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PREFACE

This thesis is submitted to the University of Stavanger and written in collaboration with Equinor ASA. The thesis fulfills the requirements needed for the Master of Science degree within the program Industrial Economics.

First and foremost, I must thank my cohabitant and girlfriend Maren Mæland for supporting me throughout the work.

Secondly, I would like to express my highest appreciation to my supervisor at Equinor, Senior Specialist Thomas Nilsen. He has shown consistent and valuable guidance throughout the period I have been working on the thesis. I am full of admiration for the way you have guided me through this process – thank you.

Thirdly, I would like to thank Associate Professor Andreas Falck, my supervisor at the University of Stavanger for valuable inputs and for influencing this work from an academic point of view.

Finally, I would like to thank the staff and the department *International and Exploration Drilling* (IED) in Equinor for including me and providing necessary resources and information essential for the work. Also, a special thanks to the project team from the exploration well project followed and other interviewees contributing in forming the basis for evaluation.

My personal interest in risk management and drilling in addition to my personal experience of having an internship within the department in 2019 has prompted this research.

The objective of the work has been to investigate the collaboration in risk management processes between the operator and rig contractor during planning of exploration wells.

As risk management is an important part of conducting petroleum activities, there are requirements, expectations and guidelines to be followed by operating actors. A collection of input from these regulations and procedures has set the framework for a good process. In this work, participation in a real project in Equinor, interviews, discussions and own considerations have formed the line of reasoning and evaluated this process.

The ongoing COVID-19 pandemic has in a few ways had an impact on my work. My presence and planned participation in the exploration well project intended to be followed from Equinor's offices have been somewhat limited, with less interaction, dialogue and input to my work as a consequence. In addition, communication and inputs from the rig contractor dealing with their internal processes have suffered as a result of the pandemic.

ABSTRACT

Drilling a new exploration well involves risk of major work accidents and considerable economic loss. Risk management is an integrated part of planning exploration wells. Collaboration between the operator and the rig contractor throughout this process is important as both parties are involved in decision processes and activities influencing risk. This Master's Thesis is an investigation of collaboration between Equinor and the rig contractor in risk management processes during planning of exploration wells.

In order to safeguard operations with zero harm to people, assets and the environment, there are several requirements and expectations to be followed throughout activities on the Norwegian Continental Shelf (NCS):

- Regulations established and enforced by the Petroleum Safety Authority (PSA) Norway
- Guidelines to the regulations, e.g. industry standards such as ISO 31000 and relevant NORSOK standards
- Internal processes and guidelines with both the operator and the contractor.

The study has shown that the PSA expects good collaboration between involved parties. Also, inclusion of key risk management elements such as uncertainty treatment, application of the ALARP principle and barrier management is expected.

ISO 31000 is used as a basis for the construction of an evaluation model investigating and analyzing aspects of the collaboration and risk management process during planning of new exploration wells.

The results of the investigation have shown that the overall collaboration process between Equinor and the rig contractor works well. There is a common understanding of roles and responsibilities between the companies. However, the evaluation has shown that involvement and utilization of relevant competency and sharing of risk related information may have improvement potential throughout the planning phase.

According to my observations, barrier management is integrated in the risk management process. Barrier solutions developed through well design and operational planning are important objects of risk analyses and management. Weaknesses and uncertainties related to barrier elements and systems are addressed systematically and iteratively throughout the risk management process, documented in risk analysis tools and finally Detailed Operational Procedures (DOPs).

In contrast, improvement potential was revealed regarding compliance with the ALARP principle and treatment of uncertainty through the risk management process. Clarified expectations – both from the PSA and internally in Equinor related to these topics on different decision and system levels could potentially improve the practice in drilling and well projects.

Complying with applicable requirements and guidelines, and sometimes even performing beyond the absolute necessary for fulfilling requirements and contractual obligations can improve not only the collaboration process between Equinor and the rig contractor, but also the risk management process. Achieving such an improvement depends on management priority.

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LIST OF ABBREVIATIONS

The following abbreviations are used in the work:

ALARP	**As Low As Reasonably Practicable**
D&W	**Drilling and Well**
DE	**Drilling Engineer**
DHSA	**Defined Situations of Hazards and Accident**
DOP	**Detailed Operational Procedure**
DSI	**Drilling Superintendent**
HAZID	**Hazard Identification**
HPHT	**High Pressure and High Temperature**
HSE	**Health, Safety and Environment**
ISO	**International Organization for Standardization**
MoC	**Management of Change**
NCS	**Norwegian Continental Shelf**
PSA	**Petroleum Safety Authority**
QRA	**Quantitative Risk Assessment**
RM	**Risk Management**
WBE	**Well Barrier Element**
WBS	**Well Barrier Schematic**

1 INTRODUCTION

1.1 BACKGROUND

History has shown that the petroleum industry causes major accidents and events with major accident potential (Petroleum Safety Authority Norway, 2017). There have been several examples of this, and some of them are listed below:

- The Alexander L. Kielland accident in 1980 where 123 people lost their lives
- The blow-out on Snorre A in 2004
- Well control incident on Gullfaks C in 2010
- The well control accident at Deepwater Horizon in 2010 where 11 people lost their lives and major oil spill of hydrocarbons led to serious environmental damages
- Hydrocarbon leakage at Gudrun in 2015 which marginally could have led to a major accident with loss of lives
- Well control incident at Songa Endurance on Troll in 2016.

Drilling and well (D&W) activities imply the potential for major accidents like some of the ones listed, and it is thus fair to refer to D&W operations as high risk activities (Nilsen, Sørli, Røed, Strømsnes, & Stavseng, 2013). There are risks related to negative impacts of such activities, and risk management is therefore essential for the performance during both planning and execution of drilling a new well.

Risk management is an integrated part of how the petroleum industry works in order to minimize and avoid events such as those listed. In order to give a fundament for efficient operations where zero harm to people, assets and environment can be achieved, the PSA has a set of regulations regarding both risk management and technical functionality applying to activities on the NCS. Among other requirements regarding risk management, the PSA expects operators to act in line with requirements regarding assessments of uncertainty, establish barrier elements and application of the ALARP (as low as reasonably practicable) principle.

Separate guidelines to the regulations indicate how compliance with the provisions in the regulations can be fulfilled. Examples of such guidelines are ISO 31000 and different NORSOK standards. In addition, the companies performing the operations have internal processes designed based on the regulations and guidelines for how to manage risk and perform drilling activities.

The project of drilling a new well normally involves both an operator, a rig contractor and one or more third parties (service companies). The involved companies collaborate in order to reach one common goal. Collaboration between involved parties in risk management processes throughout the planning phase of new drilling activities is key in order to both identify, analyze, evaluate and treat risks.

The PSA states that good collaboration between involved actors, including necessary internal and external communication must be safeguarded throughout the activities (Petroleum Safety Authority Norway, 2019).

Equinor is a broad energy company with a value chain primarily influenced by oil and gas activities. The company performs hundreds of offshore operations every year, operations which involve significant risks. Safe risk management in drilling and well operations are an important contributor in order to prevent major accidents, for instance well control situations such as kicks and blowouts.

This work will investigate and evaluate how collaboration in risk management processes between Equinor and the rig contractor works out throughout planning of a new well construction project. The investigation is limited to exploration drilling and the two project planning phases Concept selection and Detailed planning (further description of project phases will follow in Chapter 4). The project followed has been kept anonymous requested by Equinor and is henceforth referred to as *the exploration well project.* The same applies to *the rig contractor* involved in the exploration well project.

The foregoing leads us to a question that this work will try to answer:

Are the regulations, standards and expectations being followed in practice, and does the collaboration between the involved parties work in order to have a good risk management process?

1.2 OBJECTIVES

Based on the problem to be addressed, there are some defined objectives for this work:

1. Investigate requirements and expectations regarding risk management for a well planning project and how these affect collaboration between the operator and rig contractor
2. Investigate the practice regarding the collaboration and risk management practices in a real exploration well planning project in Equinor
3. Identify gaps and challenges related to collaboration in risk management between best practice and the practice in a real well planning project in Equinor
4. Suggest and demonstrate improvements for the collaboration and risk management processes in the planning phase for new exploration wells.

1.3 APPROACH

In order to reach the objectives, an evaluation model with the purpose of identifying challenges in the risk management process in a well project is constructed. Focus is on topics where collaboration is considered essential, and the model contains a set of criteria considered important for a good collaboration process in a risk management perspective. The evaluation model and the criteria are designed based on input from:

- Theory, requirements and expectations extracted from a literature search within the risk management literature, governmental documents, regulations, standards and Equinor's internal documents
- Courses at the university and internally in Equinor related to risk and risk management
- Thorough discussions with risk expertise personnel within Equinor.

Use of the model in analysis and evaluation of the process is based on input from:

- Participation in the planning phase of a new exploration well, including risk related meetings, weekly project meetings, discussions and observations. For more information about the well project and the related activities involved in, see Appendix A – Participation in an Equinor exploration well project
- Experiences from interviews conducted with four different parties, including relevant Equinor personnel, the rig contractor, the PSA and Proactima. The interview questions were constructed with basis in theory, requirements and expectations and the evaluation model developed.

1.4 STRUCTURE

This work is structured as follows:

- Chapter 2 outlines principal theoretical concepts of risk and risk management involving several stakeholders
- Chapter 3 describes requirements and expectations to be followed for activities on the NCS, including a description of the PSA regulations, industry standards and internal work processes in Equinor
- Chapter 4 contains a description of Equinor's internal work process called DW100 for construction of new exploration wells
- Chapter 5 is focusing on Equinor's internal risk management process integrated in the work process DW100. The chapter presents internal guidelines applicable during risk management processes in planning of exploration wells
- Chapter 6 presents the evaluation model which defines and evaluates findings from the investigation
- Chapter 7 presents input and experiences from different interview objects regarding collaboration and risk management throughout a new well construction project
- Chapter 8 applies the evaluation model and presents analyses of the results from the investigation. The criteria in the model are ranked, where a comparison between best practice and real practice forms the basis of the evaluation
- Chapter 9 concludes and presents the most essential empirical findings
- Chapter 10 discusses and will based on the findings and conclusions give suggestions for improvements on the way forward for risk management and the associated collaboration during planning of exploration wells.

2 THEORETICAL BACKGROUND

There are risks in D&W projects. These risks need to be identified, analyzed, evaluated and handled through risk management. Risk management in D&W often involves several parties and there is a need for collective decision-making. Within collective decision-making, collaboration and communication are important elements. As illustrated in Figure 1, this chapter describes concepts such as risk, risk management, risk governance, communication and collaboration – all considered important for this work.

Figure 1: Key concepts relevant for this work

2.1 RISK

In order to effectively deal with and comply with what regulations, industry standards and internal processes say about risk and risk management, a theoretical and professional understanding of risk is important. There are several definitions of risk, but one, internationally agreed definition of risk does not yet exist. Aven and Renn (Aven & Renn, 2010) state that the concept of risk is used as an expected value, a probability distribution, as uncertainty and as an event. Further, Aven and Renn have defined some common definitions of risk:

1. Risk is equal to the expected loss
2. Risk is equal to the expected disutility
3. Risk is equal to the probability of an adverse outcome
4. Risk is the measure of the probability and severity of specified adverse effects
5. Risk is the combination of probability and extent of consequences
6. Risk is equal to the two-dimensional combination of events/consequences and associated uncertainties (will the events occur, that will be the consequences)

7. Risk refers to uncertainty of outcome, of actions and events
8. Risk equals a situation/event where the stake is something of human value and where the outcome is uncertain
9. Risk equals an uncertain consequence of an event/activity with respect to something that humans value.

Definitions 1-5 above describe risk by means of probabilities and expected values. Earlier definitions of risk which support these definitions say that:

Risk = probability x consequence.

