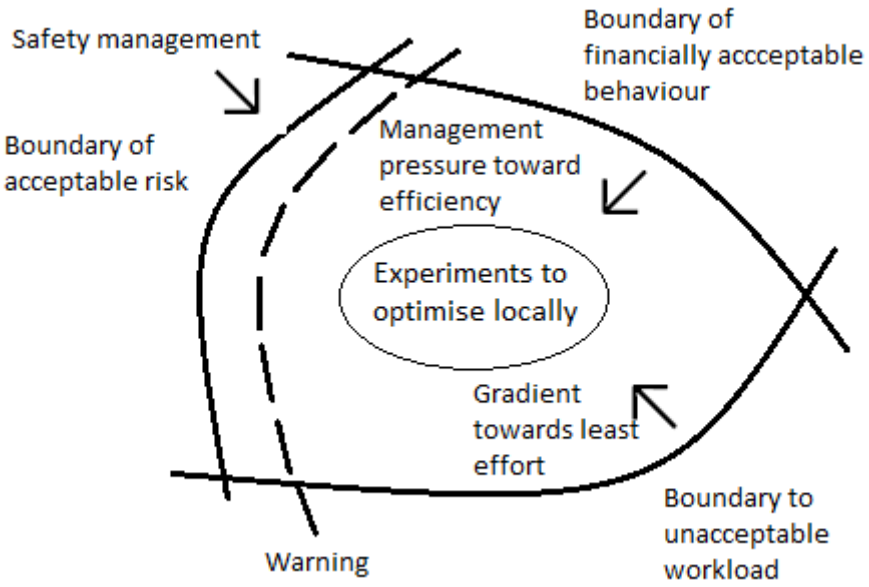

Figure 5: Model of drift and boundaries. Conflicting objectives tend to make activities migrate toward the boundary of acceptable risk. There is ideally a "warning" or proactive indicator of some kind when one comes close to the boundary of acceptable risk (Adapted from Rasmussen 1997).

2.4.2 Efficiency-thoroughness trade-off

> *"Being thorough as well as efficient is the hallmark of success"*
> (Hollnagel et al. 2006 p.3)

The efficiency-thoroughness trade-off (ETTO) describes the trade-offs people and organisations have to do between the resources they choose to spend on planning and preparing (thoroughness), and the resources they use on performing the actually task (efficiency). These trade-offs are done at all levels of an organisation and by all occupations. This is also something people do in their everyday life outside of the workplace. Thorough planning and a lot of time and effort used on this part may contribute to a better and safer execution of the operation, because people have the sufficient amount of time to identify potential risks. On the other hand, a lot of time spent on planning and preparing may not necessarily be good for production since there will be too little time left to carry out the operation. And vice versa, if efficiency is the priority over thoroughness, the operation may be badly planned and prepared, and in worst case this can lead to something going wrong. The ETTO principle tells us that in order to succeed with an operation, there must be a minimum level of both efficiency and thoroughness. That said, it will be impossible to maximise both of these at the same time (Hollnagel, 2013a).

It is expected of people that they are both thorough and efficient at the same time. In many cases people do not have the opportunity to choose how they do this trade-off, because of limited time and resources. Time pressure can force people to maximise efficiency at the expense of thorough planning and preparing. Different situations can demand different trade-offs. It is difficult to come up with one definitive answer on how this trade-off should be made in a specific situation. This will therefore depend on individual judgment and the available resources. How trade-offs are made might also be related to the culture of the organisation. Some organisations tend to favour efficiency above thoroughness, and the opposite.

2.5 Prerequisites for safe operation

Schiefloe (2012) has described 5 organisational prerequisites for safe operation. Figure 6 illustrates these five prerequisites.

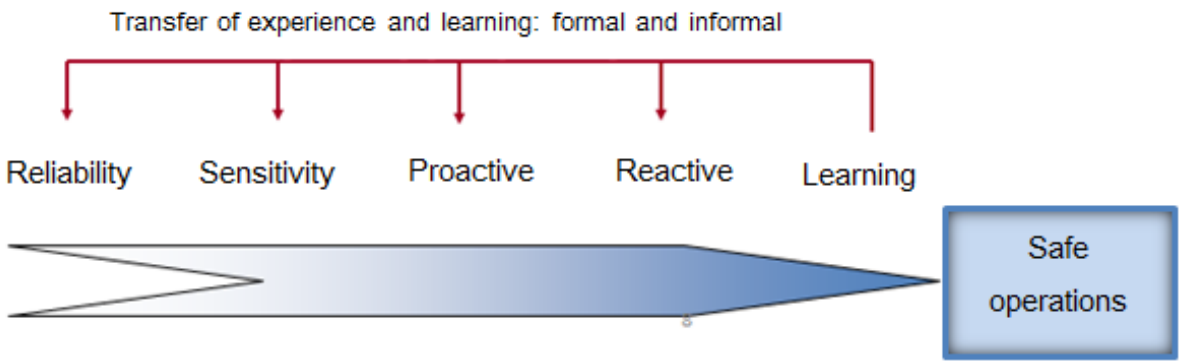

Figure 6: Five pre-requisites for safe operations. (Schiefloe, in Albrechtsen 2012)

(1) Reliability: An organisation that is reliable makes use of good planning and risk assessments, an adequate regulatory framework and robust technology and operation. Such organisations "make no mistakes". Good planning and thorough risk assessment implies the ability to anticipate potential events of the future. If the people in the organisation know what to expect, both from potential threats and opportunities, they can try to prepare for these future events. (2) Sensitivity is about being able to detect and understand early warning signals. This resembles "the ability to address the critical" in resilience. A sensitive organisation monitors ongoing events and developments and continuously evaluate whether this might be a potential threat. (3) The ability to make proactive actions includes corrective actions to stabilise and restore balance in the system. This includes both anticipation and response. A proactive response will most often be something the organisation has prepared for in advance. To be proactive is about always being one step ahead. In situations where this is no longer possible, the organisation needs to be reactive (4) and know how to make reactive actions. This becomes relevant when disturbance or accidents have already happened. Reactive responses can also be prepared in advance in the form of procedures and emergency plans, but in some cases the organisation has to make adjustments of its normal function that might not be described in any procedure. The last prerequisite is the ability to learn from past events. This could be done by recording and analysing accidents and other events, and monitor the statistics of these. The lessons learned should be used to further improve all of the four previous prerequisites.

2.6 Contributing Success Factors

A study on Resilient Recovery Factors (Størseth et al., 2010) has identified some central "Contributing Success Factors" (CSF's) which can possibly contribute to successful recovery in operations. These factors where described as 1) Risk awareness, 2) Response capacity, and 3) Support. The CSF's where based on theoretical studies which included both aspects from Resilience Engineering as well as other approaches to resilience, and some improvisation theory.

Risk awareness was considered an important factor because failure to recognise risks, or underestimation of the risks will often play a major role on the way towards failure (Størseth et al., 2010). Underneath Risk awareness and Response there have also been identified some sub factors: Risk understanding, Anticipation, Attention and Response. These are based on the adaption process in Resilience engineering: Anticipation-Attention-Response(A-A-R) (Størseth et al., 2010). Figure 7 illustrates the A-A-R process. It follows that anticipation, attention and response should not be exercised chronologically, this should be a continuous process. One can recognise the A-A-R from the four pillars of Resilience. Anticipation in the "Potential", Attention in the "Critical" and Response in the "Actual". Resilience has by Hollnagel et al. (2010, p. xxxvi) been described as "*The intrinsic ability of a system to adjust its functioning(…..)* it is from this implied that adaption is central to "*adjust its functioning*". Størseth et al (2010) have considered improvisation as an aspect of the adaption process. In facing unexpected situations, which often has never occurred before, it is necessary to continuously adapt to the new developments. Such situations are rarely described in any procedures and it is therefore no clear prescription on how to act. In order to handle the situation it may be necessary to use improvisation to some extent.

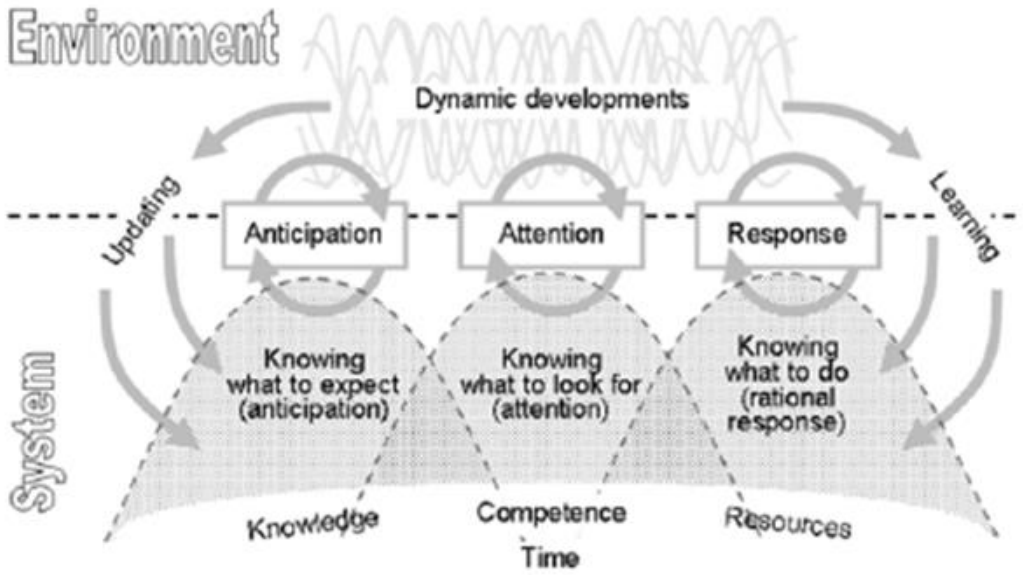

Figure 7: The process of Anticipation-Attention-Response (A-A-R). The system should try to learn both from failures and success in order to update its knowledge, and always be prepared to respond (Hollnagel et al., 2006).

Robustness, Resourcefulness and Redundancy are three other Contributing Success Factors identified by Størseth et al. (2010).

The CSF of Support has its basis in support in decision-making and "sacrifice judgments" described by Woods and Wreathall (2003). Sacrifice judgments is when one choose to sacrifice production above safety. In order for the decision-maker to know when to stop or reduce the production, there need to be some guidelines or in other words decision support.

Størseth et al. (2010) have found that these Contributing Success Factors can be useful both in studying cases that have already happened, and as a proactive tool revealing risks in potential new situations.

2.7 Crew resource management

Crew resource management (CRM) skills are considered the same as non-technical skills, which is a term developed by the European aviation industry (Flin et al., 2014). These skills have been defined as:

> *"The cognitive, social and personal resource skills that complement technical skills, and contribute to safe and efficient task performance"*
> (Flin et al., 2008, p.1)

The value of non-technical skills or CRM skills in high risk operations have been recognised for a long time and unwanted incidents in drilling operations have been connected to lack or failure of these skills (Flin et al., 2014).

Flin et al. (2014) have conducted a project where the goal was to identify key categories of non-technical skills required by wells personnel. They have used this to create a training syllabus for Well Operations Crew Resource Management (WOCRM). The project identified 6 main categories of WOCRM skills:

1. *Situation Awareness*
2. *Decision Making*
3. *Communication*
4. *Team Work*
5. *Leadership*
6. *Performance shaping factors- stress and fatigue*

(Flin et al 2014)

In table 2 each of the six categories are presented with sub elements.

Table 2: WOCRM skills components, adapted from Flin et al. (2014, p. 12)

Main category	Sub elements
Situation Awareness	▪ Gathering information ▪ Understanding information and risk status ▪ Anticipating future state/developments
Decision Making	▪ Identifying and assessing options ▪ Selecting an option and communicating it ▪ Implementing and reviewing decisions
Communication	▪ Briefing and giving feedback ▪ Listening ▪ Asking question ▪ Being assertive
Team Work	▪ Understanding own role with the team ▪ Coordinating tasks with team members/other shift ▪ Considering and helping other ▪ Resolving conflicts
Leadership	▪ Planning and directing ▪ Maintaining standards ▪ Supporting team members
Performance shaping factors- stress and fatigue	▪ Identifying signs of stress and fatigue ▪ Coping with effects of stress and fatigue

2.8 Error tolerance

Rosness et al. (2008) have discussed the term error tolerance:

> *"The ability to stop or change a chain of events which could have led to an accident, in such a way that the accident is prevented, or at least the consequences are mitigated"*
>
> (Rosness et al., 2008, p.13).