Definitions 6-9 express risk through events/consequences and uncertainties. A new concept of risk, highlighting uncertainty and strength of knowledge as main features of risk has among others been introduced by Aven and Renn (Aven & Renn, 2010). Definitions 8 and 9 consider risk to be an event (consequence of an event), subject to uncertainties. This leads us into a new understanding, or new definition of risk (Aven & Renn, 2010) (illustrated in Figure 2): *Risk refers to uncertainty about and severity of the events and consequences (or outcomes) of an activity with respect to something that humans value.*

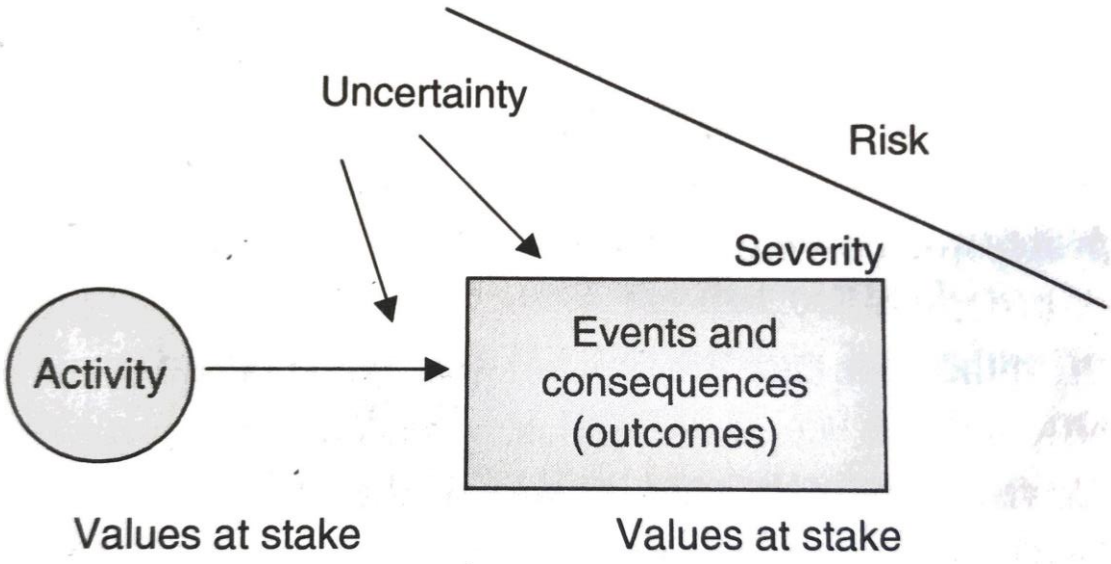

Figure 2: Illustration of the main features of the new risk definition (Aven & Renn, 2010)

The PSA's definition of risk, specified in *Risikobegrepet i Petroleumsvirksomheten* (Petroleum Safety Authority Norway, 2016) also emphasizes the importance of uncertainty regarding the consequences, and mentions two important aspects of risk:

- Uncertainty about the consequences
- Consequences of the activity

The PSA's definition of risk: *Risk is the consequences of activities, with associated uncertainty.* The PSA clarifies that probability still is important in order to understand risk, but that there is a need to move away from a practice of pure 'mechanical' assessment of probabilities, because such an assessment disrupts uncertainties. PSA's definition of risk will be used from this point.

The activity of drilling a new exploration well involves several risks. The following events and conditions are examples of typical risks in such a project:

- Well control incidents
- Shallow gas
- Challenging environmental conditions (weather etc.).

The consequence of the two first examples might be a blowout, whereas challenging environmental conditions may cause delays in operations, huge downtime costs and threats towards the integrity of the installation.

In order to systematically deal with such risks, there is a need for risk management.

2.2 RISK MANAGEMENT

Due to its severe consequence potential, risk management has a high priority within the petroleum industry and also within the discipline D&W in order to prevent major accidents like blowouts, but also to prevent economic loss. Risk management is an important concept in this thesis as Equinor's risk management process during planning of new exploration wells will be evaluated.

Risk management is defined in many ways, but this work will use ISO's definition (International Organization for Standardization, 2009) which defines risk management as a set of coordinated activities to direct and control an organization with regard to risk.

The construction process of a new exploration well entails a set of coordinated activities such as selection of rig, well design and mud weight. Equinor as an operator is therefore responsible for these activities and the project as a whole and thus also owner of the risks and associated risk management process.

There are high expectations that risk management is a proper framework from obtaining high levels of performance (Aven & Vinnem, 2007). Within risk management related to D&W operations, there are requirements related to both technical design and operational procedures. In addition, one will find definitions of responsibilities and division of responsibilities. However, proper risk management is important because it equips companies with solutions for financial value creation and for protecting humans, material assets and the environment (Petroleum Safety Authority Norway, 2018).

Risk management with applications from well construction processes is about ensuring that adequate measures are taken to protect the environment, people and assets from harmful consequences of the activities being undertaken, in addition to balancing different concerns, in particular HSE (Health, Safety and Environment) and costs (Aven & Vinnem, 2007).

2.3 RISK GOVERNANCE AND COLLABORATION AMONG INVOLVED STAKEHOLDERS

Risk governance describes structures and processes for collective risk decision-making involving different actors (Aven & Renn, 2010). The different actors do have different roles which must be defined and given. According to the International Risk Governance Council, risk governance is described as the totality of actors, processes, rules, and mechanisms concerned with the collection, analyzation, communication and decision making of relevant risk information. This defined totality and mentioned elements are among the topics which will be concluded on at the end of the work.

Aven and Renn (Aven & Renn, 2010) state that the processes for collective risk decision-making need appropriate communication between the stakeholders. Risk communication was defined by the Committee on Risk Perception and Communications of the US National Research Council in the report *Improving Risk Communication* in 1989 (National Research Council, 1989):

> An interactive process of exchange of information and opinion among individuals, groups and institutions. It involves multiple messages about the nature of risk and other messages, not strictly about risk, that expresses concerns, opinions or reactions to risk messages or to legal and institutional arrangements for risk management.

The overall goal of risk communication is to effectively discuss, assess and evaluate risk throughout an activity (Aven & Renn, 2010). Moreover, risk communication must assist stakeholders in understanding the rationale of risk-based decisions, and to arrive at balanced judgment that reflects the factual evidence about the matter at hand in relation to their own interests and values. To communicate and talk about risk and uncertainties in the right and in an understandable way is important in order to create trust among involved stakeholders (Veland & Aven, 2012).

2.3.1 RISK PERSPECTIVES

According to the journal article *Risk communication in the light of different risk perspectives*, wrote by Veland and Aven (Veland & Aven, 2012), the risk perspective of an actor forms her/his fundamental understanding of risk, and will therefore affect her/his risk communication. Veland and Aven's work defined four risk communication scenarios based on commonly found real situations. The different risk actors involved in the scenarios were assigned different risk perspectives, and the possible effects that risk perspectives can have on the risk communication between them were demonstrated. The analysis showed that differences in risk perspectives can lead to huge problems and barriers in risk communication.

Based on this, it is important that both the operator, rig contractor and other involved parties in the risk management process of planning a new exploration well are coordinated and have the same understanding of the risk picture. To elucidate the importance of a common risk understanding, the evaluation model in Chapter 6 includes criteria considering the understanding of risk. Moreover, different people both internally and externally have been interviewed and asked about their understanding of the topic.

2.4 WHAT IS EFFECTIVE RISK MANAGEMENT?

In order to satisfy requirements and expectations in the best possible manner throughout a multi-stakeholder context in the planning phase of new well construction projects, an understanding of “effective” risk management with appropriate communication and collaboration between the stakeholders is discussed.

An important message regarding this topic is that risk management and risk communication should be parallel activities that complement each other (Aven & Renn, 2010). This is also one of the main take-aways from ISO 31000, where *Communication and consultation* is a parallel activity to the risk management process (see Chapter 3.2). However, it is important to underline that risk communication not alone ensures an effective risk management process. It is a parallel activity which can help to overcome some of the perception biases and make people more susceptible to the risks and benefits of the activity in question.

For every involved party in a project to fully understand the risk picture, the way risk is communicated between the different stakeholders is important. The model in Chapter 6 includes risk communication as one of the criteria for good collaboration and risk management.

Projects and risks are complex in the petroleum industry, and the importance of having a fundamental theoretical platform of risk is therefore key. Risk communication can be seriously hampered if the people who perform the risk assessment and management do not possess such scientific platform (Veland & Aven, 2012). If this platform is in place, it is much more likely that the risk communication will work effectively as the premises for the dialogue are clear.

3 REQUIREMENTS AND EXPECTATIONS

Operators at the NCS must satisfy a set of acts and regulations outlined by the PSA which are legally binding. Moreover, these regulations have defined guidelines which again refer to different standards. The logic in the regulations is that if you follow the, by PSA referred standards, the requirements in the regulations are considered fulfilled.

Figure 3 below shows and explains the hierarchy in activities on the NCS where the governmental laws and regulations are on top, and the internal work processes are at the bottom (Norges Rederiforbund & Norsk Olje & Gass, 2015).

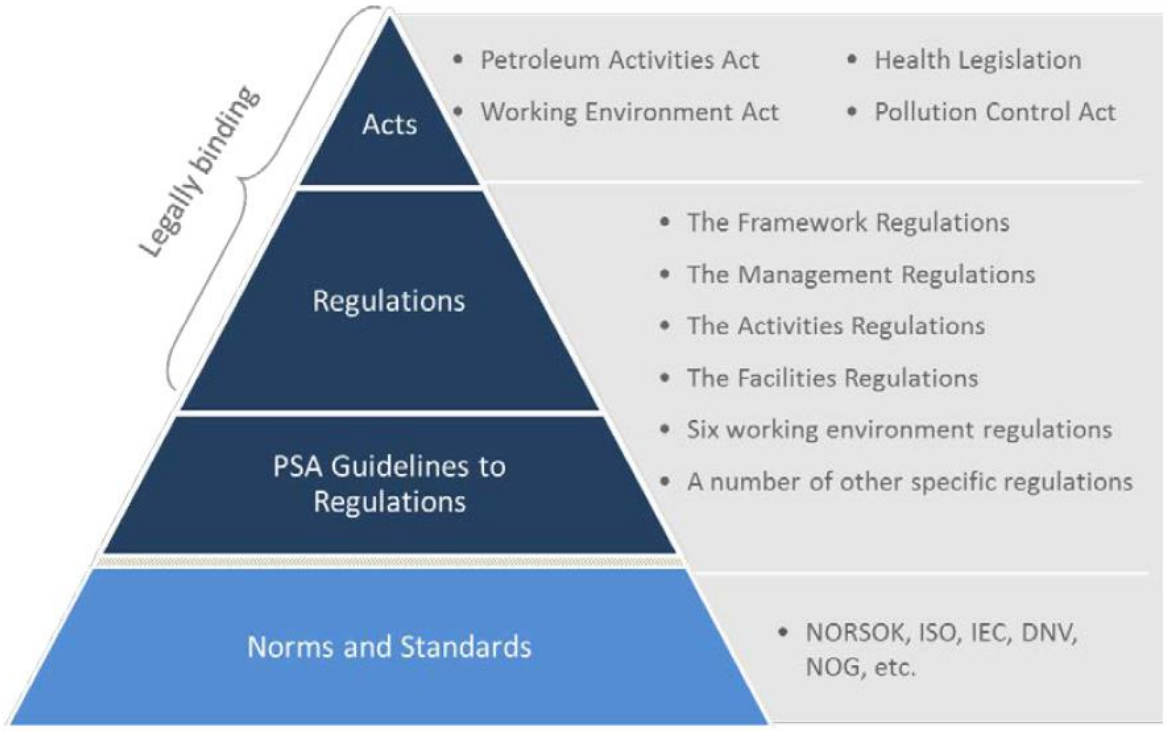

Figure 3: The hierarchy illustrating the structure of requirements and expectations yielding on the NCS (Norges Rederiforbund & Norsk Olje & Gass, 2015)

- **Acts** are made by the Norwegian government and are on the top of the hierarchy. However, the contents in these laws will not be described further
- **Regulations** are specific supplements pursuant to the laws. In Norway, the PSA is responsible for the petroleum regulations
- **Guidelines and standards** demonstrate how compliance with the provisions in the regulations can be met. External organizations have developed certified standards that complies with the regulations.

In the following, selected parts of relevant regulations, standards and Equinor and contractor internal processes are presented.

In order to evaluate the risk management process in real projects, the contents in this chapter has been part of the basis of establishing evaluation criteria for risk management and collaboration included in the evaluation model in Chapter 6.

3.1 PSA REGULATIONS

The PSA is delegated authority to establish and enforce regulations relating to HSE in the petroleum activities and at certain onshore facilities at the NCS (Petroleum Safety Authority Norway, 2019). This work focuses on four of the regulations that the PSA has, and use them as one of the pillars for how risk management should be practiced:

1. The framework regulations
2. The management regulations
3. The facilities regulations
4. The activities regulations.

Some key takeaways relevant for this work from the regulations regarding risk management are provided in the following. The takeaways contribute in making the basis for important concepts to be included in the risk management process. This will be reflected in different criteria in the evaluation model.

A more detailed overview of the contents in the four different regulations is provided in Appendix B – Details from the PSA regulations.

The role of **The framework regulation** is to set requirements and a framework for conducting petroleum activities in line with high HSE standards.

Key takeaways:

- Based on an individual and overall evaluation of risks and potential accompanying harm, the operator is required to implement solutions that offer the best results, provided that the costs are not significantly disproportionate to the risk achieved, i.e. apply the ALARP principle (see Appendix C – The ALARP principle and treatment of uncertainty)
- All phases of the petroleum activities must be accompanied by risk assessments
- The framework regulation emphasizes that the operator is the responsible party pursuant to the regulations.

The management regulation has the role of providing requirements regarding management of petroleum activities, including the duty to provide information throughout the activities.