The purpose of error tolerance is that misjudgements, human error and technical failure should not automatically lead to accidents. Several factors can help build error tolerance in an organisation. Rosness et al. (2008) have pointed out the use of barriers as an important factor. Barriers can help recovery by blocking the chain of events that lead to an accident. This could be the case both for technical/physical barriers such as gas alarms and fire walls, and for more abstract barriers such as procedures and work permits. The barrier could also be humans detecting threats, e. g. an operator detect a gas leak. Pariès (2011) has also discussed barriers as factor in successful recovery in relation with the airplane that made a successful ditching on the Hudson River in 2009, where no lives were lost. The airplane had multiple layers of "defence in depth" to manage possible engine failure from birds hitting the engines. This is described as "strategic resilience". As one move through the line of defence, one has to sacrifice preferred solutions in order to save what can be saved. The pilots of this airplane had to sacrifice the possibility of a safer landing on a nearby runway in order to save as many lives as possible. Even though the ditching in the river was more risky than landing on a runway, they knew that if they failed at reaching the runway in time, the consequences would be far more severe (Pariès, 2011). Multiple barriers that make up "defence in depth" can be important contributions to success if they work as intended. For this to be the case, one has to make sure the barriers are independent. There is little use in multiple barriers against the same threat if all of the barriers are being put out of function by one common failure (Rosness et al., 2008). A gas alarm and a fire extinguisher system not working because of failure in the main power supply can be an example. After all barriers are only intended and designed to work in foreseen situations.

Another factor that contributes to error tolerance is the level of competence among the operators. A high level of competence, knowledge and skills will make the operator more prepared to handle unwanted and unforeseen situations (Rosness et al. 2008). When there is no clearly defined prescription on how to act, competence and experience could help compensate. A high level of competence could maybe also increase the operator's ability to detect unwanted and unforeseen developments at an early stage and thereby increase the chances of a recovery. In order to build error tolerance the organisation need to encourage

people to correct others when they see colleagues making misjudgements and errors. The organisation needs to build a culture where this is an acceptable practice among everybody. It also needs to be room for mistakes without creating any scapegoats or accidents (Rosness et al. 2008). Error tolerance consists of barriers, robust work practice and improvisation.

2.8.1 Robust work practice

Robust work practice has been described as:

> «*The small actions skilled professionals do to protect themselves and others from hazards that may occur during the execution of the work*" (Tinmannsvik 2008 p. 13**)**

An example can be when a person notify a colleague who is about to do something wrong, that can lead to negative consequences for him or others. Another example can be the operator taking two minutes to mentally go through the task and related risks before he starts. Robust work practice could be a way of building error tolerance (Skjerve, 2008). According to Skjerve (2008), robust work practice is to a great extent based on the individual's own thinking and interpretation of the situation. This means there is no "blueprint" on how people consider the situation. One person may decide to intervene in a safety critical situation, where another person does not see this as necessary. Because of this one might say that there is a lot of uncertainty related to this type of robust work practice. How different individuals interpret the same situations can vary a lot depending on what kind of experience they have and if they have encountered a similar situation earlier. Robust work practice and how people think about situations are based both on rules and procedures and on their previous knowledge. The process of robust work practice does also take place in both a formal and informal context (Rasmussen, 1986). The organisation can include this as a routine by incorporating such practice into the procedures and work prescriptions; "take-two" can be an example of this. "Take-two" is a term used for stopping the operation and taking a few minutes to evaluate the situation. The organisation can also train its personnel in how to apply different methods of robust work practice in their daily work. In the more informal context, there is a great variety in how people exercise this type of work practice. Since there are no procedures or descriptions on how this shall be done, it becomes very individually dependent. As mentioned earlier people's perception and judgment can be strongly related to their knowledge and past experience. People will also be influenced by their colleagues. An apprentice or new employee will most likely adopt the same practice as the colleagues he or she works with on an everyday basis. This is related to safety culture and the informal norms and attitudes in the group and organisation.

2.8.2 Improvisation

Andresen et al. (2008) have described improvisation as:

> "*A high degree of proximity (in time) or correlation in time between composition / planning and execution of an action"* (Andresen et al 2008 p.122)

The acts of improvisation do not necessarily lead to success every time, but it can be a way of increasing the likelihood of success. Improvisation is something that can be done both by individuals and groups (Andresen et al., 2008).

In unexpected situations one often relies on the skills, knowledge and experience of individuals in order to make successful improvisations. Confidence in yourself and your colleagues will also be of importance (Andresen et al., 2008). The successful ditching on the Hudson River is also an example on how improvisation can turn a very severe situation into a successful recovery. The decision to ditch the plane into the river was an act of improvisation (Pariès, 2011).

The opportunity to improvise in unexpected and unknown situations will often depend on the organisation. In many cases it is the organisation that set up the boundaries within where the individuals and groups can act (Andresen et al., 2008). Cunha, Cunha & Kamoche (1999) have identified three main characteristics of an organisation, which can promote improvisation. 1) The organisation must have an experimental culture. This is the type of culture that allows people to try new things and experiment. 2) The organisation must have minimal structure, and management and control should instead be carried out indirectly through the organisation's culture and ideology. 3) The organisation should also have a low procedural memory, which means little formalised procedures and prescriptions on how the different work tasks shall be solved.

Successful improvisation can also be influenced by the organisation's ability to adjust the operational mode, reallocate resources and use these available resources in a flexible manner (Cunha, Cunha & Kamoche, 1999).
Weick (1995) has pointed out that promotion of improvisation can help build trust and close relations among colleagues, and that this will improve cooperation and interaction during stressful situations and time pressure.

2.9 Mindfulness

Weick & Sutcliffe (2007) have explained mindfulness as the ability to see the bigger picture. This is when people do not only consider single actions, but also the context where the actions are carried out. At the same time they focus on how details differ. When speaking of mindfulness, the context can be described as the bigger picture of the moment. Mindfulness is also about noticing development of the unexpected. When working in complex systems, mindful organising could be one factor which contributes to success in the way that such organising give people the chance to detect unexpected developments and stop or change the course of these, or adjust and restore functions (Weick & Sutcliffe, 2007). Mindfulness involves five principles, divided into two groups: Anticipation and Containment (Weick & Sutcliffe, 2007). The principle of anticipation includes being 1) focused on details, 2) focus on potential failure, and 3) being sensitive to the operation. If one is preoccupied with failure, one might be able to pick up early signals of development of unexpected events. Being focused on details can prevent weak signals of unexpected developments from being missed or overlooked. A low degree of differentiation among such details can prevent the ability to detect important signals of new unexpected events. Being sensitive to the operation means that one have to consider the whole context and adapt the intentions from plans and design to the specific context applicable to the specific operation. The context is something that is often not considered in planning of the operation. The principle of anticipation can be recognised from the concept of anticipation in resilience. Anticipation is about detecting and preventing unexpected developments. The principle of containment is used when unexpected events continue to develop. Where anticipation is about being proactive, containment is about being reactive. Containment includes 4) commitment to resilience and 5) respect for expertise. Resilience, in this sense, means the ability to maintain the original functions of the system when exposed to disruptions. This can be compared to a rubber band returning to its original shape after being stretched. This ability implies knowledge on how to use existing practice in new ways, a wide range of response repertoires, the ability to control emotions in stressed and chaotic situations and rich information sharing. Respect for expert judgments is about leaving the decision making to experts rather than the management. Experts, especially in the sharp end of the organisation often possesses valuable knowledge about the operation that can in fact make them more capable in decision making than people that is higher in rank (Weick & Sutcliffe, 2007).

2.10 Sensemaking

According to Haavik & Wærø (2012) it is important to look at the relationship between work-as-imagined and work-as-done in order to understand the factors which lead to resilient operations. Work-as-imagined are the prescriptions, procedures and plans made in advance on how the work operation should be done. This is the intended way the operation should be carried out. On the other hand there is work-as-done, which is the work practices that actually is done. The work-as-done will most often be very alike the prescriptions on how the work is to be carried out, but it will also be coloured by how people interpret different situations and how they make sense of these (Haavik & Wærø, 2012).

Sensemaking is defined as the processes where people give meaning to observations and experiences (Weick, 1995). Sensemaking are closely related to decision-making, understanding and interpreting (Schiefloe, 2013). Haavik & Wærø (2012) found that the process of sensemaking was influenced by people's theories and models conceptualizing safety and risk. Clegg et al (2008) have described seven characteristics of the sensemaking processes. 1) The processes are on-going in the sense that people are making sense of situations all the time. 2) The processes are retrospective in the way that people make sense of things by interpreting present situations in the light of the past. 3) People consider their interpretations to be "good enough" to make up a basis for their actions. In other words, the sensemaking processes are plausible. 4) The processes are built on images because people work with models, plans and mental maps. 5) People try to make the meaning of things more clear and justifiable by rationalising. 6) Organisations of today do often have a lot of technology for information processing. However sensemaking is performed by people. 7) Last, but not least, the processes of sensemaking is connected to actions. Thinking and actions define one another (Clegg et al., 2008). It is not always easy to define the "correct" sensemaking in a given situation, but good sensemaking can help improve management (Schiefloe, 2013). Managers should try to obtain as correct and comprehensive picture as possible, both of the organisational system as a whole and of specific situations (Schiefloe, 2013).

2.11 Learning and knowledge

2.11.1 Tacit and explicit knowledge

Jacobsen & Thorsvik (2007) have described tacit knowledge and explicit knowledge. Tacit knowledge is the knowledge that individuals carry. This knowledge is hard to describe and therefore difficult to share with others. This tacit knowledge is based on experience that individuals develop over time. It is common that individuals are not aware of the knowledge they possess, it is just something they make use of without reflecting upon it (Jacobsen & Thorsvik 2007). On the other hand there is explicit knowledge. This is the shared knowledge in the organisation and among colleagues. Explicit knowledge are often found in procedures and written routines (Jacobsen & Thorsvik 2007).

2.11.2 Single loop learning and double loop learning

Argyris & Schön (1996) have presented the theory of single loop learning and double loop learning. This theory is based on people's behaviour being motivated by a goal, something we wish to achieve. However in some cases people can experience that the things we work to achieve are not really the same things that we wish. The theory of single and double loop learning describes the learning when people are starting to realise this. The focus changes from being occupied with how to do things better, also called single loop learning to looking at the overall goals behind the actions, double loop learning. The focus shifts from *how* to *why* (Jacobsen & Thorsvik 2007; Argyris & Schön 1996). Figure 8 illustrates the two types of learning.

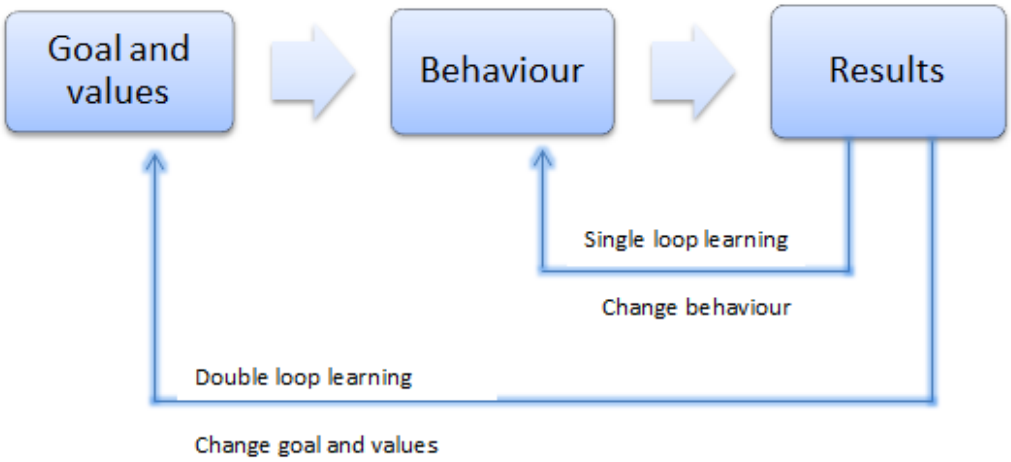

Figure 8: Single and double loop learning (Adapted from Jacobsen and Thorsvik 2002, p. 326)

2.11.3 Exploration and Exploitation in organisational learning

March (1991) has distinguished between exploration and exploitation in organisational learning. Central terms in exploration are experimentation, risk taking, variation, search, discovery, innovation and flexibility. Exploration can be described as finding new possibilities (March, 1991). Exploitation consists of terms like production, efficiency, selection, implementation, refinement and execution. Exploitation can be described as utilising old certainties (March, 1991).
Organisations must do a trade-off between exploration and exploitation. Favouring exploration above exploitation could lead to large costs without that many benefits. This would result in too many undeveloped ideas with little distinctive competence (March, 1991). On the other hand, favouring exploitation at the expense of exploration could lead to a "*suboptimal stable equilibria"* (March, 1991, p.71)

2.12 The Pentagon model

The Pentagon Modell by Schiefloe is a tool for cause analysis, which can also be used in the collection of data and analysis of correlations and interactions. The model can be used on different organisational levels, from individuals to the general organisational structure. As the name implies, the Pentagon model involves five aspects that affects safety critical work in an organisation. Figure 8 illustrates these five aspects.

Formal structure is often described as "organisation" or "organisational factors". This includes roles and responsibility, authority, procedures and regulations and staffing, among other things related to the formal structure of the organisation (Schiefloe, 2013).

Technology includes all the tools, machinery, equipment, ICT-systems and material infrastructure that the employees use to do their work. Maintenance, operating routines and the equipment's condition is also relevant for the technology-aspect. Technology has to been seen in relation to formal structure because different types of technology and equipment have different requirements regarding procedures and management, and the other way around (Schiefloe, 2013).

Culture includes factors as language, values and norms, attitudes and habits, competence/knowledge, symbols and expectations on how the work shall be done. The aspect of culture covers what people understand, know, think and believe (Schiefloe, 2013).

Social relations and Network covers the information structure, network structure and social capital in the organisation. It tells us something about the relationship between individuals, but also between groups or alliances. Key words here are trust, friendship, sharing of knowledge and experience, alliances and power, competition and conflicts (Schiefloe, 2013).

Interaction is how the people in the organisation communicate, cooperate and coordinate. People adapt, interact and influence each other. This aspect also includes leadership and information flow. Interaction is a precondition for social relations and network, and a foundation for organisational culture, learning and transfer of experience (Schiefloe, 2013)

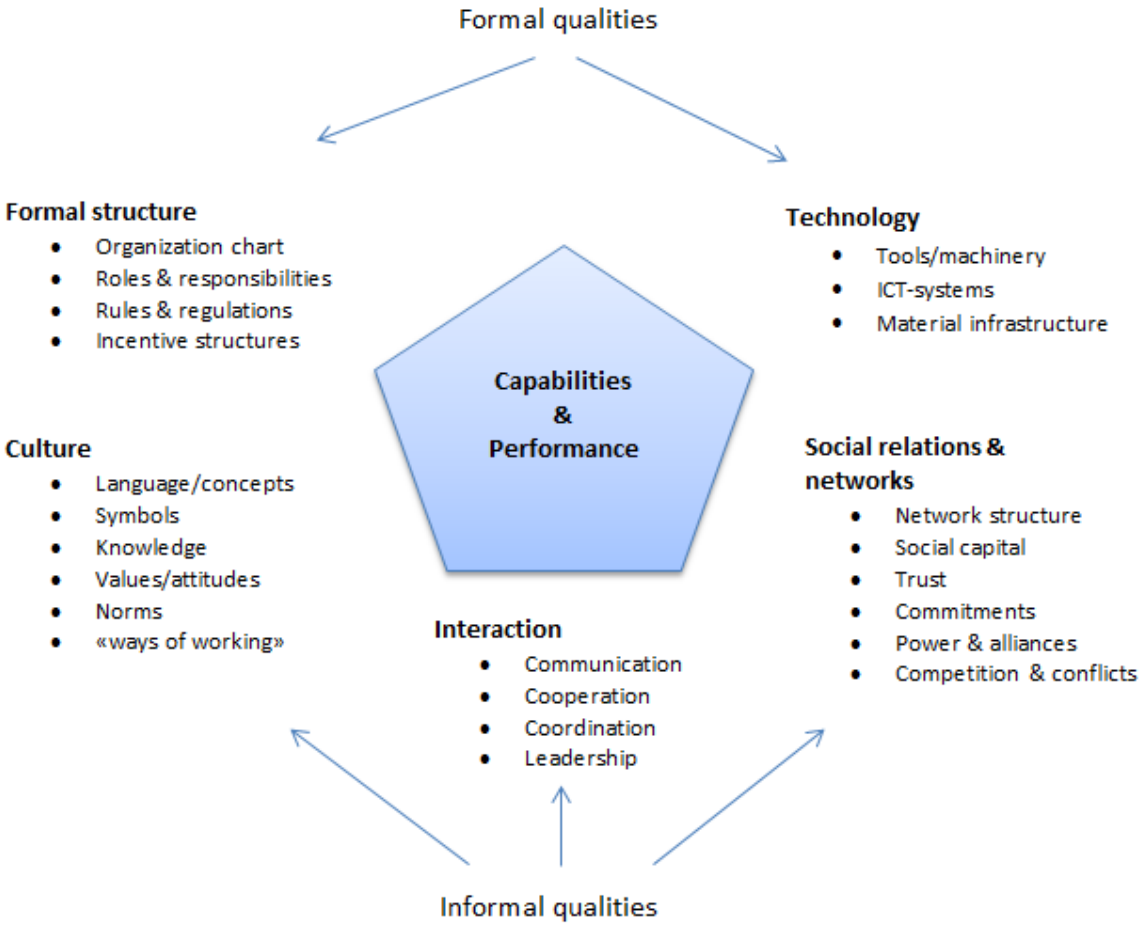

Figure 9: The Pentagon Model (Schiefloe, 2013)

It is important to consider all of the aspects as dependent of each other to a greater or less extent. Changes in one of the aspects can have impact on the others (Schiefloe, 2013). By considering all of these aspects when studying an organisation or an event, such as an accident, one can get a better understanding of the "bigger picture". It can also be a great help for sorting and systemising information. The pentagon model has been used for cause analysis after accidents and failure, for instance in connection with the blow out on Snorre A in 2004.

3 Methodology

This chapter presents the methods that were used in this study. There is also a presentation of the strengths and weaknesses related to these methods.

3.1 Research design

This study is performed as a qualitative study. If we are to compare quantitative and qualitative research, qualitative research focuses on word-based descriptions rather than the quantitative numbers and statistics. In qualitative research there is often an inductive point of view where observations lead to a theory or hypothesis (Bryman, 2012). A qualitative research design do also often emphasise the participant's point of view:

> *….the stress is on the understanding of the social world through an examination of the interpretation of that world by its participants.*
>
> (Bryman, 2012, p.380)

The approach in this study was to obtain rich word-based data from interviews, especially on organisational and social processes. Therefore, based on the properties of qualitative research methods, this seemed to be the most adequate design for this study.

Case

This study is built up with a case study design. A case study focuses on a single case; it could be a person, a group, an organisation or an event or situation, among other things. However, case studies are not only limited to qualitative research (Bryman, 2012).
According to Yin (2009) case studies can be divided into five categories: the critical case, the extreme or unique case, the revelatory case, the longitudinal case and the representative or typical case. Bryman (2012) has named the latter one "exemplifying case". It is most reasonable to categorise the case in this study as an exemplifying case. This type of case can be seen as an example of a wider category. In this study the case could turn out to be an example of a wider category comprising successful operations in drilling in Norwegian sector.

This is a case which is based on drilling operations on a rig currently operating in the Norwegian sector. This rig has been operating internationally in several other places in the world. The rig was recently brought to Norway to drill in the North Sea. In connection to the

transition to Norwegian sector there was a major change of crew. Nearly the entire drilling crew was replaced with a Norwegian crew. The new crew consisted of both experienced and quite new employees. The rig has a contract with a consortium of five operator companies.

The case was conducted through interviews. People in different positions have been interviewed to ensure as wide a range of perceptions as possible. People's point of view might vary depending on their position and type of work and responsibilities. Eight out of the ten interviewees came from the rig contractor company, one person was from the operator company and the last one was employed by a third party service company. The majority of the informants come from the rig contractor company because they represent the largest group on board the rig compared to the service companies. There are only a few people representing the operator company on board.

3.2 Literature study

In order to build the theoretical framework for this master thesis, a literature study was carried out. This can be described as a narrative review. The goal of a narrative review is to gain an initial impression of the topic area and is thus a more uncertain process of discovery. A narrative review will often be ranging over a wider scope and be less focused than a systematic review (Bryman, 2012). The search for literature was mainly conducted during the previous fall semester when I wrote a project preparing for this master thesis. A literature study is a way of mapping the existing research and publications on the chosen area. Knowledge about the findings in previous research can be helpful in assessing the relevance and significance of your findings. A literature study is not just about giving a pure reference of the findings of others, but to use these findings and theories to underpin your own results and interpretations (Bryman, 2012). Previous research and other literature related to the topic have been used as a foundation for the theory chapter and the discussion of the results.

The literature search was carried out primarily by the use of BIBSYS, which is the university's library search engine and Google Scholar. References to additional literature were also given by the supervisors and members of the research team. When using public internet-based search engines it is important to bear in mind that the sources might not always be equally reliable. It is important to look at the findings with a critical eye and evaluate the quality and reliability of your findings (Bryman, 2012). In selecting relevant literature, the focus was on relatively recent publications; however some older publications also proved useful.

3.3 Interview

In this study, 10 interviews were carried out with individuals. The purpose of the interviews was to gather empirical data in order to answer the research questions. All the interviews were conducted over a period of four weeks. The interviews lasted from 30-60 minutes. Some of the interviewees were at home while others were at work on the rig. When performing this study the goal was to interview people in several different positions. A Roughneck might have a different perspective and emphasise on other factors than a driller or a toolpusher.

The data collection was based on qualitative interviews**.** The interviews could be characterised as semi-structured, which means there is an interview guide with certain topics and questions, however the interviewer is not very conservative with respect to this guide. There is room for an open conversation, and new input is encouraged. A semi-structured interview allows the interviewee to talk about topics besides the questions in the interview guide and the interviewer will often ask new questions related to this. The topics and questions in the interview guide may not be asked in the exact order they was written, however most often all the topics will have been touched upon by the end of the interview (Bryman, 2012).

Before the interview started the interviewees were informed of their rights related to the project and the interview. They were informed that they could choose to withdraw from participating in the project at any time during or after the interview. The interviewees did also give their oral consent regarding use of a recorder.

The interview guide was developed by the research team and consisted of 7 main topics with subsequent questions (See appendix A). The questions were developed on the basis of different theoretical perspectives addressed in two workshops. I did not participate in the development of the interview guide myself, but both of my supervisors did. In consultation with my supervisors we agreed that this interview guide served my purpose. Since the interview guide was made to cover a wider range of topics than the scope of this thesis, some of the 7 main topics are not directly related to the research questions. However these are included nevertheless because they can help shed light on the scope of this thesis.

Strengths and weaknesses related to the interviews

Nine out of ten interviews were recorded. Recording the interviews can be a great advantage because it gives us the opportunity to collect every bit of data provided by the

interviewee, not only what we have the time and memory to write down. In the tenth interview the recorder was not operating. However, this was discovered immediately and the interviewer sat down with his notes and produced an extensive summary. Bryman (2012) point out that concentrating on taking notes in parallel while interviewing might distract the interviewer and make it difficult to catch important information given by the interviewee. Even though recording can be very useful, it is important to bear in mind that this could affect the interviewee's responses. People can be less open and more self-conscious when they know they are being recorded (Bryman, 2012).

The recorded interviews were transcribed in full, word by word by me. This was a time consuming process, however it was a great help in the process of initial analysis (Kvale, 1996)

During 6 of 10 interviews conducted in this study there were two or three people present, one person had the role as interviewer while the one/two others made notes as backup in case there was any technical problems with the recording. Another strength when conducting the interviews as a group is that the data from the interviews where discussed immediately afterwards. This enriched the initial analysis of the interview. This also helped in preparing for the next interview. Due to practical reasons and logistics I only had the opportunity to participate on 4 of the interviews. My external supervisor who is a part of the research group participated on all the 10 interviews.

Due to practical concerns the interviews were conducted by telephone. Telephone interviewing can make it difficult to create the same relation and interaction between the interviewer and interviewee, as if they were face-to-face. It will also make it impossible to observe or use body language. That said there is no definite evidence that interviewees will answer differently in a telephone interview compared to a face-to-face interview (Bryman, 2012). There were some minor problems regarding the sound quality of the recording, which possibly would have been better if the interviewee was in the same room as the recorder; however this did not significantly affect the transcription.