Key takeaways:

- In order to reduce the likelihood of harm, hazard and accident situations, the operational, technical or organizational barriers most suitable must be chosen
- There are often several participants involved in petroleum activities. The operator must therefore ensure an agreement between its own and other participant's requirements
- Risk analyses must be updated throughout a project as regards changes influencing the risk

- Necessary assessments regarding sensitivity and uncertainty must be carried out (see Appendix C – The ALARP principle and treatment of uncertainty)
- Performed risk analyses must be easily available for involved parties in a comprehensive overview
- The operator must follow up both its own and other participant's management systems.

The role of **The facilities regulation** is to provide information to companies performing operations regarding design and outfitting of the facilities.

Key takeaways:

- The regulations include specifications on well barriers, well equipment control, floating facilities, the cementing unit, Christmas tree etc.

The activities regulation has restrictions on how petroleum activities must be performed.

Key takeaways:

- Important risk contributors must be kept under control throughout both the planning and execution phase
- There must be implemented plans and strategies for emergency preparedness against hazard and accident situations
- It is emphasized that good collaboration between the involved parties, including necessary internal and external communication must be safeguarded during installation and operation.

3.2 ISO 31000 STANDARD

ISO 31000 is a risk management framework, including guidelines, principles, framework and a process for managing risk. The standard recommends that organizations develop, implement and continuously improve a framework whose purpose is to integrate the process for managing risk into the organization's overall governance, strategy and planning, management, reporting processes, policies, values and culture (International Organization for Standardization, 2009).

As ISO 31000 is an international standard for risk management and is used in the industry as well as an outline for Equinor's internal risk management process, the process is used as a baseline for the evaluation model regarding risk management and collaboration in a real exploration well project. The risk management process comprises of a set of activities as illustrated in Figure 4.

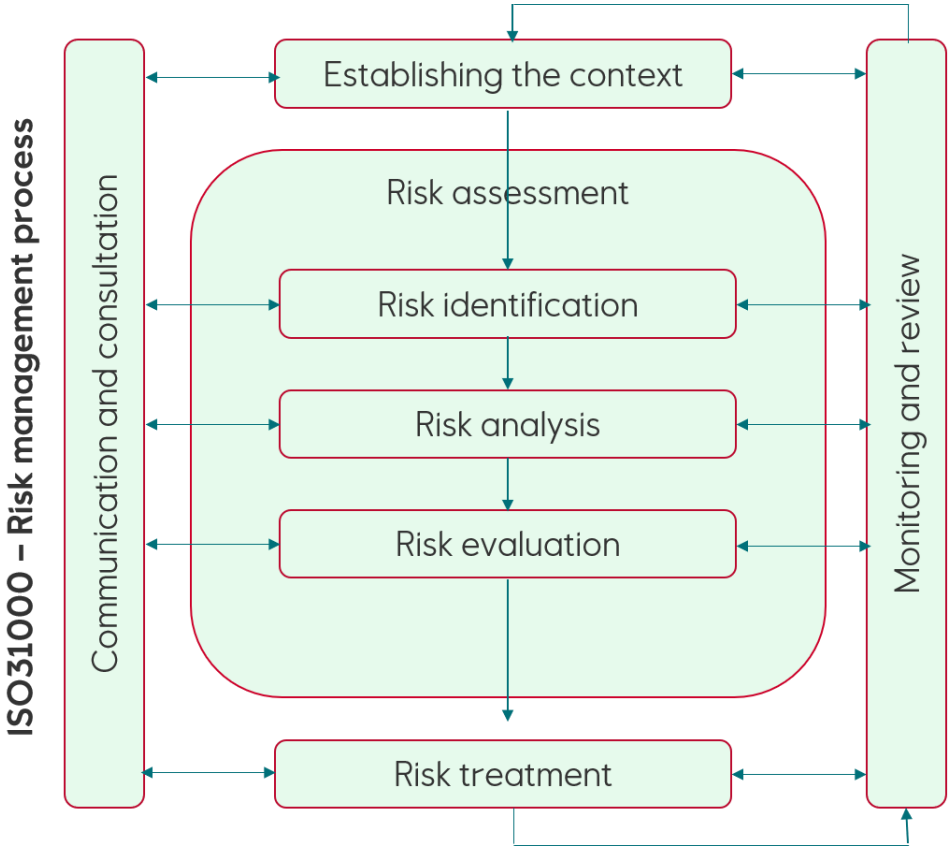

Figure 4: ISO 31000 risk management process (International Organization for Standardization, 2009)

Communication and consultation and Monitoring and review are two parallel activities which go on alongside the different stages in the process. For a more detailed description of the ISO 31000 risk management process and its containing activities, see Appendix D – More details on ISO31000 Risk management process.

3.3 NORSOK STANDARDS

As mentioned initially in Chapter 3, the guidelines in the regulations refer to industry standards. The operator's and contractor's own governing documents build on these. The NORSOK standards are developed by the Norwegian petroleum industry to ensure adequate safety, value adding and cost effectiveness for petroleum industry developments and operations (Standard Norge, 2019).

There are two standards highly relevant for this work:

- NORSOK D-010: Well integrity in drilling and well operations
- NORSOK Z-013: Risk and emergency preparedness analysis.

Parts of NORSOK D-010 and Z-013 state expectations to management and risk assessments, respectively. Both will be used as part of the basis for the criteria used in the evaluation model.

3.3.1 NORSOK D-010 WELL INTEGRITY IN DRILLING AND WELL OPERATIONS

Barrier management is an integrated part of risk management and is a key element in how to maintain well integrity in D&W operations. Barrier management is highly emphasized by the PSA. For example, the PSA states that barrier management must be part all phases of a project's life. Reference is made to the PSA's Barrier Memorandum, see Appendix E – Summary of parts of the PSA's Barrier Memorandum. NORSOK D-010 point towards barrier management and given guidelines on well barriers and their technical functionality.

NORSOK D-010 focuses on the establishment of well barriers by use of well barrier elements (WBE), their acceptance criteria, their use and monitoring of integrity during their life cycle (Standard Norge, 2013). This standard is actively being used by D&W personnel in the work with barrier elements by referring to the different tables and requirements included in it.

The main takeaways from D-010 are presented in Appendix F – Excerpts from NORSOK D-010 Well integrity in drilling and well operations. The takeaways are extracted from two relevant topics in the standard:

- General principles
- Drilling activities.

3.3.2 NORSOK Z-013 RISK AND EMERGENCY PREPAREDNESS ASSESSMENT

NORSOK Z-013 has the purpose of providing guidelines for effective planning and execution of risk and/or emergency preparedness assessment (Standard Norge, 2010).

Z-013 describes how risk assessments should be performed. The standard is based on ISO 31000, and the same structure, principles and model as the one used in ISO 31000 have been applied for the processes of performing a risk and emergency preparedness assessment covered by NORSOK Z-013. The main difference is that the last element, *Risk treatment,* is not covered. See Figure 5 for the use of ISO 31000 in this NORSOK standard.

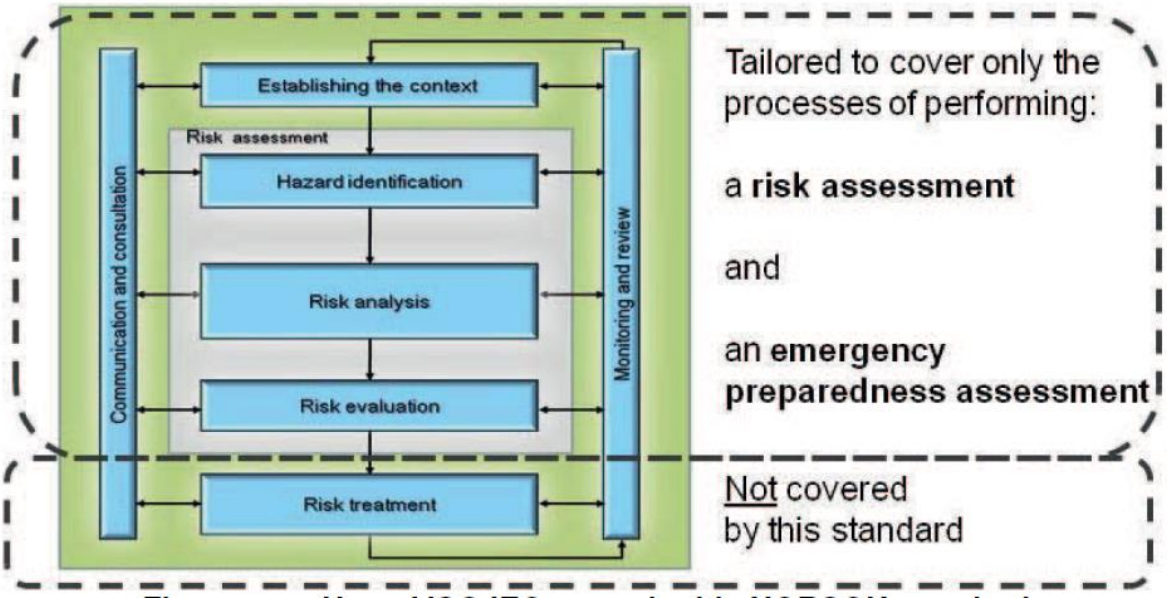

Figure 5: The use of ISO 31000 in NORSOK Z-013 (Standard Norge, 2010)

Appendix G – Excerpts from NORSOK Z-013 Risk and emergency preparedness assessment provides a more detailed description of the general requirements regarding risk and emergency preparedness assessments. These requirements contribute in forming the criteria for the risk assessment activity in the evaluation model in Chapter 6.

3.4 RISK MANAGEMENT IN EQUINOR

Equinor as an operator must implement the PSA requirements described and relate to the guidelines and standards. The operators have their own internal requirements, work processes and guidelines – reflecting these acts, regulations and standards. This chapter will present Equinor's overall internal requirements and guidelines regarding risk management: *FR08 – Functional requirements Risk Management* and *RM100 – Manage risk.*

FR08 and RM100 are central documents and forms the basis for the internal requirements regarding risk management. Their content provides the basis for the internal risk management requirements to be followed. Like the contents earlier in Chapter 3, guidelines contribute in making the basis for criteria for the evaluation model to be followed in Chapter 6.

How RM100 is applied in the well construction phase of new exploration wells will be discussed in more detail in Chapter 5.

3.4.1 FR08 – FUNCTIONAL REQUIREMENTS FOR RISK MANAGEMENT

FR08 states that risks in Equinor arises from the company's activities and are categorized as; Safety/Security, Human Rights Business Integrity and/or Monetary (ARIS, 2019).

Some of the overall requirements and fundamentals regarding risk management in FR08 particularly relevant for this work are:

1. Risks must be assessed, managed and documented
2. Key risks must be communicated to relevant stakeholders and the entity responsible for the risk
3. Risks shall be measured in impact, probability and uncertainty
4. The evaluation of risk shall be done according to risk figures (combination of impact and probabilities)
5. Risk management shall be an integrated part of prioritization processes and major decision cases
6. Risks of disastrous events (major accidents) shall be identified and subject to separate and more detailed assessments.

3.4.2 RM100 – MANAGE RISK

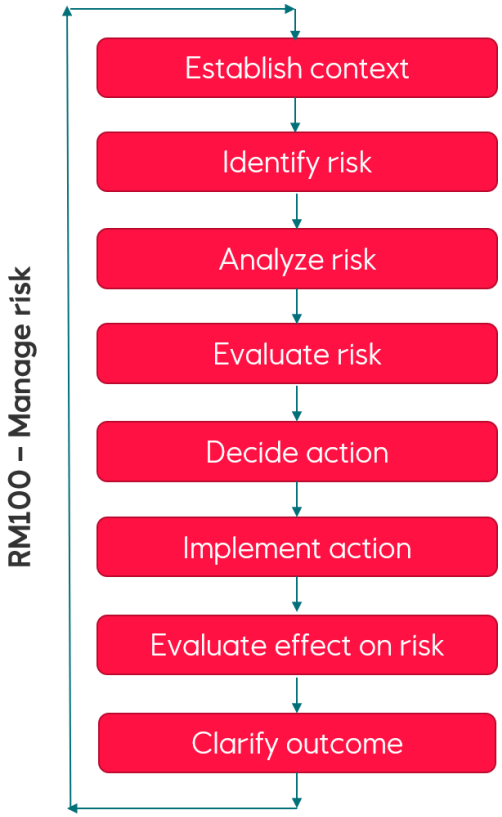

Figure 6: RM100 - Manage risk in Equinor (ARIS, 2020b)

RM100 is a risk management process with the objective to enable Equinor to create lasting value and to avoid incidents (ARIS, 2020b). The target group for the process are all Equinor leaders and personnel with specific role within risk management. The Equinor risk management process is shown in Figure 6.