Sampling

The sampling in this study can be described as purposive. This means the participants were not chosen entirely randomly. Purposive sampling is often preferred in qualitative research in contrast to probability sampling, where the goal is to have a more random selection (Bryman, 2012). The initial sampling was based on a list of desired positions on the rig that was sent to the rig contractor. The company suggested 4 candidates in different positions. One of these informants was asked if he could provide us with some more candidates in

order to get a wider range in work positions, including people from the Operator Company and service companies. As follows 6 new people were interviewed. Table 3 presents the range of positions. The informants will later be referred to as informant A-J. The positions in table 3 are listed randomly and are therefore not directly corresponding to informant A-J.

Table 3: The informants' positions

Mud logger
Senior toolpusher
Subsea section leader
Technical section leader
Driller
Senior cementer
Roughneck
Company man
Rig Superintendent

The informants' work experience in the offshore industry ranges from a few years to over 20 years. Table 4 presents the distribution in experience.

Table 4: Years of working experience

Work experience:	Number of respondents
< 10 yrs.	2
10-20 yrs.	4
>20 yrs.	4

The majority of the informants are within the interval 10- >20 years.

3.4 Analysis

The three first phases of the analysis process is; 1) immediate while the interview is ongoing, 2) directly after the interview and 3) during the transcription and review. The analysis can be described as an ongoing mental process that already started during the first interview (Kvale, 1996). However since I was not present at all the interviews my main initial analysis was conducted during the transcription phase, thus I conducted phase 3 of the analysis. When all the empirical data was collected the information in the interviews were summarised in table form. The information was divided into categories reflecting the topics of the interview

guide. In addition some new categories were also created on the basis of topics introduced by the informants. This facilitated comparisons and interpretations in an organised manner and created a basis for further analysis of factors that might contribute to successful operations. The contributing factors were addressed in a separate analysis. This analysis was based on the five categories from the Pentagon model by Schiefloe (see chapter 2.12). Thagaard (2003) has described a main separation in qualitative analysis. One type of analysis focus on the significance of how the informants express themselves rather then what they express, while the other type focus on the content in the text. The analysis in this study can be described as the latter; the focus is on the content in the text.

3.5 Strengths and weaknesses

The external validity or generalizability of case studies are two aspects that have been pointed out as possible weaknesses. This is because the results and findings from a case study might be too specific for that single case, and thus it will be difficult to generalise these findings to other cases (Bryman 2012).
The goal of this study is not to generalise, but to obtain an understanding of the topic. One advantage by doing a qualitative case study is the opportunity to immerse in a single case in order to get a fuller understanding of the topic. This goal was achieved in the way that the informants' perceptions, opinions and experience with successful operations was uncovered and elaborated and thus a deeper understanding of the topic was obtained.

Bryman (2012) has described reliability whether or not the study is repeatable. Reliability in this study will be about all the interviews being performed in the same way and the same questions being asked. Kvale (1996) has pointed out that the reliability of qualitative studies can be "disturbed" because the interview does often have the form of a conversation. This can also be said to be the case in this study. The fact that there are different interviewers can also contribute to such a "disturbance" of the reliability. However Kvale has argued that the term reliability is best used in quantitative studies (Kvale, 1996). Even though the interviews proceeded slightly differently, all the informants were asked about the same topics and had the same opportunity to present their view. One could say that the reliability would be stronger by the use of very structured interviews or questionnaires where there is no room for diverting from the questions. However, in this study the goal was to obtain as rich and wide picture of the topic as possible and a semi-structured interview was therefore most appropriate.

The internal validity is about whether we measure what we want to measure (Bryman, 2012). In this case it will be whether we are actually studying successful operations. Based on this one could argue that the validity in this study is good because the empirical study has

given answers to the research questions. The informants did in fact give information about successful operations.

The case in this thesis was studied only through interviews. It would clearly have been an advantage to conduct observations as well. Observations of how the work and operations are done in practice would add another dimension to the results because it is likely that the informants could have missed out on some factors. This could be things that they do not pay much attention to on an everyday basis simply because it is so normal and ordinary to them.

4 Results, analysis and discussion

In this chapter I will present the findings from the interviews together with discussion of these findings. The analysis is divided into two: 1) Findings based on the analysis of each topic from the interview and 2) Analysis of contributing factors to successful operations. I have chosen to merge the results and discussion in order to create more flow in the text.

In order to analyse and discuss the factors that might contribute to successful operations that were identified from the interviews I have divided them into five groups much inspired by the pentagon model (Schiefloe 2013). In chapter 5 I have discussed the findings in relation to the research questions.

4.1 Background and experience

The majority of the informants have long experience from working in the offshore industry. 8 of the 10 informants have more than 10 years of experience. These people have worked in different positions throughout their career and some of them have worked both in Norwegian sector and international. This rich experience and variety of positions makes these informants provide a broad view on the topic of successful operations.

One will often consider the most experienced employees to be the ones who are the most aware of changes or best able to come up with problem solutions. You might be able to handle a situation or problem better if you've previously experienced something similar. That said one shall not underestimate the value of less experienced colleagues. They often have a way of looking at things in a different light. If you're new, you might be more open to new solutions and new ways of performing the operation. From the interviews one has heard stories about people with long experience refusing to make use of new suggestions because "this is the way we've done things around here for 30 years". However it seems like this kind of attitude is more and more belonging to the past. This will be discussed further later in this chapter.

4.2 Why the rig has not experienced a major accidents

When asked the question about why their rig has not experienced a major accident like Deepwater Horizon several of the informants point out the complexity of such an accident.

They believe that such an accident had many causes and probably started already in the planning phase. Many things went wrong in advance and during the accident.

Requirements, regulations, guidelines and good procedures are described as some of the reason why they have not experienced such an accident. One informant emphasise that the regulation is a lot stricter and have a stronger position in Norwegian sector. Requirements and guidelines are taken seriously by everyone on board. Not everyone read specific procedures related to all the operations they do, but everyone is informed on what is allowed and not allowed and how it should be done according to procedure.

The importance of good reporting is spoken of by a couple of the informants. By good reporting they mean that every little incident shall be reported as a way of preventing bigger accidents. They say that it is important that everyone is active and that everyone can give a heads up or a warning if they see something that doesn't seem right. One informant does also talk about focusing on the bigger picture as a way of preventing accidents. He says that details are important, but you must be able to place these into a bigger context.
Almost everyone mention the open culture on board and the relatively flat organisational structure. Some say that there was probably more hierarchy in the organisations related to Deepwater Horizon. The more open culture in Norway allows everyone to utter their opinion, make suggestions and ask questions. Everyone communicates with everyone, no matter what positions they have. All the informants confirm the low time and efficiency pressure. Anyone can say that the operation needs to be stopped if they see something that's about to go wrong or something that doesn't seem right. The operation will be stopped and everyone takes a few minutes to think through how it can be done better. It's important not to doubt each other's judgement on this. Everyone agree that it's ok to use a bit more time to make sure the operation is performed properly and as safe as possible, this also includes the operator company.
This is consistent with robust work practice as described by Skjerve (2008). Robust work practice requires that you have the adequate latitude, that you have time to «take two» and to stop the operation and change the plans.

Two of the informants talk about the high level of education and training among the Norwegian crew. Another one emphasise the importance of involving everyone, especially the newest and youngest on board.

> *"They can often notice things that the more experience of us do not see" – Informant D*

He also says that planning is important and that everyone knows what is happening.

The informants have a lot of suggestions of why this rig has never experienced a major accident, however some point out that there have been incidents in Norway that could have ended just as bad. It would therefore be wrong to say that this could never happen in Norwegian sector.

The informants' perception of their contribution

When asked about their contribution to avoid major accidents the informants' answers vary based on their position and work responsibilities. However some things are repeated. Several say that they focus on reporting and passing on information if they see something wrong or something that might lead to a problem. They focus on always giving the correct information. Several of the informants do also say that they are occupied with following procedures as a means of avoiding major accidents. And last but not least they talk about the importance of being one step ahead and planning for what might happen.

Two of the informants say that the equipment has a special focus, and they always make sure they have the right equipment for the job and that the equipment is functioning properly.

The informants in leadership positions focus on a close follow-up with every section, well control and making the right decisions depending on the surrounding conditions. One of them described the challenges related to weather conditions. Since you cannot always just press the button and disconnect the drilling equipment at any time, you have to assess each situation and plan ahead. It is important to know the time limits related to the weather.

One informant says that he and his colleagues try to look out for each other, especially when working with heavy machinery on the drill floor.

4.3 Critical phases and pure luck

Some of the informants talk about the critical phases of a drilling operation. These critical phases will typically be when drilling close to or inside the reservoir. They describe some focus areas related to this phases. Such a focus area could be to check the mud weight more often and having an extra person on the drill floor. There is also a pre job meeting before such an operation. On this meeting they discuss what is going to happen and they have designated tasks appointed to them in case something unwanted do happen. It is important that everyone involved have a clear picture of the potential situations that might occur.

When asked about luck and if they feel something went well due to pure luck none of the informants have any example. It seems like the term “pure luck” or luck at all is not widely used or spoken of on the rig. The concept of luck might be considered somewhat unprofessional. It is possible that luck is perceived to be incompatible with good skills, knowledge and education.

4.4 New crew and new in Norway

This rig has been operating internationally for the past few years and was recently brought to Norway. When the rig came to Norway there was a change of crew and a major part of the crew was new on the rig.
Due to the rig being new in Norwegian sector they have not developed the same procedure system as other well-established companies in Norway. The crew are very much involved in making the guidelines and internal procedures. One informant says that this means that they have to evaluate the operations they are about to do a bit more than others, operations that might be routine in other places. He believes this can be an advantage and that they focus on how to do things in alternative ways:

> *“We have to do things in new ways and not just do things the way it has always been done” – Informant A*

He also says that the personnel receive good training and the more experienced personnel are important. There are a lot of young people on the rig, but the people in leading positions are very experienced. Another person confirms that a core of people with long experience from this rig remained when they came to Norway and he think this has contributed to maintaining the good culture. One of the more experienced informants says that they take into account that many of the crew members are new and they focus on building competence:

> *“It is important that everyone learns how things are done and how the procedures are to be followed” – Informant I*

There seem to be an overall opinion that the new crew consist of very skilled and educated people who know what they are doing. Some say that there is a very high standard among Norwegian drilling crews in general. One mention that there have been some minor issues regarding unfamiliar equipment, but everything has exceeded all expectations. One of the informants says that working with them same people and people you know contribute to good routines and safe work. This is also confirmed by others. Many of the new crew members have worked together before on another rig. There was some team building when

the new crew started, but some of the informants expressed a wish for more of these activities, including more social activities when the crew is onshore. They say that this would be valuable for the social relationship between the colleagues and that this would further help build good working routines and efficiency.

4.5 A generational change

All of the informants confirm that there is an open culture on board focused on dialog and mutual respect for each other. Everyone can make suggestions. Everyone do also say that there is little time pressure and the focus is on doing the operations safe even if it might take a bit longer. Some of the informants talk about an "old generation" and a "new generation" in terms of organisational structure and the way of working. The old generation is characterised by more hierarchy and less dialog. One person say that this type of generation might make it more difficult to ask questions and make suggestions, especially if there is a very strong "old generation" leader on top. However on this rig there are a lot of leaders emphasising the new generation way and this facilitates the open culture that they have here. The new generation way is also supported by the operator company and their representatives on board. Less time pressure and more safety focus is also related to this change of generation. One of the informants describes it like this:

> "*If we have a problem we fix it and it doesn't matter if it takes a bit more time as long as we do it safe" – Informant C*

One of the informants with the longest experience says that when he started working there was almost nothing called safety, operation came above everything else. There was not the same information flow from well tools either and the driller was virtually blind while drilling and could never know for sure what came up.

4.6 Third party companies and foreign workers

Two of the informants work for a third party service company. Both of them say that the rig is a very good place to work and they feel that they are included and that they are part of one big team. They also describe that this has not always been the case when they've been working other places in the world. One of them have experienced that people do not communicate well enough in other places he's been and it seems like they don't care about each other as much as here. On this rig people are interested in their work and who they are and often ask questions:

"We are not anymore the "guys from the cage" " – Informant H

One informant thinks that the third party service companies, the operator company and the contractor are equally important in their respective fields in terms of safety. A couple of the other informants emphasise that everyone depends on everyone on the rig and in the end they all become one big team.

The service companies, especially mud loggers and data operators have a close dialogue with the drillers and the rest of the drilling crew. They communicate on a daily basis through radio, telephone or face-to-face. They are also invited to all the pre job meetings held by the drilling crew. However they are not that much involved in debrief meetings unless something has happened. Even though the service companies have their own internal meetings, the OIM and Rig Superintendent have meetings with both the service companies and the operator company in order to include them in everything that happens and make sure they are informed. This is confirmed by an informant form a service company.

One informant say that they have pre job meetings with the people from the service company who owns the equipment they're about to use. Casing equipment is one example of such equipment. In these meetings the people from the service company explain how the operation is supposed to be performed, what should be taken into account and what might be dangerous.

One of the informant say that people from the service companies might see things from a different perspective and therefore discover things that the drilling crew do not see. Third party companies are not that much involved in the internal procedures of the contractor. The informant thinks that it would be an advantage if they were more involved in order to improve the procedures:

> *"If you do something a hundred times you might get a bit blind and it would be good if someone asked why it is done exactly like that and came with suggestions of improvement" - Informant C*

He also says that this was not welcome in the old generation, but now days, people are more open to suggestions.

4.7 Differences between Norwegian sector and International

Several of the informants are talking about the difference between working in Norwegian sector and working internationally. Some of the informants have experience from British sector, Falkland Islands, Africa and the Black Sea among several other places in the world. All the informants talking about these differences mention the difference in culture, both related to safety and the overall organisational culture. They say that there is much more hierarchy in international sectors while in Norway the organisational structure is more flat. They all talk about the openness in the Norwegian way of working. There is an open dialog where everybody can say their opinion and questions are encouraged. One informant says that he notices that foreign employees on board are not used to this and therefore they ask a lot less questions than the Norwegians. One of the informants with international experience says that the biggest difference, that he experienced, in terms of safety is use of the "red zone". He says that there exist a red zone in other places as well, but this is not so much in use. Two of the informants also mention the big efficiency focus that they experienced when working international. When working in Norway they are told that it's ok to use a bit more time to make sure the job is done properly and as safe as possible.

4.8 Learning from successful operations

There are hand-over meetings every day with the corresponding crew. On these meetings they try to focus on the things that go well in order to do the job the same way next time. The respective sections have separate hand-over meetings.
There are crew meetings where the potential for accidents and potential for improvement in the operation is discussed. The focus is primarily on what went wrong or what can go wrong, and they share views on how to do things in another way to make it safer or more effective. They have pre job meetings where they discuss how the job shall be done. There are also often debriefings after the job is done, especially if they have found a better way to do things. These debriefings are a part of the process of improving the internal work procedures.
The driller and toolpusher makes notes in the drilling instructions during and after the operation. This is written into a log which is evaluated by the operator company onshore who makes the drilling programs. Both positive and negative things are written. Some of it might be included in the next drilling programs in order to improve these.

This could be considered as an example of double loop learning. Instead of learning and adjusting the behaviour only locally, the learning is used to adjust more overall goals.

At least once during the 14 days shift there is a crew meeting lead by the safety representative in the crew. Questions from other crews are discussed and they get an insight in what the other crews have been working on.
All the section leaders have a daily meeting. All the service companies have morning and evening meetings with the operator company, logistics, Rig Superintendent and OIM. The service companies have internal systems for reporting and experience transfer.

They have a system of "share cards" on the rig. This is a reporting system where you make notes on a small card if you see something that you think needs reporting. This information is shared with everyone both on the rig and in the rest of the organisation. Nothing is too little or too stupid to write down on one of these cards.

There is a system of lessons learned. A lesson learned is a documented incident that is reviewed by all the crews. This is discussed on every safety meeting and drilling meeting. It is also passed on to the land organisation and from there to the entire fleet. One of the informants says that he thinks these lessons learned are very important to share with everybody. Everything in a lesson learned is anonymous and he thinks this is a better way of learning and preventing the incident from happening again than e.g. the use of warning letters to the people involved. Warning letters can make people anxious and sleepless which would increase people's stress levels and thus affect their work performance, cf. WOCRM by Flin et al. (2014).

One of the informants believes that the most important arena for learning is to get together and discuss in groups. He also says that the most important learning is at the sharp end. In relation to this the driller and toolpusher's daily meeting with the drill crew is very important. This is to inform everyone about what is going to happen. It is important that everybody have a good understanding of this. He also sees the value of simple and straightforward information that cannot be misunderstood.
One person says that training and good follow-ups are important for experience transfer inside the crew. Good ideas for improvement are encouraged.
One informant says that you learn a lot from trying different things yourself and it is important that the supervisor encourage you to try by yourself. People with long experience work alongside people with less experience in order to learn. That means that work and procedure are quality assured one might assume. It also allows for sharing of tacit knowledge (Polyani, 1967; Nonaka & Takeuchi, 1995; Jacobsen & Thorsvik, 2007). This way of working do resembles redundancy in HRO. Quality checks of each other's work are a means of creating redundancy (LaPorte & Consolini, 1991).

When asked about the potential for improvement of learning arenas, one of the informants mention that it would have been good to have some more cooperation between the service companies and the rig contractor regarding handovers.

Stories about successful operations

The informants where asked if they knew any stories of successful operations and things that had gone particularly well. If there were any such stories that was passed on among the crew on the rig or even from other places. One of the informants answered the question like this:

> *"You do not often hear about successful operations. There is much more focus and stories about things that go wrong"- Informant B*

The other informants do also answer in a similar way. This confirms the thoughts presented in the introduction chapter. Accidents and things that went wrong have been in the centre of attention, most probably because of their visibility compared to things that go right. Accidents investigations, lessons learned and reporting of negative observations have manifested itself as the primary source for learning. Learning from accidents has proved to be a valuable resource for improving operations and avoiding similar situations. This kind of experience transfer should absolutely be benefited from in the future.

One reason there are so few stories about success among colleagues might be related to the Norwegian or Scandinavian culture. The law of Jante is a widely used term in Norway and is referring to the text by the author Aksel Sandemose (Sandemose 1933) The law of Jante is based on a negative attitude and criticism towards individual success. One can ask whether this somewhat colours the stories that are told.

4.9 Definition of successful operations

One of the research questions I seek to answer in this thesis is: **What are successful operations in terms of safety?** Below I will present the main findings related to this research question.

When asked about the definition of a successful operation the answers vary a lot, this reflects the subjective nature of this question. However there are some common features in most of the descriptions. One of these common features is the absence of accidents or injuries to people. Another one is no problems or damage to the equipment. Several do also

describe a successful operation as when everything goes according to plans and you're able to do what you intended and deliver the intended product. One says that it is a success when everything goes according to plans, even though it might take a bit longer in order to do it safe. Two of the informants emphasise that a successful operation can consist of many smaller operations and that the big operation can be successful in the end even though there are trouble in some of the smaller operations:

> *"If you make it one by one in a proper way, at the end small successes will become a big success. For me it is a success when you have solved all the problems in the end" – Informant H*

One person says that a successful operation should have some flow. This doesn't mean that it needs to go very fast, but at least there is some flow. However he also says that there can be challenges related to such a flow. If you are in a "flow zone" for too long you risk losing some of your focus because you enter a sort of comfort zone. He believes that accidents often happen in this kind of situation when you have your guards down. In order to prevent this from happening and still maintain the flow they try to rotate on the different work stations. Table 5 presents some of the informants' definitions of successful operations. This will further be discussed in light of the research questions in chapter 5.

Table 5: Definitions of successful operations as quoted from the informants

Informant:	Definition of a successful operation:
A	*"The operation goes well despite the challenges. People are able to anticipate things that can happen and they focus on practical solutions if difficulties occur"*
B	*"A successful operation is when there are no injuries, no accidents, nothing happens to the equipment, everything goes as planned, even though it might take 10 minutes longer"*
C	*"Successful can be many things; it's a very broad question. One big operation consists of many smaller operations. The big operation can be successful in the end even though there is trouble in a few of the smaller ones. A successful operation is when:* - *We manage to do what we intended* - *No problems with equipment that leads to down time* - *HSE is looked after* - *Having some flow in the operation. Doesn't mean that it needs to go very fast but at least there is some flow"*
E	*"Success is when everything goes according to plans and there are no incidents with people or equipment. When you manage to do what*

	you're supposed to and deliver the intended product. No emission, no down time, no incidents or accidents"
G	*"A successful operation is when everyone can go home in the same state as they were when they came out, that's the most important point. It is of course positive if we manage to do the operations we planned and stay inside the budget and time frame, and maybe even more effective than planned"*
H	*"Everything is an operation with a success. If you make it one by one in a proper way, at the end small successes will become a big success. It is a success when you have solved all the problems in the end"*
J	*"A successful operation is an operation that is well planned and you manage to do it according to plans, first of all when it comes to safety"*

Example of a successful operation

The informants provided various examples of successful operations which they had participated in. One such example was when they managed to change a valve on the BOP when it was down on the sea bed. This was done by using the ROV. Normally this operation would require the BOP to be pulled up. By doing this while the BOP was down they saved a lot of time and money. The ROV was operated for 17 hours and by using some extra time and doing a thorough job they managed to solve the problem in a good way. This particular example was mentioned by three of the informants and they all said that this was an unusual and quite special job. One of the informants says that he doesn't think this has been done before. Everyone involved agreed on the solution and the cooperation was good. The operator company did also express their support in the decision. I have discussed this example in the following paragraphs.

Størseth et al (2010) have considered improvisation as an aspect of the adaption process. In facing unexpected situations, which often has never occurred before, it is necessary to continuously adapt to the new developments. Such situations are rarely described in any procedures and it is therefore no clear prescription on how to act. In order to handle the situation it may be necessary to use improvisation to some extent.

This seems like quite an extraordinary job. It is not a routine operation and there is probably no procedure on how this shall be done. One could say that this is an example of successful improvisation. This kind of improvisation will require good knowledge of the equipment and operating skills. Improvisation will also require a high degree of confidence, both in yourself

and your colleagues (Andresen et al. 2008). The opportunity to improvise will often depend on the organisation since the organisation set up the boundaries within the people can act; cf. Andresen et al. (2008). In this case the people involved in the operation had support both from their own organisation and the operator company. Improvisation is influenced by the ability to adjust the operational mode, reallocate resources and use these available resources in a flexible manner (Cunha, Cunha & Kamoche 1999). One of the informants said that all of the drilling activity was stopped during this operation and they had skilled people that were able to perform the job. Instead of immediately pulling up the BOP and do things the same way as always they saw new possibilities. This does also reflect central terms in resilience thinking, such as adjustment, adaption and flexibility (Hollnagel et al. 2011). Størseth et al. (2010) have also described improvisation as a part of the A-A-R adaption process.

According to Cunha & Kamoche (1999) there are three main characteristics of an organisation which can promote improvisation: 1) the organisation must have an experimental culture. This is the type of culture that allows people to try new things and experiment, 2) the organisation must have minimal structure, and management and control should instead be carried out indirectly through the organisation's culture and ideology and 3) the organisation should also have a low procedural memory, which means little formalised procedures and prescriptions on how the different work tasks shall be solved. There is a possibility that the rig being new in Norway and with a relatively new crew can help facilitate improvisation. Several of the informants confirms that the organisational culture on board encourage people to try new ways of doing the jobs and to continuously build and improve procedures.

Even though an experimental culture can contribute to successful improvisation, it is important that the flipside does not lead to a higher risk level for accidents. In allowing people to experiment and try out different solutions one has to keep in mind that these actions should not automatically lead to accidents if the experimentation or try should fail, cf. error tolerance. In the example with the ROV the operation was not of such character that it would have led to an accident if the operation had failed. In worst case they would have to pull up the BOP in order to change the valve.

March (1991) has described exploration in organisational learning as when people utilise something in order to learn. In light of this theory the valve change on the BOP could be considered as exploration of a new possibility.

4.10 Contributing factors to successful operations

Up until now I have presented the results from each of the interview topics along with analysis and discussion. In this section I will present the findings related to research question **2: What factors can contribute to successful operations in terms of safety?** These findings are based on the preceding topics as well as the informants' direct answers to this question. The informants suggested many factors that might contribute to successful operations. Their answer seemed to be somewhat coloured by their positions and previous experience, however most of the contributing factors where described by several of the informants. When analysing the interview transcriptions 27 contributing factors were identified, these are presented in table 6. The informants were asked to mention some factors that they thought could contribute to successful operations. In addition some of the factors were identified from the answers to other questions in the interview.