As seen from the figure, RM100 has clear similarities to ISO 31000. The main steps in the ISO process coincide with RM100. Both processes examine the importance of seeing the process as an iterative process, and the different steps in the process have clear similarities.

Under the different steps, some detailed requirements are given for some of risk management processes used in particular areas in the company. The detailed risk management process for exploration drilling projects is described as a part of DW100 (described in Chapter 4.1) and is based on RM100 principles.

3.5 RIG CONTRACTOR RISK MANAGEMENT

The rig contractor has internal guidelines regarding risk management although these guidelines are more focused towards the execution phase of a project. As will be discussed in Chapter 4 and 5, Equinor's planning process consists of several project phases including activities performed months before an operation is starting (e.g. risk assessments). The rig contractor contributes and participates in Equinor's planning phase and does not run a planning process comparable to Equinor's comprehensive planning process in parallel.

The rig contractor's own risk management during planning takes to a greater extent place immediately before execution. One relevant directive constructed by the rig contractor focusing on risk assessment is presented in Appendix H – Summary of rig contractor governing document within risk management.

3.6 CONTRACTUAL MATTERS RELATED TO RM

Beside regulations, standards and internal processes, there is a contract which was signed between the operator and the rig contractor prior to the project start-up and operations. This contract regards marine drilling services at the NCS on the mobile drilling unit performing the operations (Equinor, 2018).

Among many other topics, the contract has specific requirements regarding both risk management and collaboration. A list presenting the relevant requirements for the rig contractor is provided in Appendix I – On contractual requirements.

3.6.1 ONE TEAM COMMITMENT

A new initiative called *One Team* was for the first time signed between the operator, the contractor and a third party (service company) in January 2020 (Equinor, 2020a). The concept was initiated by Equinor, and is a commitment between the three parties with the purpose of having a collaborative win-win performance culture and actively contributing in developing a One Team culture across the companies.

The commitment is not bound by the contract, but it encourages effective collaboration between the companies. The initiative will therefore be used as another perspective for establishing the criteria regarding collaboration in the model in Chapter 6.

A copy of the commitment is provided in Appendix J – On the Equinor One Team Commitment.

4 PLANNING OF EXPLORATION WELLS IN EQUINOR

Exploration drilling is an important part of the value chain in Equinor. In 2019, the company drilled 27 exploration wells worldwide, 19 of which were at the NCS. 12 of them were characterized as discoveries. This work focuses exclusively on offshore exploration wells at the NCS and the associated Norwegian regulations. For such wells, a mobile drilling unit is used to perform the operation.

Exploration drilling projects are complicated projects where many decisions must be made. This includes investigations of the underground, choice of drilling target, well design, decisions of downhole measurements to be made and operational planning. There are also many actors and cross-disciplinary contributors involved both from Equinor and the rig contractor side, all with specified roles and responsibilities. In addition to Equinor and the rig contractor, there are also sub-contractors (service companies) involved. However, this work is limited to investigating the interaction and collaboration between Equinor and the rig contractor.

In an exploration drilling project, there is a lot at stake. 100+ people are typically working on the mobile drilling unit performing the operation and in the event of major accidents, their lives are in danger, refer e.g. to the well control accident at Deepwater Horizon in 2010 (Petroleum Safety Authority Norway, 2017). In addition, there are huge financial values at stake – daily rig rates are high, and the construction of a complete exploration well is expensive. The main goal of drilling exploration wells is to determine whether there are hydrocarbons in the underground – this is uncertain due to uncertainty of the predictions of the geology, based on seismic and information from any relevant reference wells.

All the elements and risks mentioned above must be managed by Equinor and put into system throughout a work process. The work process for construction of exploration wells in Equinor is called DW100, which is presented briefly in Chapter 4.1. This work process contains several project phases; three sequential planning phases, the execution phase and an experience phase. Risk management is an integrated part of this process and will be described in more detail in Chapter 5. The rig contractor has its own management system, but they also participate and contribute in Equinor's work process.

4.1 DW100 – CONSTRUCTION OF EXPLORATION WELLS

In planning of new exploration wells, Equinor has a framework called *DW100 – Construction of Exploration wells* which must be followed (ARIS, 2020a). This is a work process containing five different project phases as illustrated in Figure 7.

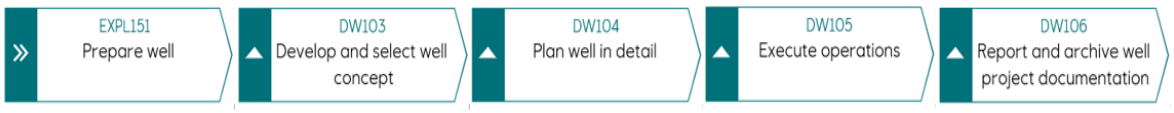

Figure 7: DW100 - Construction of Exploration wells (ARIS, 2020a)

1. Prepare well
2. Develop and select well concept
3. Plan well in detail
4. Execute operations
5. Report and archive well project documentation.

The last two project phases *Execute operations* and *Report and archive well project documentation* will not be discussed further in this work. Each phase is terminated at a decision gate, which is an approval event in order to decide whether to continue to the next stage in the process or not. The results from the embedded risk management process contributes to the basis for the decision on whether to proceed to the next project phase or not (see Chapter 5 for details).

The objectives/purposes in the first three project phases are:

- In *Prepare well*, it is verified whether there is at least one viable solution to the project
- In *Develop and select well concept*, a concept is selected and the project must get provisional sanction in order to continue to the next phase
- In *Plan well in detail*, detailed plans regarding execution of the operation are finalized and final sanctions prepared for approval.

For more detailed information about the content in each stage in DW100, see Appendix K – More details from Equinor DW100 process.

5 RISK MANAGEMENT AS PART OF EXPLORATION WELL PROCESS

FR08 and RM100 introduced in Chapter 3.4 serve as the primary governing documentation from Equinor regarding risk management. Planning and execution of exploration wells are governed by the Equinor work process DW100 presented in Chapter 4. The purpose of this chapter is to describe the risk management process integrated in DW100, customized for exploration drilling projects. This process involves own objectives, organization, activities, tools and deliveries.

The tailored risk management process for exploration wells is constructed with basis in RM100, which again is based on ISO 31000. In that way, following this process should automatically align it with both internal governing documents and the acknowledged risk management process ISO 31000.

As touched upon in Chapter 4, there are potentials for major accidents, work accidents as well as different types of economic losses related to drilling operations. There are considerable uncertainties associated with drilling activities, especially exploration drilling. Examples are the properties of the geology in underground formations to be exposed and the performance of equipment, the organization and operators.

Negative consequences of events in D&W activities can affect people, the environment and the economy. Therefore, Equinor distinguishes in this process between three categories of risk:

- HSE
- Well objective
- Time and cost

5.1 RISK MANAGEMENT IN DW100

Figure 7 in Chapter 4.1 shows the different project phases in DW100, and they form the structure also for the risk management activities throughout the project.

The risk management objectives and focus in the scope of work change throughout the project phases as the level of detail and amount of information available increase. The purposes of risk management in the first three phases are listed (Nilsen et al., 2013):

1. *Assess feasibility of well:* The objective is to determine whether at least one concept is available for conducting the planned operation. Therefore, the risk in this phase is related to possible showstoppers that have the potential to prevent any concept from being realized. Additionally, major risk issues that require attention at an early project stage are considered.
2. *Develop and select well concept:* The objective is to recommend one concept among different alternatives. Risk in this phase relates to uncertainties of the conditions for the concept recommendation. The risk analysis should therefore challenge the chosen solution and pinpoint any hazards or uncertainties that relate to the concept design for its specific application.

3. *Plan well in detail:* In this phase, risk relates to potential deviation from the operational plans that may occur, which in turn can result in unwanted consequences.

Figure 8 is an overview of the risk management activities in the different phases in the well construction process.

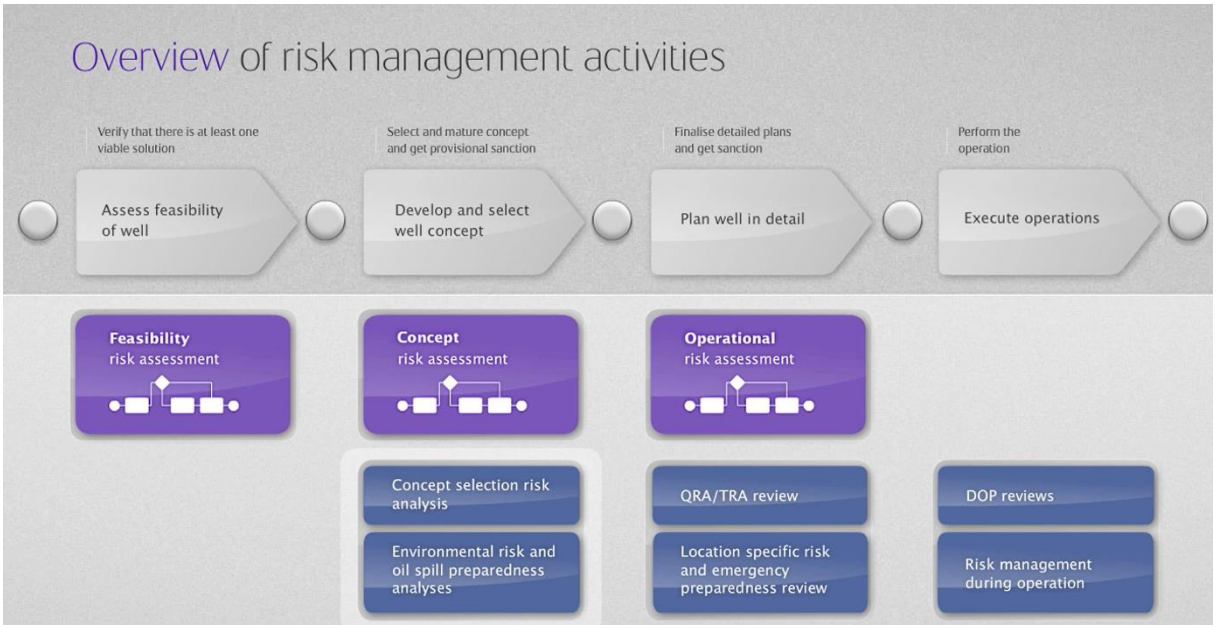

Figure 8: Risk management activities in the Well construction process (Nilsen et al., 2013)

As seen from the figure, a risk assessment sub process containing risk identification, risk analysis, risk evaluation and risk treatment is iterated in each of the three planning phases (described further in Chapter 5.1.1). The risk assessment will provide a basis for:

- Identification and decision on risk reducing measures
- Consideration of whether detailed studies (will be described) are necessary or not
- Update of the project risk register (will be described) and thereby support the forthcoming milestone decisions.

In addition, there are six blue boxes with activities to be performed in the last three phases illustrated:

- *Concept selection risk analysis* compares the risk picture between the different concepts considered.
- *Environmental risk and oil spill preparedness analyses* is an own analysis considering blowouts. These analyses are performed by HSE personnel in Equinor with input from D&W expertise.
- *QRA (Quantitative risk assessment) review* evaluates the major accident potential, and is a document constructed by the rig contractor and belongs to the rig. The project must ensure that it is in accordance with the QRA.
- *Location specific risk and emergency preparedness review* is a document which analyze the use of a rig in a specific area.

- *DOP (Detailed operational procedure) reviews* are done prior to planned operations and go through the planned operation including its associated risks and related measures.
- *Risk management during operation* is at least as important as in the planning phase but is not focused on in this work. It includes various activities such as safe job analyses and risk assessment related to dispensation and change management processes.

5.1.1 RISK ASSESSMENT SUB PROCESS

The most essential sub-process for the risk management process is the *risk assessment*, used to cover identification, analysis and evaluation of risk. The structure and main activities in the risk assessment process are generic even though the level of detail in the different phases is different, reflecting the purpose and project maturation in the different phases.