Table 6: Contributing factors to successful operations identified from the interviews

1. Having a plan B	15. Experience, both from previous situations and from your colleagues
2. Plan and think ahead and anticipate what might happen	16. Training and building competence
3. Thorough planning	17. Right people on the right place
4. Good procedures	18. Give people meaningful responsibilities
5. Good reporting	19. Support from the operator company
6. Good understanding and knowledge about the operation, work and rig	20. Flat organisational structure
7. Understanding the bigger picture	21. Good culture among everyone with mutual respect, transparency and dialog
8. Correct equipment	22. Good communication and cooperation
9. Daily maintenance of equipment	23. Working as a team and working for a common goal
10. Being practical and focus on solutions	24. Trust your colleagues and the quality of their work
11. Evaluation of the job, both before and after	25. Good working environment
12. Little time pressure: focus on performing the operation properly and safe even though it might take some more time	26. Working with the same crew and people you know help build good routines
13. Everyone can provide input, make suggestions and ask questions	27. Meet on the free time
14. Involve everyone, form the newest and youngest to the most experienced	

4.10.1 Analysis and discussion of the contributing factors

The 27 contributing factors that were identified can be grouped into categories. Table 7 presents five categories with their respective factors. The five categories are inspired by the Pentagon model by Schiefloe. This model has been used as a tool for cause analysis in accident investigations; however it should also be possible to use such a model when studying things that go well (Schiefloe, 2013). Some of the factors belong in more than one group as they can be looked at from different perspectives. In the following sections each of the factors are discussed.

Table 7: Contributing factors to successful operations grouped in five main categories

Culture and working environment	Interactions: Communication, cooperation and leadership	Social relations and networks- Human factors and skills	Formal structure and organisational factors	Technological factors
13. Everyone can provide input, make suggestions and ask questions	18. Give people meaningful responsibilities	6. Good understanding and knowledge about the operation, work and rig	1.Having a plan B	8. Correct equipment
21. Good culture among everyone with mutual respect, transparency and dialog	22. Good communication and cooperation	7.Understanding the bigger picture	2. Plan and think ahead and anticipate what might happen	9. Daily maintenance of equipment
25. Good working environment	23. Working as a team and working for a common goal	10. Being practical and focus on solutions	3. Thorough planning	
		13. Everyone can provide input, make suggestions and ask questions	4. Good procedures	
		14. Involve everyone, form the newest and youngest to the most experienced	5. Good reporting	
		15. Experience,	11. Evaluation	

		both from previous situations and from your colleagues	of the job, both before and after	
		23. Working as a team and working for a common goal	12. Little time pressure: focus on performing the operation properly and safe even though it might take some more time	
		24. Trust your colleagues and the quality of their work	16. Training and building competence	
		26. Working with the same crew and people you know help build good routines	17. Right people on the right place	
		27. Meet on the free time on shore	18. Give people meaningful responsibilities	
			19. Support from the operator company	
			20. Flat organisational structure	

4.10.1.1 Culture and working environment

(13) Everyone can provide input, make suggestions and ask questions

In an environment where everyone can provide input, no matter how little, there might be easier to convert tacit knowledge into explicit knowledge. Good dialog and involvement can help individuals share their tacit knowledge. Encouraging questions can also help reveal some of this knowledge. As described by Jacobsen & Thorsvik (2007) individuals do often lack awareness of the knowledge they utilise and questions from colleagues might make

them reflect more on this and find the right words to describe it. An environment where everyone can provide input resembles HRO, e.g. in the aviation industry, where a co-pilot can give suggestions to the captain and even correct his actions (LaPorte & Consolini, 1991).

(21) Good culture among everyone with mutual respect, openness and dialog

Respect for each other's field of expertise and work responsibilities is important to maintain a good dialog and teamwork. It seems like the crew on board this rig have acknowledged that everyone has an equally important role and that everyone's work are equally important to achieve a successful operation, both in the terms of safety and efficiency.

(25) Good working environment

A couple of the informants spoke of the shift scheme where they work one week on a daytime shift and one week on a night time shift. This scheme implies a very abrupt transition which they thought had a negative effect on people. As one of the informants pointed out, most people's bodies need time to adjust to this transition. Little sleep and fatigue can be considered a performance shaping factor as described by Flin et al. (2014). One can argue that enough sleep and being well rested help people stay focused, increasing their level of attention and thereby decreasing the number of mistakes. Good working conditions might also make people more receptive to learning. Everyone should feel responsible for creating a good working environment both for themselves and for their colleagues.

4.10.1.2 Interactions: Communication, cooperation and leadership

(18) Give people meaningful responsibilities

This is related to leadership. Allowing people to work with something they feel good at and to make full use of their skills can be a motivational factor. This also goes for having meaningful responsibilities. One of the informants said that his supervisor was very good at giving him responsibilities and allowing him to try for himself. The supervisor was always there to support and guide him, but he did not "take the work out of his hands" as he described it. Meaningful responsibilities will make people feel appreciated and perhaps they will focus more on the safety aspects of their responsibilities as well.

(22) Good communication and cooperation and (23) Working as a team and working for a common goal

Working as a team is one type of cooperation, therefore (22) and (23) are discussed in the same paragraph. Both teamwork and cooperation are two of the CRM skills described studied by Flin et al. (2014). Well-functioning communication and cooperation seems to be crucial for successful operations. One of the informants emphasise that the communication should be clear and easily understood without any room for ambiguity. The fact that there is a relatively flat organisational structure on board that facilitates close dialog will make a good foundation for communication and good cooperation across disciplines. There are no A-team and B-team and the focus is on involvement. Working for a common goal which is in everyone's best interest can make people feel stronger relations to their colleagues and this will perhaps further enhance communication and cooperation. As described by Schiefloe (2013) interaction is a precondition for social relations and network, and a foundation for organisational culture, learning and experience transfer.

4.10.1.3 Social relations and networks- Human factors and skills

(6) Good understanding and knowledge about the operation, work and rig

The understanding and knowledge about the operation, work and rig constitutes a foundation for several of the other factors. This is particularly important in order to see the bigger picture and when making plans. One of the informants said that everyone should have an understanding of the upcoming operation, how it is planned and what challenges they might encounter. It will also be important that people are motivated and self-confident enough to use their knowledge and competence.

(7) Understanding the bigger picture

> *We focus on the big picture as well as the little things. On Deepwater Horizon they might have focused too much on only the small things. I believe they celebrated 7 years without any LTI on the same day as the accident.*
> - Informant F

Understanding the bigger picture is about mindfulness. According to Weick and Sutcliffe (2007) mindfulness can be explained as the ability to see the bigger picture. The ability to

see the bigger picture could be central in the process of a successful operation. Today's complex systems consist of many activities, components and conditions which are dependent and interact with each other all the time. In order for the operations to go well it is required good knowledge of these interactions and one must therefore always have the big picture in mind. Mindfulness also represents the concept of resilience in the way that resilience seeks to anticipate future situations and monitor ongoing developments to always be prepared for what's next. On the other hand, it will probably be impossible to be aware of all the possible interactions and combinations all of the time. In situations where one have not been able to foresee certain interactions and unexpected situations occur, the ability to respond becomes important. Unforeseen interactions and unexpected developments do not necessary lead to an accident; it could just as well have no negative consequence at all. It is important to have the ability to determine if unexpected developments are a warning sign or not. This is all about knowing how and when to respond.

The ability to understand the bigger picture might also be a motivational factor. One might be more motivated and feel a different ownership towards the job if you feel that what you do is an important contribution to a bigger product.

(10) Being practical and focus on solutions

> "If you have a problem, do not create another problem. Solve the first problem before you go on"- Informant J

These are some wise words from one of the informants. Being practical and focus on solutions are central features when facing challenges and especially new and perhaps unknown challenges. Dealing with one problem at a time, if possible, can prevent the situation from becoming more complex, thus it will be easier to foresee interactions and keep track of the bigger picture.

Several of the informants emphasised that if a challenge or problem occurred the operation could be stopped and everyone involved got together and discussed possible solutions. This kind of collective brainstorming seems to be very helpful for the crew. Not only do they more easily solve the problem, they do also facilitate the opportunity to learn from colleagues and their ideas. This can help increase the overall level of knowledge in the crew.

(13) Everyone can provide input, make suggestions and ask questions

This bears witness of the good and informal relations among the crew. Schiefloe (2013) has described sharing of knowledge and experience as a key word for Social relations and network. This was further elaborated in section 4.10.1.1.

(14) Involve everyone, form the newest and youngest to the most experienced

One of the informants is particularly concerned with the involvement of the newest and the youngest. He says that they can often see things that the more experienced do not notice. This could be things that the more experienced do not reflect upon simply because they're so used to it, even though it might have a big potential for improvement. One informant did also talk about the dangers related to very frequent routine operations and the flow that comes with such operations. If you have done the operation a hundred times you might become a bit "blind" and a new pair of eyes can therefore be most helpful.
To involve the newest and the least experienced on board are also important for learning and the building of competence. This is an example of exploitation, cf. March 1991), in the sense that knowledge is transferred from the more experienced two the less experienced.

(15) Experience, both from previous situations and from your colleagues

In several of the interviews experience and skilled people came up as a prerequisite for success. Experience from previous operations and with the equipment will probably increase the ability to catch early warning signals and to find solutions, cf. the ability to respond and monitor in Resilience (Hollnagel et al 2011). Rosness et al (2008) do also argue that a high level of competence and experience may increase the operator's ability to detect unwanted and unforeseen developments at an early stage.

The informants described a core of very experienced leaders on board. These leaders can be a very good resource for experience transfer and learning for the people with less experience. It was described by the informants that everyone's opinion were equally respected regardless of experience. All the knowledge, both silent and explicit, and experience of the crew on board can be considered one large experience database. It is important to have mutual respect for each other's competence, to see the value of your colleagues' experience and to use this as a resource in planning, decision making and problem solving.

(23) Working as a team and working for a common goal

This factor was elaborated in section 4.10.1.2

(24) Trust your colleagues and the quality of their work

One of the informants described a situation where the driller would choose to stop the operation because he did not feel that everything was ok. Even though there was no indication of anything wrong the company man and the senior toolpusher would respect and support the driller's decision. The operation would be stopped and they would check for problems. Even though sometimes it turned out that everything was in fact fine, the others would never criticise the driller's decision. This does again illustrate the "better safe than sorry" policy on board.

(26) Working with the same crew and people you know help build good routines and (27) Meet on the free time

Several of the informants said that working with the same crew and people you know was a great enrichment for the operations and work itself. Working in a fixed crew helps build good working routines and create an effective team. It will also be directly linked to a good working environment where people trust each other and feel confident in their roles.
One of the informants expressed a wish for more social events on the free time on shore. He felt that such events or team building would further facilitate good and efficient working routines. Team building can also help develop social relations that might contribute to a greater sense of responsibility for your colleagues. People caring about each other and looking out for each other might improve the level of safety. Skjerve (2008) has described robust work practice as e.g. when a person notify a colleague who is about to do something wrong, that can lead to negative consequences for him or others. It requires good, well established relations and trust to be able to tell a colleague that he or she has made, or is about to make a safety critical error. One must be able to trust each other and do not take offense when someone point out an error or mistake.

4.10.1.4 Formal structure and organisational factors

(1) Having a plan B (2) Thorough planning (3) Plan and think ahead and anticipate what might happen

Thinking ahead and anticipate what might happen is one of the four pillars of a resilient system, the potential (Hollnagel et al., 2011). This could also be recognised from Schiefloe's five prerequisites for safe operation which describes a reliable organisation as one that make use of good planning and risk assessment (Schiefloe, 2012). Størseth et al. (2010) have described risk awareness as one of the Contributing Success Factors(CSF's). This includes the adaption process in resilience engineering: Anticipation-Attention-Response(A-A-R). Planning and anticipation of future events have a central role in this process.

It is reasonable to believe that the range and variety of the potential events one will be able to anticipate are related to previous experience and knowledge and so will the sensemaking should such an event occur. Clegg et al. (2008) have described seven characteristics of the sensemaking processes; one of these characteristics tells us that the processes are retrospective in the way that people make sense of things by interpreting present situations in the light of the past. However it is important to "look outside of the box", and not rely solely on own experience. A broad specter of knowledge and experienced people will help improve planning and anticipation.

A plan B will be a result of some kind of risk assessment, job evaluation or anticipation process. This would be a way of ensuring that the crew knows how to respond if irregularities occur cf. the four pillars of Resilience (Hollnagel et al 2011). A plan B can be prepared on different levels. It could be specified as part of the original plans, but it can also be less specific actions that are based more on the ability to be flexible, adapt and improvise.