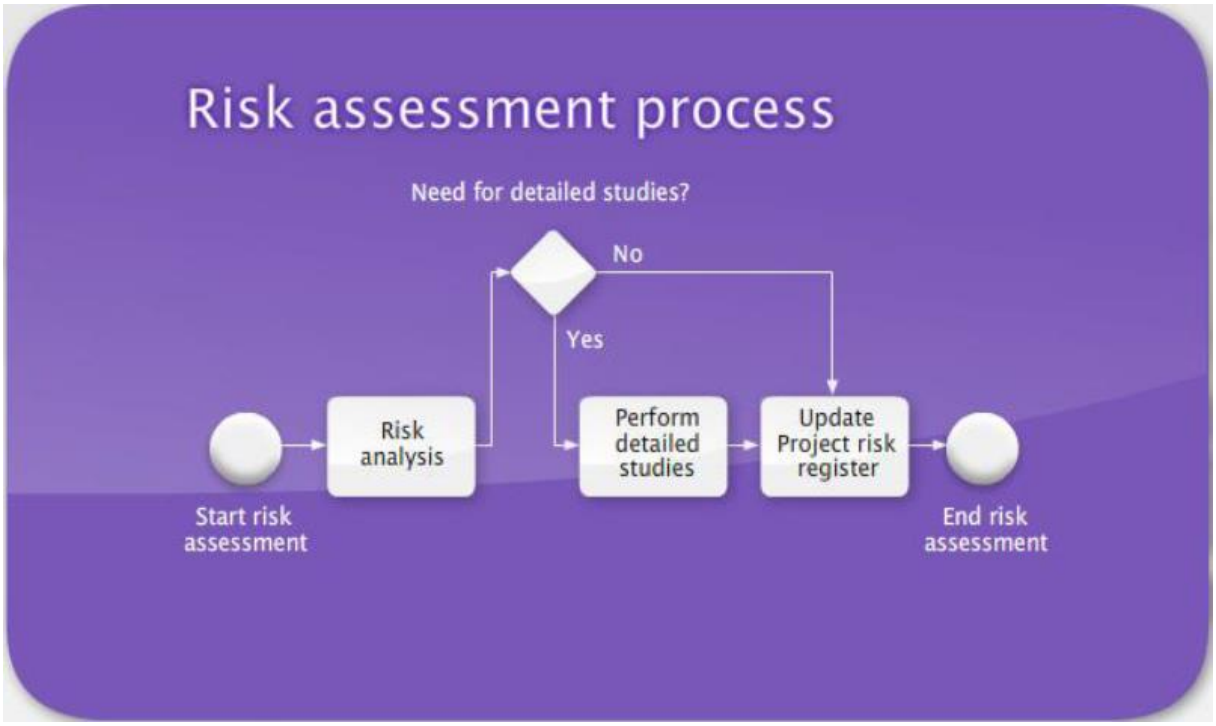

Figure 9: Steps in risk assessment process (Nilsen et al., 2013)

The results of the risk assessment process end as seen from Figure 9 in the project risk register which contains the final evaluation of the consolidated risk picture and the plan for dealing with the risks in terms of risk reducing measures. The risk register is updated at the end of each project phase and provides both actions in terms of risk reducing measures but is also used as part of the basis for deciding on whether the project can continue to the next project phase.

Depending on the results from the first box risk analysis, the project leader must consider whether one can proceed to the next step (update project risk register) or whether detailed studies must be performed. Detailed studies may for instance have the form of more detailed risk analysis on selected topics, critical sub systems or operational sequences. This could also

be gathering of more data or an engineering study which will shed more light on risks of interest.

When the main risk analysis in each planning phase and any detailed studies are completed the final project phase risk register is completed and will be included in and approved as a part of the activity program of the project (milestone document).

5.2 RISK ASSESSMENT TOOLS

The risk assessment tools are more detailed for each phase reflecting the level of detail in the risk assessments in each phase. The three phases with the associated risk assessment tools are listed:

1. *Assess feasibility of well* – Feasibility risk analysis template
2. *Develop and select well concept* – Risk analysis log sheet
3. *Plan well in detail* – Risk analysis log sheet

The most essential results of the risk assessments are included in the project risk register which is a description of the most important risks for the project. Appendix L – Selected Equinor D&W Risk assessment tools and organization of risk analyses provides detailed descriptions of the risk assessment tools and the organization of risk analyses.

6 EVALUATION MODEL

In this section a model is developed for the purpose of evaluating the goodness of the risk management process in development of drilling projects, with focus on the collaboration between the operator and the rig contractor. The model is based on the contents in requirements and expectations, including Chapter 5 regarding risk management in new exploration well projects.

The model is limited to and applied in the planning phase of a new exploration wells, including the Concept selection and Detailed planning phase.

The model will provide basis for information gathering and elements in the interviews in Chapter 7 and evaluation in Chapter 8.

The model will be a simplification as it will not include all relevant criteria for quality risk management processes. This is necessary for the model to be applicable in practice. The challenge is then to make it sufficiently detailed to enable a relevant evaluation of the collaboration aspects of the process.

6.1 PURPOSE

The purpose of constructing an evaluation model is to identify strengths and weaknesses in the process investigated. The intention is to discover findings in a framework dedicated and adapted to the activity of planning a new well project. The findings of the investigation are placed into different activities in the risk management process necessary for a process in line with requirements and expectations. Challenges related to the collaboration process between the operator and rig contractor can therefore be revealed in a professional context.

6.2 MODEL STRUCTURE

The choice is made to base the model on the main structure of *ISO 31000 – Risk management principles and guidelines*. ISO 31000 is a general description of the steps in risk management, and this process is used as a baseline for the evaluation model as it is being referred to in regulations, governing documents in Equinor and in the industry in general. It is assumed that the different steps or activities in ISO 31000 are a necessary minimum for a good and holistic risk management process. If the ISO 31000 principles are being adhered to, other existing guidelines and requirements regarding quality risk management are to a great extent considered fulfilled.

Overall, the standard is an acknowledged and respected document regarding the main elements and principles of risk management in the oil and gas industry.

Beyond the main activities of the ISO 31000 process, the PSA points out other concepts such as

- barrier management
- uncertainty and
- the ALARP principle

as essential parts of risk management. On this background, these elements are also included in the evaluation model.

In Figure 10, the main activities of the ISO 31000 process (also presented in Chapter 3.2 and Figure 4) are summarized, including my short descriptions of the activities. This will form the base framework of the evaluation model.

	ACTIVITY	DESCRIPTIONS
CONTEXT	**1** Establishing the context	Understand background and factors influencing risk. Define scope
RISK ASSESSMENT	**2** Risk identification	Identify contributions to risk in the project
	3 Risk analysis	Analyse risk; describe causes and consequences, quantify probability and impact
	4 Risk evaluation	Compare results of risk analysis with risk criteria to determine whether risk is tolerable or not. Basis for considering need for risk treatment
TREATMENT	**5** Risk treatment	The process of modifying risk: measures decided based on risk evaluation. Planning and implementation of preventive and mitigating measures
PARALLEL PROCESSES	**6** Communication and consultation	Involve relevant expertise, stakeholders and decision makers. Exchange of information between involved parties according to roles/responsibilities
	7 Monitoring and review	Responsible parties to monitor and review RM objectives, scope, assessments, results, decision making and follow-up/implementation throughout the process

Figure 10: Activities as in ISO 31000. The descriptions are my professional understandings of the activities

The next step in the development of the model was to establish criteria for adhering to this process, with focus operator-contractor collaboration.

6.3 CRITERIA FOR FULFILLING ISO 31000 MAIN ACTIVITIES

Within each of the seven different activities, one or more criteria are designed to evaluate the investigated process. The criteria address important elements for collaboration within the framework of ISO 31000 and its risk management process.

A selection of topics within risk management were used as a starting point for developing the criteria. Below, an overview of topics considered important for this purpose are presented. The topics are linked to requirements and expectations described earlier in the report (Chapter 3 and 5).

Topic	Link to sources
Methodology used in risk identification and analysis, including progression in the risk management process	- The framework regulation - The management regulation - ISO 31000 - Risk management as part of exploration well process in Equinor
Treatment of uncertainty	- The management regulation
Fulfillment of internal (Equinor), legal, regulatory and other requirements, including barrier management and the ALARP principle	- The PSA regulations - ISO 31000 - the NORSOK standards - Equinor internal processes (RM100, Chapter 5)
Involvement and utilization of relevant competency in different project phases	- ISO 31000 - Risk management as part of exploration well process in Equinor
Common understanding of roles, responsibility, risks and decided actions	- ISO 31000
Availability and access to risk related project information throughout project for all parties	- The management regulation
Monitoring and follow-up throughout project	- The management regulation - ISO 31000
Communication	- The management regulation - ISO 31000

Table 1: Topics included in evaluation model linked to requirements described

The model will not provide answers regarding:

- Design and outfitting of facilities, including technical specifications on well barriers
- Contractual matters, including requirements
- Fulfillment of the rig contractor's risk management requirements as those guidelines have been difficult to retrieve. In addition, the ones received are more relevant applied closer to execution.

The criteria developed based on the ISO 31000 structure and the above listed topics are presented in Figure 11.

The criteria should be understood as something that needs to be in place in order to fulfill the given ISO activity and considered relevant for collaboration. The main criteria are numbered and typed in bold. For some criteria, sub criteria are added to address aspects of collaboration in more detail. These are numbered a, b, d, etc. The criteria regarding uncertainty, barrier management and the ALARP principle are currently marked in blue.

Some criteria are included in more than one ISO activity. An example is involvement and utilization of relevant competency. Involvement and utilization of relevant competency is considered as an important activity throughout all phases of the risk management process, not only in *Establishing the context*.

		#	CRITERIA
CONTEXT	Establishing the context	1.1	**Common understanding of the basis - scope, goals, roles and responsibilities**
		1.2	**Utilize available competence** **a.** involvement of relevant expertise/competence in start-up meetings
		1.3	**Everyone has access to all necessary information in order to understand and contribute to the context** **a.** shared platform containing essential information
		1.4	**Awareness of well/area specific conditions** **a.** Equinor (geologists, drilling engineers etc.) share important area/well information **b.** contractor(s) contributes with relevant experiences and knowledge of rig aspects/capabilities
RISK ASSESSMENT	Risk identification	2.1	**Utilization and involvement of relevant expertise and competency in identification of risks** **a.** utilization and involvement of relevant contractor competencies in risk identification
		2.2	**Methodology for identification of new risks - both a systematic and creative process** **a.** preparations before meetings and discussions **b.** both operator/contractor contribute with experiences and identified risk aspects
		2.3	**Documentation - availability/sharing of identified risks** **a.** risks idetified in risk meetings are documented **b.** shared platform containing essential information
	Risk analysis	3.1	**Utilization of relevant expertise and competency - analysis is an interdisciplinary task** **a.** utilization and involvement of relevant contractor competencies in risk analysis meetings
		3.2	**Methodology used to break down, understand and describe the risk (meetings agenda etc.)** **a.** clear responsibilities in meetings (facilitator, expert panel, secretary). Expectations to contractor representative communicated and clarified
		3.3	**Quantification/agreement on likelihoods and impacts of risk contributions**
		3.4	**Risk analysis tools known and common for all parts** **a.** relevant parties must be familiar with tools before risk analysis meeting
		3.5	**Necessary assessments of uncertainty, including description of strength of knowledge** **a.** uncertainty reflected in risk analysis tools
		3.6	**Barrier managament - establishment and continuously use of barrier functions and elements in all project phases** **a.** common understanding of the purpose of barrier elements
	Risk evaluation	4.1	**Sufficient risk analysis and understanding of the risk established**
		4.2	**Involvement of adequate competence/authority** **a.** involvement of relevant competency/authority with contractor as applicable
TREATMENT	Risk treatment	5.1	**Identify measures based on risk assessment**
		5.2	**Utilization of relevant expertise and competency (identification, evaluation of effect, applicability, costs)** **a.** utilization and involvement of relevant expertise including contractor
		5.3	**Decisions on measures made in accordance with internal, legal, regulatory and other requirements, including ALARP principle** **a.** mutually ensure common understanding of requirements, expectations and cost and benefit between operator and contractor
		5.4	**Common understanding of the purpose of chosen treatments** **a.** clear communication between decision makers and parties performing operations regarding purpose of treatment
PARALLEL PROCESSES	Communication and consultation	6.1	**Common understanding of stakeholder, descision maker and contributor roles** **a.** two-way communication operator/contractor **b.** clarified expectations between parties on who communicates what and when
		6.2	**Ensure stakeholder interests are covered** **a.** involvement of stakeholders when applicable
		6.3	**Involve sufficient competence** **a.** utilization and involvement of relevant competency outside the project (e.g. earlier projects, HPHT-competency) **b.** consultation of relevant expertise when applicable
		6.4	**Inform decision makers** **a.** efficient communication channels across companies and management levels
		6.5	**Make sure contractor understands risks and decisions** **a.** informal updates on risk and risk treatment throughout project
		6.6	**Access to documentation and reporting - (contractor always updated on progress/agenda)** **a.** web-based collaborative document platform
	Monitoring and review	7.1	**Well RM process in line with external requirements, RM100 - Manage risk in Equinor and DW100** **a.** Equinor follow-up of contractor process and vice versa
		7.2	**Common understanding of stakeholder, descision maker and contributor roles** **a.** common understanding ensured on management level between parties
		7.3	**Access to documentation and reporting - (contractor always updated on progress/agenda)**
		7.4	**Those responsible for RM follow up deliveries from contributors throughout process** **a.** make sure contractor knows and understands risks, decisions and required actions **b.** progress on deliveries (actions) systematically followed up across parties **c.** correspondance between operator/contractor risks ensured
		7.5	**Updating and revision of the risk picture according to ISO 31000 and objectives in the internal project phases**

Figure 11: Criteria for evaluation of the collaboration and risk management process linked to ISO 31000 activities

The criteria are established based upon my overall professional, but subjective understanding of key elements in this process. My understanding is based on

- subjects studied at the University of Stavanger, including Risk Analysis and Risk Management
- findings in the literature, including risk management theory (Chapter 2), governmental and recommended requirements and expectations (Chapter 3) in addition to internal processes in Equinor (Chapter 3.4, 4 and 5)
- courses internally in Equinor, including *Risk Management in the Well Construction Process (Nilsen et al., 2013)*
- discussions with my supervisors both from Equinor and the University of Stavanger.