Some of the informants talk about thorough planning as an important factor for success. Here one can draw parallels to the Efficiency-Thoroughness trade-off (ETTO) as described by Hollnagel (2013a). According to the ETTO principle there must be a minimum level of both efficiency and thoroughness in order to succeed with an operation, however it will be impossible to maximise both at the same time (Hollnagel 2013a). It seems like the organisation on board this rig has found a well-functioning balance between efficiency and thoroughness. They continuously work to improve efficiency, but never at the expense of safety. One might get the sensation that this is an organisation that favours thoroughness above efficiency pressure.

(4) Good procedures

Procedures are important not only as a means of fulfilling laws and regulations, but also as a fundament creating a certain common standard in all the operations. A well-functioning structural fundament can be important to have success. One of the informants point out that not all the procedures are as easy to follow in practise. He believes these procedures are often written by people on shore who do not have the adequate knowledge about how the work is actually done. A good procedure should have a professional foundation, serve the purpose and be pedagogically good. It is essential that the user can understand the value of the procedure and why procedures are needed. One way to obtain this can be to make people feel ownership towards the procedures. On this rig the culture is characterised by openness and involvement and everyone can make suggestions. This might help facilitate people's involvement in the writing and editing of procedures. Even though it might be

crucial with a structural fundament of procedures, one must keep in mind that too rigid procedures might leave little room for adaption and flexibility.

Reading of procedures is not a part of everyone's work on board, it seems like the procedures are often transferred orally to the user:

> *I do not often read specific procedures, but my supervisor informs us of what is allowed and not allowed and how the job should be performed.* – Informant A

From what the informants have told it seems like procedures and regulations are taken seriously by everyone on board

(5) Good Reporting

Reporting of not only unwanted, but also wanted incidents can contribute to learning from things that go well. In order for people to appreciate the opportunity of reporting it is important to give response and to discuss the reported incidents. Good reporting is not only about having a high number of reports, but to also have good quality (Kjellén, 2000). It might seem like the focus on board is on reporting of unwanted incidents:

> *"My most important contribution is to tell people if I see something that is, or might become dangerous"* – Informant A

> *"I report when something happens that can lead to a bigger problem"*
> – Informant F

(11) Evaluation of the job, both before and after

Evaluation before the job starts would be a part of planning and risk assessment. Pre-job meetings and pre- job evaluations are rather common and often embodied in procedures. Debrief or evaluation after the job is perhaps more uncommon. One of the informants says that they do have debrief meetings on board the rig, but this does rarely involve everyone that contributed to the job. Another informant says that debriefs are most common after operations where something did not go according to plan. More focus on debriefs also after successful operations might contribute to learning from things that go well. Resilience tells us to make use of learning not only from previous accidents and failures, but also to draw knowledge from success and normal operations (Hollnagel et al 2011).

(12) Little time pressure: focus on performing the operation properly and safe even though it might take some more time

The overall impression is that there is little time pressure or pressure related to increasing efficiency on this rig. According to the informants this also applies for the rest of the Norwegian sector. This does not mean that they don't focus on improving efficiency, they do always have this in mind and are continuously working on finding new and more efficient ways to perform the operations and avoid down time. However the main focus seems to be on performing efficient, high quality operations without compromising the level of safety. Several of the informants did also emphasise that this trade-off was supported by both the land organisation and the operator company. According to Rasmussen's model of drift both management efficiency pressure and the effort to avoid unacceptable work load can steer the operation towards the boundary of acceptable risk (Rasmussen 1997). Being able to minimise this pressure to an acceptable level can therefore be essential for safe work. What the acceptable level of pressure is will most likely vary between different operations. It will probably be more acceptable to try optimising the efficiency in routine operations than in more challenging and less frequent operations or critical phases. Flin et al (2014) have described stress as one of the performance shaping factors, the low time pressure on board contributes to a low stress level and can therefore increase the level of high quality work performances.

Some of the informants describe the culture on board as opposite of a "Texas culture", meaning little focus on safety, favouring efficiency above thoroughness and a stressful work environment. This seems to be more the way of working in the international sectors where these informants have been. Some, especially the ones with long experience do confirm that this was also the situation in Norway in the earlier days of the offshore industry.

(16) Training and building competence

Training and building competence are directly linked to experience. One of the informants point out that it is important that everyone learn how things are done and how the procedures are to be followed, and that everyone get the same prerequisites for learning. He emphasise that 1:1 training can impair the quality of the competence. If number one teaches number two, number two teaches number three and so on, you risk that number nine in the row might be "lazy" and only pass on the shortcuts to number ten.
Several of the informants said that Norwegian offshore employees represent an overall high standard in competence. The professional status are raised through formalised education and training of good quality.

A high level of competence, skills and knowledge will make the operator more prepared to handle unwanted and unforeseen situations. Competence and experience might help compensate in situations where there is no procedure or clearly defined prescription on how to act (Rosness et al 2008).

(17) Right people on the right place and

To have the right people working on the right place could be just as important as using the correct equipment. Allowing people to work with something they feel good at and to make full use of their skills can be a motivational factor. This is also an aspect of planning and resource management. In the example of the valve change on the BOP that was presented in chapter 4.9 they had very skilled ROV operators on board that had the confident to carry out the operation.

(19) Support from the operator company

As a contractor company the operator will be your client. The operator company makes the drilling program and will often be on top of the decision making. It is therefore very important for the contractor and the crew on board that they have support from the operator, especially the company man who is the operator company's main representative on board. The informants say that the operator company support the favouring of little time pressure and high focus on performing safe operations above efficiency pressure. One of the informants emphasised that the company man was part of the great team and there was no "them" and "we".

Woods and Wreathall (2003) described sacrifice judgements. This could be when you choose to sacrifice production above safety. In order for the decision-maker to know when to stop or reduce the production, there need to be some guidelines or in other words decision support. Support from the operator company could help make these decisions easier when you know the client approve. Disapproval from the client would have made the threshold for stopping the operation much higher.

(20) Flat organisational structure

A flat organisational structure implies that decisions are made on the lowest possible level of the organisation, as near the sharp end as possible. Proximity to the operation will be an advantage. As pointed out by one of the informants, procedures and work routines are often written by people on shore who does not have a full understanding of the operation in question. This can make it difficult to follow the procedures. Flat organisational structure

does also imply short communication routes and it is therefore less likely that messages are misunderstood. It seems like the leaders are good at delegate decision making without pulverising of the responsibility. Such an organisational structure will make it easier to build relations across different levels and it could thus be easier to give a heads up or to make new suggestions.

4.10.1.5 Technological factors

(8) Correct equipment (9) Daily maintenance of equipment

The use of correct equipment can be linked to the planning phase of an operation. One of the informants pointed out that they always tried to prepare all the equipment they needed before the operation started and it was important that they knew exactly where to find the equipment needed. Maintenance of equipment can be seen as an act of proactivity. Maintenance and testing of e.g. the BOP are performed to prepare for potential unwanted events. The bigger picture does also play a role in maintenance of equipment:

> *"It's important to keep the details in mind as well, but we often see that it's the basics that's lacking. Like basic maintenance and such"* – Informant F

Technical aspects did not come up as a very significant topic in the interviews. However it was briefly spoken of in relation to some of the other topics.

5 Summarising discussion

In chapter 4 I presented the main findings from the empirical study, including the informants' definitions of successful operations and the 27 factors that might contribute to success. In this chapter I will discuss these findings in relation to my research questions and in the end reach a conclusion which is presented in chapter 6.

What are successful operations in terms of safety?

To define successful operations can prove to be quite challenging. First of all people might disagree on whether a successful operation is the same as a normal operation, or if a successful operation is something that goes exceptionally well against all odds. I have earlier pointed at the very visible nature of accidents and failure. When operations go well people rarely reflect upon why or pay any extra attention to this. In most cases people probably do not know if their work could have led to an accident under a minor change of circumstances, as long as there are no such signals and the operation go well. One can therefore raise the question: Is it a successful operation even though we are just seconds or "inches" away from having an accident instead? Many would probably say that everything that does not go wrong can be defined as a successful operation because in most cases we do not know that we are "inches from the cliff". Others again would argue that in order to have a successful operation we must know for sure that we are on safe ground, and on safe distance from an accident. This could probably be discussed in the infinite and therefore I chose to consider only the findings in the interviews when trying to answer this question.

7 of the 10 informants presented what they meant were characteristics of a successful operation. These are highly subjective opinions, even so they all have something in common. It seems like the focus is on the outcome of the operation, rather than the operation itself. This could be because the word success is associated with a result, just like failure on the opposite side. The operation do not necessarily need to be perfect from start to end, there might be some challenges, but as long as these challenges are dealt with in a good way the result is a success.

Plans seem to be central to the characterization of a successful operation. Several of the informants think that the operation is a success if it goes according to plans and intentions determined in advance. It seems like "everything going according to plans" do not necessary include financial plans and time budgets. All of the informants agree that the operation can be a success and go according to plans even though it might take some more time to do it safe and properly. However in the example with the ROV operation on the BOP, the informants focused on the saving of time and cost as a way of describing why it was

particularly successful. This is probably because repairing and maintaining the BOP is considered a very expensive affair.

Another central aspect of a successful operation is when the safety is maintained and no people are injured. The life and health of people should be the first priority when it comes to maintaining safety, followed by damages to the environment and damages to equipment.

What factors can contribute to successful operations in terms of safety?

In chapter 4 I presented 27 factors that were identified in the empirical study. These are factors that might contribute to successful operations in terms of safety. Figure 10 illustrates these factors divided in to the five groups inspired by the Pentagon model (Schiefloe, 2013). Three of the groups can be characterized as informal factors. These factors are related to humans and how they interact. Two groups consist of more formal factors such as technology and factors related to the organisation. There is not necessarily always a clear distinction between formal and informal factors; some might belong in both categories. Formal factors might also be a prerequisite for informal factors and the other way around. Some of the groups in the figure are bigger than others to illustrate the distribution of factors among the five groups. The group of “technology” is the smallest. However this does not necessarily imply that technological factors are less important than others. It seems like the informants had a greater focus towards the other four groups. This could of course be due to the nature of the questions or the subconscious focus of the interviewers.

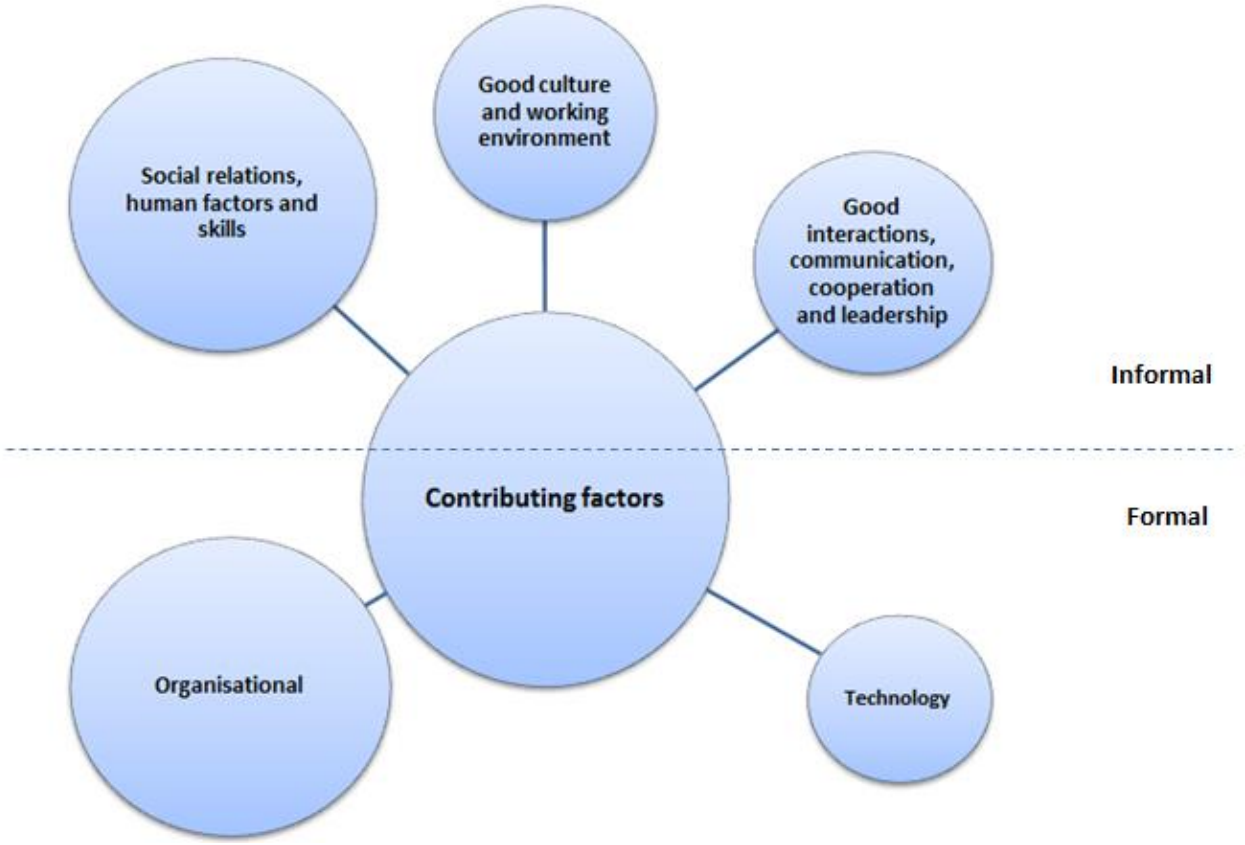

Figure 10: Factors that might contribute to successful operations in terms of safety