After deciding that the model should be built on ISO 31000, each activity was reviewed and assessed against important elements and sub activities for each of them. By extracting key takeaways from regulations, standards and internal requirements, these were assessed against ISO 31000 to decide in which activity they belonged.

6.4 DISCUSSION OF THE MODEL

Different alternatives to the evaluation model were discussed. An alternative approach considered was to construct a model listing all relevant requirements regarding risk management that the PSA points towards and simply tick off the requirements fulfilled. However, this setup would not enable to highlight the collaboration aspect between stakeholders. It would also have been difficult to link such a model to a specific project, and the logical progression from establishing the context and onto risk evaluation and treatment would, in my view have been less structured.

To base the model solely on internal Equinor processes would also have led to challenges, as Equinor's internal risk management process is not in itself an acknowledged industry standard used across companies.

In my opinion, the current setup with the ISO 31000 activities can cover criteria regarding all aspects of the risk management process in a logical and chronological setup. The model is also capable of including collaboration as an integrated part of risk management.

As ISO 31000 is a respected and commonly used framework for risk management across disciplines, using the standard as a basis for this model and work can be related to other projects and industries as well.

6.5 USE OF THE MODEL AS BASIS FOR INTERVIEW QUESTIONS

In this thesis, information gathered through interviews with a selection of representatives from the industry forms an important basis. The evaluation criteria in Chapter 6.3 were used as part of the basis for setting up the questions used in the interviews (presented in Chapter 7). Therefore, a complete overview of the interview of the links between interview questions and relevant evaluation criteria in the model is presented in the table below.

Interview question	Relevant criteria
1. How are the operator's internal risk management processes complied with, and are they in line with a. The PSA's regulations? b. Standards like ISO 31000 and NORSOK D-010 and Z-013? c. DW100 and RM100? d. Are the contractor's processes compatible with the operator's? Do they complement each other well?	5.1 5.3 7.1
2. The ALARP principle is an important principle which lies at the core of risk management and implementation of actions. To what degree and how is the ALARP principle applied when risks are evaluated in planning of new wells? a. Is there a common understanding of what the principle entails? b. Is the principle actively being used in risk evaluation and decision about solutions and measures? c. How is the ALARP principle used in practice?	5.3 5.3a 5.4
3. How does the collaboration in a risk management project with several involved parties to work out? What works well? a. Does the communication between the involved parts work good enough? b. Are decisions which influence risk on the operator- and contractor side coordinated? c. Is there a good connection with regards to document structure on the two sides?	1.3 1.3a 2.3 2.3a 2.3b 6.4 6.4a
4. What challenges do you experience in relation to risk management in a drilling project where both an operator and a contractor is involved? a. Where are the improvement potentials in relation to collaboration in the RM process? What can be done to optimize the process? b. What are the weaknesses of the operator? c. The contractor?	General – may affect all criteria
5. Involvement and utilization of relevant personnel or competence in all phases of the risk management process is important. Relevant competence might come from different disciplines internally, but also from drilling contractor. To what extent are all parts involved in the risk management process as they should – yields identification, analysis, evaluation of risk and decisions on actions?	1.2 5.2 1.2a 5.2a 2.1 6.2a 2.1a 6.3 6.3a 3.1 6.3b 3.1a 4.2 4.2a
6. Is all information easily available for all involved parts throughout the process? a. Does everyone have access to information about the project throughout a shared platform? b. Can the contractor easily navigate to find the identified risks? c. Are the parties' risk management systems mutually known on both sides?	1.3 3.4 1.3a 3.4a 2.3 6.4 2.3a 6.6 2.3b 6.6a 7.3
7. Common understanding is important in a collaboration process. Do you experience that there is a common understanding of roles and responsibility in the risk management process?	1.1 3.2a 3.3

a. How does the contractor look at their role/responsibility in the operator's risk management process? b. How is the operator involved in the contractor's risk management process? c. Do you experience that there is a common understanding av the risks and their accompanying actions/measures? d. It happens that the operator and the contractor has different risk understanding and/or conflicting objectives and practices. Examples may be time and cost. How are such situations handled? e. Do we find the operator's risks in the contractor's system? f. Is the content in the risk analysis quality checked by both parts?	4.1 5.4 6.1 6.5 7.2 7.2a
8. According to ISO 31000, monitoring and review is an important parallel activity throughout the whole risk management process. To what extent and how does Equinor follow up the contractor and vice versa throughout the process?	7.4 7.4a 7.4b 7.4c
9. Both Equinor's risk management process and standards such as ISO 31000 emphasize the importance of risk management processes being iterating and cyclical – it should be revised and updated throughout the process. Do you experience that the risks and their actions are revised and updated in the planning- and/or the execution phase? a. How is new information communicated between the involved parts? b. How is the distribution of responsibility when new risks arise – and who communicate to who on the operator- and contractor side?	6.1b 6.5a 7.1 7.5
10. Dealing with uncertainty is an important part of risk analysis- and management. How is uncertainty dealt with? a. How is uncertainty captured in the tools such as risk analysis log sheet and the risk register?	1.4 3.2 3.3 2.2 3.4 3.5 4.1
11. The PSA says that barrier management is part of risk management, e.g. in their Barrier Memorandum 2017 and in the Management regulations. Tell about the focus on barriers and barrier management in the work with risk? a. Barriers must be tagged in the risk analysis log sheet and in the risk register – is this being used? Is there a link towards the barrier diagrams? b. Does Equinor/contractors see a connection between risk- and barrier management? c. How does Equinor/the contractor keep control of the contractor's responsibility when it comes to risks regarding well barriers?	3.6
12. Meetings in the risk management process cover both risk identification and risk analysis. <u>Risk identification:</u> tell about the methodology used to identify risks? <u>Risk analysis:</u> tell about the methodology used to break down, understand and describe the risks? a. Who are attending the meetings? Do you have guidelines telling who must participate in the meetings? b. How is the focus regarding meeting attendance? Who is responsible for this, and what happens if X is not participating?	1.4 4.2 4.2a 2.1 2.2 5.2 2.2b 5.2a 3.1 6.3 3.1a 6.3a 3.2

Table 2: Links between interview questions and relevant evaluation criteria

7 INTERVIEWS

7.1 PURPOSE

The objective of conducting interviews is to evaluate compliance and gaps between requirements and intentions and real practice regarding the collaboration in the risk management processes including the operator and the rig contractor in the planning phase of exploration drilling projects in Equinor.

The purpose of conducting interviews is to use experiences gained both from personnel involved in operational activities (operator and rig contractor), but also from experienced people outside the operational organizations. The latter would provide answers from a more objective point of view. The answers have been used as input to my analysis and conclusions.

7.2 INTERVIEWEES

Four different parties have been interviewed. Equinor and the rig contractor have been interviewed as they are part of the activity followed. The PSA and Proactima have also been interviewed in order to get input seen from governmental and objective perspectives. A brief presentation of the interviewees follows.

The PSA:

- **Interviewee: Representative from D&W in the PSA**
- **Interview date: 15.04.2020**

The PSA is a government supervisory and administrative agency with regulatory responsibility for safety, the working environment, emergency preparedness and security in the petroleum sector. As a watchdog, the PSA follows up that companies always operate prudently and exercise their enforcement powers if they fail to do so.

The representative has earlier in his career worked in Statoil (today Equinor) within D&W for more than 14 years and knows the company well.

Proactima:

- **Interviewee: Risk Management Senior Consultant**
- **Interview date: 16.04.2020**

Proactima offers risk management advice for all sectors and has for many years helped to solve challenges related to this topic in the oil and gas industry.

The representative from Proactima has many years of experience working within risk management in the oil and gas industry, also within exploration drilling for other operators than Equinor.

Equinor 1:

- **Interviewee: Drilling Superintendent (DSI), D&W Operations International and Exploration Drilling**
- **Interview date: 23.04.2020**

The representative has worked in D&W in Equinor and former Statoil since 2006, within exploration drilling since 2008. The person has many years of offshore experience as a Drilling Supervisor and is currently working as a Drilling Superintendent for the exploration well project on an onshore location.

Equinor 2:

- **Interviewee: Drilling Engineer (DE), D&W Operations International and Exploration Drilling**
- **Interview date: 27.04.2020**

The representative is currently working as a Drilling Engineer for the exploration well project.

Rig contractor:

- **Interviewee: Onshore Planner**
- **Interview date: 06.05.2020**

The representative works as an Onshore Planner, meaning the person is the link between Equinor D&W (exploration drilling) and the rig contractor organization, including the rig performing the planned operation. The representative has several years of offshore experience as a Roughneck and Assistant Driller.

7.3 QUESTIONS AND ANSWERS

The interviews were conducted via Skype for Business. In the below tables a summary of the statements most relevant for the evaluation criteria is given. An overall summary follows after the tables. This is used as a basis for the evaluation in Chapter 8.

All complete minutes of the interviews have been recorded and archived in their full format and can be provided upon request.

Note that the questions 6, 7, 10 and 11 were not asked the PSA and Proactima. Question 10 was answered by the PSA although the question was not asked.

1. How are the operator's internal risk management processes complied with, and are they in line with

a. The PSA's regulations?
b. Standards like ISO 31000 and NORSOK D-010 and Z-013?
c. DW100 and RM100? (Question for Equinor)
d. Are the contractor's processes compatible with the operator's? Do they complement each other well?

Interviewee	Key findings
The PSA	• Internal processes are generally aligned with guidelines to the regulations • Rig contractor is involved in the operator's risk management and planning • There are often constructed bridge documents, identifying gaps between the operator's and contractor's practice
Proactima	• Most operators and rig contractors follow the PSA's regulations and take them seriously • Have seen examples of rig owners being frustrated of Equinor's comprehensive processes
Equinor, DSI	• Expect that governmental requirements are covered throughout Equinor's internal process • Does not always follow the methodology described in the internal processes, but aware of deviations
Equinor, DE	• Do not have full knowledge about detailed risk management requirements from the PSA and other standards • Expect that governmental requirements are covered throughout Equinor's internal process • Has impression that the risk management activities carried out in the projects are in line with the internal work processes • Has less knowledge about the rig contractor's risk management process – not sure whether they have their own process
Rig contractor	• Not sure whether the operator complies with governing regulations • As a rig contractor we have a confirmation from the authorities that we are in line with the regulations

2. The ALARP principle is an important principle which lies at the core of risk management and implementation of actions. To what degree and how is the ALARP principle applied when risks are evaluated in planning of new wells?

a. Is there a common understanding of what the principle entails?
b. Is the principle actively being used in risk evaluation and decision about solutions and measures?
c. How is the ALARP principle used in practice?

Interviewee	Key findings
The PSA	• ALARP principle not always applied • There are evidences showing that there is an understanding of the principle, but it is not applied as it should in practice • There are examples showing that Equinor and the industry in general have an improvement potential when it comes to fully utilizing the ALARP principle

Proactima	• ALARP principle applied in minor degree in Norway • Relatively weak understanding of what the principle entails and not applied as intended
Equinor, DSI	• States that the term is not used at all at the NCS • The government and the PSA must be more challenging regarding the principle
Equinor, DE	• We do not focus on the ALARP principle as a concept, but have an expectation that it is covered by internal processes • Not a common understanding of what the principle entails
Rig contractor	• Would say that ALARP principle is used • Not clear whether there is a common understanding of the ALARP principle

3. How does the collaboration in a risk management project with several involved parties to work out? What works well?

a. Does the communication between the involved parts work good enough?
b. Are decisions which influence risk on the operator- and contractor side coordinated?
c. Is there a good connection with regards to document structure on the two sides?

Interviewee	Key findings
The PSA	• Both yes and no – collaboration seems OK based on audits
Proactima	• Collaboration tends to work out if those from the contractor performing the operations from onshore are co-located with the operator's project organization • Decisions not coordinated, and this is a result of financial factors • Important project information is being structured at shared platforms
Equinor, DSI	• The process of including operational/offshore personnel when an operation approaches works well
Equinor, DE	• We include people on both the operator and rig contractor side when decisions regarding risk influencing both sides are to be taken
Rig contractor	• Collaboration works well • Discussions with Equinor makes us see the whole risk picture, we gain broader understanding of the whole context • Communication between rig contractor and Equinor is good

4. What challenges do you experience in relation to risk management in a drilling project where both an operator and a contractor is involved?

a. Where are the improvement potentials in relation to collaboration in the RM process? What can be done to optimize the process?
b. What are the weaknesses of the operator?
c. The contractor?