The results from this study imply that both formal and informal factors are necessary to achieve success. Resilience engineering and HRO tend to focus on factors such as adaption to the situation and flexibility through more informal factors. From table 7 one can see that the informants are equally concerned with both formal and informal factors. The factors identified in this study are also perhaps not so much based on the properties of HRO and Resilience as first assumed. That said, HRO and Resilience are not only about informal qualities and many of both the informal and formal factors could be recognised from these theoretical perspectives. However, these results raise the question of why the informants tend to focus so much on the formal. It can seem like the informants are more oriented towards compliance and Paradigm 1 than resilience and Paradigm 2 (Hale & Borys, 2011). Some of them emphasise that the legislation and regulations in Norway are a lot stricter than it was in the Gulf of Mexico on the time of the Deepwater Horizon accident. They also say that good procedures, reporting and following routines are important to avoid major accidents. Despite this I think it would be wrong to place the organisation and people on board in one of the two categories. They do not completely match the criterions for either one of the paradigms. The informants describe a flat organisational structure and a type of leadership that is not consistent with the top-down approach in Paradigm 1. This might imply that both compliance and resilience are equally important for successful operations and that a certain degree of both are required.

The purpose of studying the factors that might contribute to successful operations is use the knowledge to learn in order to create further success. Learning in itself will be one factor that can contribute to success. Some of the factors identified in this study will help facilitate learning. A flat organisation with openness, involvement, good communication and little hierarchy, will create a good learning platform. Involvement of everyone will make sure that even though you're not always the one providing input you will always have the opportunity to learn.

Recommendations for further work

The number of informants was limited by time and availability; however the number of ten informants seemed to provide a degree of empirical saturation serving the purpose of this study. One can of course agree that more informants and an even wider range of positions would have strengthened the results of the study.

The interview guide was developed by very experienced researchers, and it is therefore unlikely that the interview guide would be of better quality if I had developed it by myself. That said, it is possible that the interview guide could have been even more specific in relation to my research questions, however this would perhaps prevented me from discovering related interfaces and topics.

For further work it would be interesting to study more cases similar to this one. It would be interesting to see if there are similar interpretations and opinions among crews in other companies operating in Norway. This study comprises a relatively small number of informants with a predominance of people from the contractor company. In order to gain a wider understanding of the topic more interviews should be conducted. Successful operations is a very positively charged topic and people will most likely be open and honest, however observations of the operations on a drilling rig would also provide another dimension to the study. It can be difficult to fully understand the complexity of the work only through word-based information. To conduct observations on the rig would also allow a closer dialog with the informants. As described in the methodology chapter all the interviews were conducted by telephone. Face-to-face interviews would maybe create a better interaction between the interviewer and the informant and you would also be able to observe the informants reactions and body language. The interviews in this study were of a semi-structured nature that was carried out partially as an open conversation. It would be interesting to conduct group interviews of the same structure allowing colleagues to discuss the topics.

This study focused on drilling operations in the oil and gas industry. However it would be interesting to conduct a similar study in other areas such as the construction industry to see if there might be some common characteristics of successful operations in terms of safety.

The research project “Learning from Successful Operations” seeks to develop methods and tools that can be used to analyse and learn from successful operations. I will now present some opinions on the subject. Experience transfer from things that go well can take place in two dimensions, internally in the organisation and externally between organisations. Every minute spent on investigation and analysis of accidents costs money, this will also apply for analysis of successful operation. I think it would be wise to make use of already existing arenas for experience transfer as much as possible. Because of time and cost it will be easy to choose not to spend time on analysis of things that go well. It will therefore be important that such methods and tools become an integrated part of the organisation’s strategy. It will most likely be impossible to look at every successful operation since they constitutes the majority of all operations, however the organisation can choose some key areas which they find particularly interesting to learn from. When considering the other dimension, the experience transfer between organisations, it might also be a good idea to use well established arenas. One might also consider if there should level of commitment to learning from successful operations, e.g. through the Petroleum Safety Authority (Ptil) or Norwegian Industrial Safety Organisation (NSO). As mentioned earlier this is no definite answer to how the methods and tools should be, it is merely a few recommendations.

6 Conclusion

The objective for this thesis was successful operations in terms of safety. The main goal was to study what characterises such operations and what factors might contribute to success. The results from the empirical study were analysed and discussed in light of the theory. In this chapter an answer to each of the research questions are presented.

What are successful operations in terms of safety?

It can be difficult to reach a clear definition of successful operations. The definition will probably vary depending on who you ask and what areas their occupied with. This was confirmed by the informant's answers in the interviews. However there seems to be some common features of a successful operation that they all agree on. The safety of people is the main priority. If the life and health of people are maintained the operation is successful in terms of safety. In a successful operation one should also achieve the intended result, even though it might take a bit longer than planned. An operation is successful in terms of safety if everyone on board can return home in the same state as they were when they came out to work and the goal of the operation is achieved. It will be a bonus if the operation stays inside of the budget and time frame and maybe even more effective than planned.

What factors can contribute to successful operations in terms of safety?

27 factors that might contribute to successful operations in terms of safety have been identified in this study. These factors can be grouped into: 1) Culture and working environment, 2) Interactions: Communication, cooperation and leadership, 3) Social relations and networks- Human factors and skills, 4) Formal structure and organisational factors and 5) Technological factors. The majority of these factors belonged to the group Social relations and networks- Human factors and skills and Formal structure and organisational factors. The theory mainly focuses on informal factors related to humans and their actions; despite this, the empirical findings in this study do clearly indicate that both formal qualities and informal qualities must be present in order to create successful operations. Due to the complexity in drilling operations it might be difficult to explain exactly what is causing it to go so well. It can be hard to pin point because people might not know the exact reasons. Things that go well have not been the focus of traditional safety thinking, and people and organisations are not used to reflect upon the causes behind success. Just like accidents are rarely caused by only one reason alone, successful operations is the result of multiple conditions and factors.

Recommendations for further work

In this study 27 factors were identified as possible contributions to successful operations. However this study can be characterised as merely a pilot study. Further studies are required to confirm if these factors are the ones that really create the foundation for a successful operation. Such further studies should also include observation of the operations in addition to interviews. One should also study several different drilling rigs and their operations in order to increase the validity of the results.

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Appendix

Appendix A – Interview guide

Introduction

First of all we would like to thank you for your time. We are a research group with an interest in the oil and gas industry and with many years of experience of the industry. We have in particular worked on understanding and preventing major accidents. Since we have worked with learning and improvement within the industry, we have seen a need to look not just at the accidents and undesired events etc., but also to learn from successful operations. That is to learn from things that go well.

In this project we are interested in talking with you on the topic of successful operations and we are interested in your points of view and experiences. We therefore ask to conduct interviews with relevant individuals, although interviews in groups can also be of interest. The interviews will last maximum 1,5 hours.

All participation in this project is voluntary. Information about people (name, occupation, education and vocational experiences) will be kept confidential and reporting will be anonymous. So no link to the people who are interviewed will be made. Only the research group will have access to that data.

The project is financed by the Norwegian Research Council, and part of the Petromaks programme.

We have an interview guide with questions. However, the intention of the interview is to have a conversation and get your thoughts, opinions and experiences with regards to successful operations. All participation is voluntarily. If you should regret participation you can withdraw from the interview at any moment.

We want to use a tape recorder during the interview. The purpose is to record the interview as accurately as possible. Only the research group will have access to the raw material. The recordings will be stored in office facilities with access control and kept locked. All data will be deleted after the project is over.

Is it ok for you that we use a tape recorder?

Do you have any questions before we start?

1 The informant's job

- What is your background (Experiences, education, course)
- What is your main responsibility?
- Who are important persons you co-operate with in order to perform your job?

2 Can you explain why the rig has not experienced a major accident like Deepwater Horizon or similar accident?

2.1 What is your contribution to the rig to avoid a major accident?

3 Identification of successful operations (Examples)

Can you provide an example of an operation where safety and prevention of a major accident was ensured?

4 Assessment of success of operations

- **Make use of the example. What are the reasons that would you say that the safety was well taken care of?**

4.1 How is it possible to know that the risk for major accident is well taken care of in the middle of a critical phase in the operation?

4.2 How is it possible to know afterwards (in retrospect) that the risk of major accidents was well taken care of (Maintained)?

4.3 Are there stories told in your organisation with regards to successful operations or successful recovery?

5 Explaining success

5.1 Are there particular conditions/circumstances/plans/procedures that ensured that you did not end up in a hazardous situation?

- This might also involve planning and risk assessment beforehand, involvement in the planning etc.

5.2 Were there phases in the operation, which required you to be constantly prepared for surprises? Why did it work so well? What resources could you use/call upon?

- This includes situations faced with a weak and ambiguous danger signals, i.e. small increases in mud volume. The interaction between the land organizations is also of interest.

5.3 Did critical situations occur? How did you regain control? What resources did you use?

5.4 Did situations occur when things went well due to pure luck (”griseflaks”)? Did you do anything to assist the luck?

Catchword/ guide words if the informant need some time/assist:

- Ability to anticipate the problems that may occur (different time horizons)
- Preparation for the unexpected
- Resources to deal with the unexpected
- Backup-behaviour (double anticipation, two pair of eyes seeing the same phenomena, looking at data and response and preparation in order to unload/relieve), organizational redundancy, authority gradient.
- Experiences as a resource
- Interaction with the land organization
- Handling of conflicting goals (decision dilemmas)
- Ability to improvise

- Ability to co-ordinate
- Overview and control with (well) barriers.
- Intuition, ”bad feeling, unease” (This might be a form of pattern recognition)

Alternative follow-up topics:

1. Knowing what to do, that is, how to respond to regular and irregular disruptions and disturbances either by implementing a prepared set of responses or by adjusting normal functioning. This is the ability to address the actual.

2. Knowing what to look for, that is, how to monitor that which is or can become a threat in the near term. The monitoring must cover both that which happens in the environment and that which happens in the system itself, that is, its own performance. This is the ability to address the critical.

3. Knowing what to expect, that is, how to anticipate developments, threats, and opportunities further into the future, such as potential changes, disruptions, pressures, and their consequences. This is the ability to address the potential.

4. Knowing what has happened, that is, how to learn from experience, in particular how to learn the right lessons from the right experience—successes as well as failures. This is the ability to address the factual.

6 Learning from success

6.1 Are there arenas where you assess how well the control for major accidents (i.e. safety with regard to major accidents) was taken care of? Are there tools/methods/aids/ routines that pick up that things go well and the reason why?

(Debrief, handover-meetings, preparation offshore meetings, “End of Well Report”)

(Follow up with ”how” questions)

6.2 Is there anyone asking for information on successful operations with regard to what worked well?

- Are experiences from successful operations used with regards to training?

- Are there examples where such experiences are implemented in work descriptions/ procedures/ steering documentation?

6.3 Are there examples of positive experiences communicated to other shifts/crew or other parts of the organization (e.g. the land organisation) or to other organisations?

- "Lessons to be learned"
- "One-pagers" etc.?
- Expert centras?
- Other?

6.4 Are positive experiences (That is barriers that worked well) picked up in incident investigations?

6.5 Do you think that the rig company should do more than they do today to learn from successful operations? If "Yes", what should they do, where should they start?

7 Conclusion

7.1 We want to return to the opening question again; what are the reasons that the rig has not experienced a major accident like Deepwater Horizon (or a similar accident)?

7.2 Are there questions we should have asked that we have not asked?

7.3 Is there something urgent you want to share at the end of the interview?

Thank you for your time and thank you for sharing your thoughts and experiences in this interview. The information is of great value for us.