Interviewee	Key findings
The PSA	• Difficult and demanding to have the right people and competency always involved • Seems like operator/rig contractor feel that they are heard throughout the process, which is positive
Proactima	• Drilling contractor gets involved too late, and subsurface must be involved longer in order to coordinate decisions throughout whole project • Rig contractor not willing to do things beyond what the contract says
Equinor, DSI	• There can often be discussions related to the financial burden of decisions and measures • Equinor as a company expects rig contractor to be aligned with their process, and are less focused on the contractor's own process • Wish there was an industry standard work process regarding risk management activities in planning of exploration wells
Equinor, DE	• A challenge to find the balance between well specific risks and at the same time keep track of the most important and general risks • We have an improvement potential in focusing on the risks rather than focusing on being auditable
Rig contractor	• A challenge to find enough time for everything • Wish meetings and processes were more standardized and information given beforehand meetings

5. Involvement and utilization of relevant personnel or competence in all phases of the risk management process is important. Relevant competence might come from different disciplines internally, but also from drilling contractor. To what extent are all parts involved in the risk management process as they should – yields identification, analysis, evaluation of risk and decisions on actions?

Interviewee	Key findings
The PSA	• Refer to audits, but can say on a general basis that involvement of all relevant parties not always is done as intended
Proactima	• All parties are not involved in the process as they should • The added competency depends on what type of personnel the contractor is sending • The competency from the rig contractor is often too operative in contrast to the more academic competency from the operator
Equinor, DSI	• Experience that right people are involved, and there is a good collaboration between them when needed in RM process
Equinor, DE	• We have improved and are better in involving right people than before

	• Involve Equinor Drilling Supervisor and onshore people from contractor, not offshore personnel from contractor that much
Rig contractor	• Everyone is invited to important risk related meetings • Equinor is good at involving the right competency, and they have a lot of expertise internally • People from rig contractor also involved

6. Is all information easily available for all involved parts throughout the process?

a. Does everyone have access to information about the project throughout a shared platform?
b. Can the contractor easily navigate to find the identified risks?
c. Are the parties' risk management systems mutually known on both sides?

Interviewee	Key findings
Equinor, DSI	• Well specific risks available, general risks not always covered
Equinor, DE	• Not as easy for contractor as for operator to find well specific risk information • Not sure whether the rig contractor has access to the web-based platform containing project information – it varies from project to project
Rig contractor	• No, only a few from the rig contractor having access to systems • Equinor personnel need to send documents upon request from the rig contractor

7. Common understanding is important in a collaboration process. Do you experience that there is a common understanding of roles and responsibility in the risk management process?

a. How does the contractor look at their role/responsibility in the operator's risk management process?
b. How is the operator involved in the contractor's risk management process?
c. Do you experience that there is a common understanding of the risks and their accompanying actions/measures?
d. It happens that the operator and the contractor has different risk understanding and/or conflicting objectives and practices. Examples may be time and cost. How are such situations handled?
e. Do we find the operator's risks in the contractor's system?
f. Is the content in the risk analysis quality checked by both parts?

Interviewee	Key findings
Equinor, DSI	• Good common understanding of roles and responsibilities • Rig contractor expects to be involved and heard throughout the risk management process • Disagreements can often lead to discussion regarding contractual matters
Equinor, DE	• Good common understanding of roles and responsibilities • Equinor is responsible for the well construction, while rig contractor has more responsibility regarding operational risks (at the rig) • Good common understanding of the risks

	• Operator involves rig contractor, not opposite
Rig contractor	• Common understanding of roles, responsibilities and risks • Rig contractor's role and responsibility regarding the risks more tied to the execution phase

8. According to ISO 31000, monitoring and review is an important parallel activity throughout the whole risk management process. To what extent and how does Equinor follow up the contractor and vice versa throughout the process?

Interviewee	Key findings
The PSA	• Refer to verifications and audits • On a general basis, not all elements are followed up throughout monitoring processes
Proactima	• Monitoring is done throughout process, but there is less reviewing • Serious situations with severe consequence potential are being followed up, but minor situations without severe consequence potential often pass without more follow-up
Equinor, DSI	• There is monitoring underway, for instance go-through of the risk matrix in each Detailed Operational Procedure (DOP)-meeting, but not often after operation
Equinor, DE	• There is little follow up across the companies throughout the process
Rig contractor	• Rig contractor did not have a relevant answer to this question

9. Both Equinor's risk management process and standards such as ISO 31000 emphasize the importance of risk management processes being iterating and cyclical – it should be revised and updated throughout the process. Do you experience that the risks and their actions are revised and updated in the planning- and/or the execution phase?

a. How is new information communicated between the involved parts?
b. How is the distribution of responsibility when new risks arise – and who communicate to who on the operator and contractor sides?

Interviewee	Key findings
The PSA	• In most cases are risks are updated, especially when a management and change (MoC) process is established • Risk is communicated, but a common understanding of the risk can be a problem for those communicating
Proactima	• Risks and their actions are updated in the planning phase, but not the operational phase • It is rare that the rig contractor comes up with new risks and actions beyond the already established • The financial aspect is a limiting factor for good risk management and the safety
Equinor, DSI	• Yes, risk is updated underway in project

Equinor, DE	• Yes, risk is updated underway in project
Rig contractor	• Yes, risk us updated underway in project • Every risk as assigned to a person – rig contractor has more responsibility for risks related to operation

10. Dealing with uncertainty is an important part of risk analysis- and management. How is uncertainty dealt with?

a. How is uncertainty captured in the tools such as risk analysis log sheet and the risk register?

Interviewee	Key findings
The PSA	• This is not easy as this is a relatively new dimension in risk management requirements provided by the PSA • Uncertainty is not that well implemented/visualized in risk management processes, nor within D&W in Equinor (based on audits)
Equinor, DSI	• Equinor DSI did not have a relevant answer to this question
Equinor, DE	• Uncertainty is to some extent included in the log sheet
Rig contractor	• Rig contractor did not have a relevant answer to this question

11. The PSA says that barrier management is part of risk management, e.g. in their Barrier Memorandum 2017 and in the Management regulations. Tell about the focus on barriers and barrier management in the work with risk?

a. Barriers must be tagged in the risk analysis log sheet and in the risk register – is this being used? Is there a link towards the barrier diagrams?
b. Does Equinor/contractors see a connection between risk- and barrier management?
c. How does Equinor/the contractor keep control of the contractor's responsibility when it comes to risks regarding well barriers?

Interviewee	Key findings
Equinor, DSI	• The focus on barriers is good, but the understanding of them vary among involved personnel • Well barriers and WBS are being established early in the project and attached to DOPs. In that way, it is always illustrated which barriers are active
Equinor, DE	• Barriers are fundamental, and we are always thinking of the requirement of having two active barriers
Rig contractor	• Rig contractor focuses on operational barriers

12. Meetings in the risk management process cover both risk identification and risk analysis.
Risk identification: tell about the methodology used to identify risks?
Risk analysis: tell about the methodology used to break down, understand and describe the risks?

a. Who are attending the meetings? Do you have guidelines telling who must participate in the meetings?
b. How is the focus regarding meeting attendance? Who is responsible for this, and what happens if X is not participating?

Interviewee	Key findings
The PSA	• Risk identification often based on earlier projects – full HAZIDs are the exceptions. The downside of this methodology is to possibly overlook well- and area specific risks
Proactima	• The quality of these meetings dependent on the personnel attending the meetings • Refer to risk analyses as risk assessments – risk analyses more academical oriented • Meetings often held regardless on who is attending – yet to see a meeting be postponed due to lack of personnel present
Equinor, DSI	• Too much dependent on earlier projects, should start risk identification with blank sheets • Need better risk facilitator at early stage in the project phases • Risk meetings are prioritized among involved personnel
Equinor, DE	• Use to start risk identification meetings with brainstorming before we use information from reference wells • Specific risks may be discussed in own meetings • Try to include offshore personnel and drilling supervisors when approaching operation • Use to go through participation list in beginning of each risk meeting in order to have correct competency involved
Rig contractor	• Base risks on earlier projects (reference wells) • Risk picture always compared to reference wells • Meeting attendance is a focus area, and often is the participation list considered before start-up of meeting

7.4 SUMMARY

The interviews provided useful information about the processes of collaboration and risk management, even though some topics were answered better than others. Some of the main both coinciding and conflicting answers relevant for the model are presented in the following. For some questions the answers were relatively short, and the interviewees seemed uncertain about the topic asked. Instead of concluding that these question(s) were not answered, the lack of supplementary answers were included in the assessment of the interviewee's strength of knowledge related to the topic asked. These answers are also included in the evaluation of the criteria in Chapter 8.

The interviews revealed useful answers helpful for the model evaluation for the following topics:

- Operator's internal risk management process
- The ALARP principle
- Risk management as an iterating process
- Risk identification methodology
- Barrier management
- Involvement and utilization of competency
- Treatment of uncertainty
- Availability and access to risk related information

The interviews did not reveal useful answers helpful for the evaluation model for the following topics:

- Communication of new information
- Monitoring and review throughout risk management process
- Risk analysis methodology

Risk management

It is a common belief that the operator's internal risk management processes are in line with requirements and expectations, but Equinor interviewees explained that they are more focused on their internal work process and therefore not that familiar with the contractor's risk management process. It was in that way difficult for them to answer the question about compatible processes. By interviewing the rig contractor, it was revealed that they fully follows Equinor's planning process. Moreover, despite dialogue with the contractor it has been hard to clarify whether they have a risk management process covering the planning phase.

There is a broad agreement between the interviewees that the ALARP principle is applied in minor degree. Both the DSI and DE in Equinor doubt there is a common understanding of what the principle entails, at least at a detailed level. It should be noted that this refers to knowledge among Equinor D&W technical personnel – not risk specialists. The PSA says there are evidences showing a theoretical common understanding of the principle.

Both the two from Equinor and the rig contractor interviewee state that the risk management process is an iterating process throughout the whole project. Proactima has the impression that the risk picture is being updated in the planning phase, but not in the operational phase.

The PSA has the impression that risk identification often is based on earlier projects and reference wells, and it can therefore be challenging to be aware of well specific conditions. There are conflicting opinions in Equinor regarding the risk identification methodology, and the rig contractor strongly believes that risk identification is based on previous work.

Barrier management is according to both the DSI and DE in Equinor actively being used as an integrated part of risk management in new well construction projects. Well barriers are established at an early project stage and considered throughout the whole project. Among other places, this is reflected in the DOPs.

The question regarding how uncertainty is dealt with was not answered in detail neither by Equinor or the rig contractor. This indicates that the focus on uncertainty is not fully in line with the expectations of the PSA. The PSA states that uncertainty is yet to be fully implemented in the risk management process as intended in their regulations.

Collaboration

There is lack of knowledge among the interviewees about whether the operator's risk management process is compatible with the rig contractor's process.

Involvement and utilization of relevant personnel is a debated issue. Both the PSA and Proactima state that this tends to be challenging, whereas both the DSI and DE in Equinor emphasize that they are good in including relevant competency. The rig contractor supports the conclusion of the DSI and DE. The diverging points of view may be explained by diverse practices among operators and development of industry practice over time.

Clearly, there are web-based platforms containing important project information regarding project risks. However, the interviews revealed that not all rig contractor personnel have access to these platforms. It has not been clarified how those with access distribute the information in their own organization.

Monitoring throughout the process is according to both the PSA, Proactima and Equinor interviewees done to some extent, but no evidence is found indicating that this is done systematically to follow up specific risk management activities. A common statement is that review after projects is done in minor degree.

8 ANALYSIS AND EVALUATION

This chapter applies the evaluation model and criteria presented in Chapter 6 in order to analyze and evaluate the goodness of the risk management process and in particular operator/contractor collaboration. The interviews in Chapter 7 and my own knowledge and experiences have formed the basis for evaluation.

The activities in ISO 31000 are first evaluated one by one. Then a complete overview of the scored criteria is presented at the end. The chapter is structured chronologically as in ISO 31000, starting with the activity *Establishing the context.*

8.1 BASIS FOR EVALUATION

The core element of the evaluation is the assessment related to each evaluation criterion using a scoring system. The scoring is a subjective judgement by myself based on:

- The interviews presented in Chapter 7
- My participation in a real exploration well project (for more details, see Appendix A – Participation in an Equinor exploration well project), including:
    - Weekly project meetings
    - Risk assessment meetings and other risk related meetings
- Discussions with
    - Involved project members
    - My supervisor in Equinor.

The scoring system ranges from 1 to 5, where 5 is the best score:

Score	***Meaning***
1	Poor
2	Weak
3	OK
4	Good
5	Excellent

Table 3: Scoring system applied on criterion level in the evaluation

Definitions:

1. *Poor:* Incompliant with requirements and expectations
2. *Weak:* Major gaps from requirements and expectations
3. *OK:* To some extent aligned with requirements and expectations
4. *Good:* Largely Aligned with requirements and expectations, but with some gaps
5. *Excellent:* Fully aligned with both requirements and expectations.

The strength of knowledge and basis for evaluation have varied from criterion to criterion. For some criteria my own experiences formed the main basis for evaluation, whereas for others the interviews weighed the most.

Some interview questions were not answered comprehensively, and my own experiences from the project were not always enough for a good evaluation basis and to reveal the criteria as predicted. This is reflected by color codes on the different scored criteria in Chapter 8.9:

	Strong knowledge
	Medium knowledge
	Weak knowledge

Table 4: Color codes describing my strength of knowledge for each criterion

Definitions:

- *Strong knowledge:* The input sources collectively provided useful information regarding the criterion. The sum of the information basis was strong
- *Medium knowledge:* Some of the input sources gave useful information regarding the criterion. The sum of the information gave useful basis, but with some weaknesses
- *Weak knowledge:* None/few of the input sources provided useful information regarding the criterion. The sum of the information basis was weak.

Before the scored criteria are presented in Chapter 8.9, an analysis of all the criteria within the seven different activities in ISO 31000 is presented from Chapter 8.2.

8.2 ESTABLISHING THE CONTEXT

		#	CRITERIA
CONTEXT	Establishing the context	1.1	**Common understanding of the basis - scope, goals, roles and responsibilities**
		1.2	**Utilize available competence** **a.** involvement of relevant expertise/competence in start-up meetings
		1.3	**Everyone has access to all necessary information in order to understand and contribute to the context** **a.** shared platform containing essential information
		1.4	**Awareness of well/area specific conditions** **a.** Equinor (geologists, drilling engineers etc.) share important area/well information **b.** contractor(s) contributes with relevant experiences and knowledge of rig aspects/capabilities

Figure 12: Evaluation criteria for the first activity - Establishing the context.

1.1 Common understanding of the basis – scope, goals, roles and responsibilities

Findings in the interviews showed that there is a broad consensus among the interviewees that there is a common understanding of the scope, goals, roles and responsibilities. Both Equinor and the rig state that Equinor has responsibility related to the well construction and its associated risks while the rig contractor has more responsibility related to execution and practicality on the rig – and they are aware of the responsibilities themselves.

The impression based on meetings is that actors are aware of their own role, and uncertainties related to this have not occurred.

1.2 Utilize available competence

a. involvement of relevant expertise/competence in start-up meetings

As I did not participate in the early project stage Prepare well, it is difficult to evaluate this criterion.

Both Proactima and the PSA state that utilization of the correct competency tends to be a problem in such projects, meanwhile the involved parties (Equinor and the rig contractor) say expertise and sufficient competency from relevant disciplines is involved.

1.3 Everyone has access to all necessary information in order to understand and contribute to the context

a. shared platform containing essential information

There is a web-based platform containing information about the project, but the platform is not easily available for the rig contractor. A small number of the rig contractor's personnel (those involved in the ongoing project in Equinor) has access to the web-based platform, and the remaining must be sent documents upon request.

1.4 Awareness of well/area specific conditions

a. Equinor (geologists, drilling engineers etc.) share important area/well information

b. contractor(s) contributes with relevant experiences and knowledge of rig aspects/capabilities

Based on my participation early in the Concept selection phase, the operations geologist, petroleum engineer and drilling engineer(s) have attended, been proactive and shared important area/well specific information in all risk related meetings, weekly project meetings and operational risk analysis meetings. However, risk identification is according to both interviews and own experiences often based on earlier reference wells and therefore, well specific conditions have the potential to be overlooked. This is with reference to external interviewees common not only in Equinor but in the industry in general.

Input and relevant experiences from the rig contractor regarding rig aspects and capabilities is often dependent on a good risk facilitator. The impression is that the rig contractor not always is proactive and contributes in the same way as internal personnel in Equinor unless the risk facilitator asks for input.

8.3 RISK IDENTIFICATION

		#	CRITERIA
RISK ASSESSMENT	Risk identification	2.1	**Utilization and involvement of relevant expertise and competency in identification of risks** **a.** utilization and involvement of relevant contractor competencies in risk identification
		2.2	**Methodology for identification of new risks - both a systematic and creative process** **a.** preparations before meetings and discussions **b.** both operator/contractor contribute with experiences and identified risk aspects
		2.3	**Documentation - availability/sharing of identified risks** **a.** risks idetified in risk meetings are documented **b.** shared platform containing essential information

Figure 13: Evaluation criteria for the second activity - Risk identification.

2.1 Utilization and involvement of relevant expertise and competency in identification of risks

a. utilization and involvement of relevant contractor competencies in risk identification

This criterion is related to criterion 1.2 and is an area with room for improvement. This is explained by input from the risk management consultant from Proactima emphasizing this as a recurring issue in such

projects. Moreover, my findings throughout meetings participation seem to vary somewhat between projects, meetings and persons.

2.2 Methodology for identification of new risks – both a systematic and creative process

a. preparation before meetings and discussions

b. both operator/contractor contribute with experiences and identified risk aspects

The methodology used in risk identification is largely influenced by previous projects and reference wells. This statement is based on own experiences throughout risk assessment meetings in addition to input from involved actors, both internally and externally. The risk facilitator from Equinor often presents the risk register from a reference well and use this as basis for further identification of risks.

I have relatively weak strength of knowledge regarding preparation work in advance of meetings, but my experience throughout meeting participation indicates that meeting participants are doing pre-meeting preparations.

The rig contractor contributes with experiences and identified risk aspects when the risk facilitator asks them to contribute, but this is not always the case. However, the impression is that the involved rig contractor personnel have very useful experiences and input, and people listen to their contributions as they are relevant, concrete and operationally oriented.

2.3 Documentation – availability/sharing of identified risks

a. risks identified in risk meetings are documented

b. shared platform containing essential information

There is a web-based platform called Wellcom constructed for sharing important project information including project risks (Wellcom Risk). However, the availability and access to the platform is rather limited on the contractor side. The rig contractor states that only a few of their employees have access to the platform.

Meeting activities show that risks are documented and archived by the risk facilitator throughout risk identification meetings. In the Concept selection and Detailed planning phase, risks have been documented in the Risk analysis log sheet in Wellcom Risk.

8.4 RISK ANALYSIS

		#	CRITERIA
RISK ASSESSMENT	Risk analysis	3.1	**Utilization of relevant expertise and competency - analysis is an interdisciplinary task** **a.** utilization and involvement of relevant contractor competencies in risk analysis meetings
		3.2	**Methodology used to break down, understand and describe the risk (meetings agenda etc.)** **a.** clear responsibilities in meetings (facilitator, expert panel, secretary). Expectations to contractor representative communicated and clarified
		3.3	**Quantification/agreement on likelihoods and impacts of risk contributions**
		3.4	**Risk analysis tools known and common for all parts** **a.** relevant parties must be familiar with tools before risk analysis meeting
		3.5	**Necessary assessments of uncertainty, including description of strength of knowledge** **a.** uncertainty reflected in risk analysis tools
		3.6	**Barrier managament - establishment and continuously use of barrier functions and elements in all project phases** **a.** common understanding of the purpose of barrier elements

Figure 14: Evaluation criteria for the third activity - Risk analysis.

3.1 Utilization of relevant expertise and competency – analysis is an interdisciplinary task

a. utilization and involvement of relevant contractor competencies in risk analysis meetings

This criterion is related to the criteria 1.2 and 2.1 and is a criterion which seem to vary somewhat between projects, meetings and persons. This is explained by input from the risk management consultant from Proactima in addition to own experiences emphasizing this as a recurring issue in such projects.

3.2 Methodology used to break down, understand and describe the risk (meetings agenda etc.)

a. clear responsibilities in meetings (facilitator, expert panel, secretary). Expectations to contractor representative communicated and clarified

The process of breaking down, understanding and describing the risks was throughout the interviews understood as a highly prioritized activity even though I have not been part of a thorough risk analysis myself. The DE interviewed from Equinor emphasized that the process of identifying, analyzing and describing the risks often is divided into several meetings, and the process continues until the project team has reached the target of breaking down the risks in terms of possibilities and consequences.

In my point of view, the responsibilities of the risk facilitator and the secretary have been very clear in risk related meetings. This is also reflected throughout interviews where both interviewees in Equinor and from the rig contractor stated that there is a common understanding of roles and responsibilities. However, the problem is more that the rig contractor (part of the expert panel) must be active and share their experiences/knowledge as a part of the expert panel.

3.3 Quantification/agreement on probabilities and impacts of risk contributions

For this criterion, I have weak strength of knowledge. The interviews gave me minor input for this criterion, but my impression throughout meetings participation is that personnel agree on probabilities and impacts of risk contributions.

3.4 Risk analysis tools known and common for all parts

a. relevant parties must be familiar with tools before risk analysis meetings

Interviewees were not asked about this criterion. However, attendance at meetings has not indicated that the risk analysis tools were unknown to the different parties. Participants have contributed in meetings with input relevant for the risk analysis tools used (log sheet, risk register and risk matrix) without having issues related to knowledge of the tools.

3.5 Necessary assessments of uncertainty, including description of strength of knowledge

a. uncertainty reflected in risk analysis tools

Uncertainty does not seem to be a focused concept fully as intended in the regulations. There is a separate tab in the risk analysis tools reflecting uncertainty, but it is used in varying degree. Some aspects of uncertainty are captured in the methodology in the risk management processes, but the risk matrix used in D&W reflects uncertainty in minor degree.

These conclusions are supported by both statements from the PSA and Equinor. The PSA emphasizes that uncertainty is yet to be implemented as intended in the regulations, whereas Equinor personnel refer to uncertainty as the same concept as probability for possible events to occur. This tells me that there is not a full understanding of the uncertainty concept, where description of the strength of knowledge is an important aspect in order to consider uncertainty. The lack of answer from the rig contractor reinforces my relatively bad impression of uncertainty as a focus area. However, this was to

some degree expected partly explained by the background of the person interviewed. It was difficult to get adequate answers from risk specialists or professionals from the rig contractor.

3.6 Barrier management – establishment and continuously use of barrier functions and elements in all project phases

a. common understanding of the purpose of barrier elements

The focus on barrier management and barrier elements throughout the risk management process and in all project phases is highly prioritized. All barrier elements are reflected and included in both the activity program and the DOPs for the specific operation (including well barrier schematic). Each barrier element refers to the relevant Well Barrier Element Acceptance Criteria in NORSOK D-010. If changes occur during planning or execution and the barrier elements must be changed, a management of change process is required. This supports the argument stating that barrier management is a highly prioritized activity.

There is a requirement of always having two active, independent barriers. Barrier elements are reflected in the risk analysis tools and, in that way, barrier management is an integrated part of the risk management process. The fact that weaknesses and uncertainties related to the barriers are discussed in risk management work supports this. Input from discussions and interviews also coincide with this conclusion.

Experiences from the interviews show that there is a general common understanding of the purpose of the barrier elements even though there not always is an individual common understanding of the them.

8.5 RISK EVALUATION

		#	CRITERIA
RISK ASSESSMENT	Risk evaluation	4.1	**Sufficient risk analysis and understanding of the risk established**
		4.2	**Involvement of adequate competence/authority** **a.** involvement of relevant competency/authority with contractor as applicable

Figure 15: Evaluation criteria for the fourth activity - Risk evaluation.

4.1 Sufficient risk analysis and understanding of the risk established

Based on risk assessment meetings attended, the impression is that there is being performed sufficient risk analysis in line with the requirements in order to understand the risk established. The risk assessment meetings attended in the Detailed planning phase were examples where the meeting was split into two separate sessions in order to pay enough attention to the contents on the agenda. The final activity program including the main risks seemed to be complete.

Interviewees involved in the project followed state that there is a good understanding of the risks established.

4.2 Involvement of adequate competence/authority

a. involvement of relevant competency/authority with contractor as applicable

The main criterion regarding involvement of adequate competence is related to the criteria 1.2, 2.1 and 3.1.

There are requirements for risk analyses to be approved by a Project Leader, the risk register to be approved and that red/orange HSE-risks must be approved. However, I do not have insight to what extent this is done, and adequate authority is involved. Therefore, the criterion is given medium strength of knowledge in contrast to the other related criteria.

8.6 RISK TREATMENT

		#	CRITERIA
TREATMENT	Risk treatment	5.1	**Identify measures based on risk assessment**
		5.2	**Utilization of relevant expertise and competency (identification, evaluation of effect, applicability, costs)** **a.** utilization and involvement of relevant expertise including contractor
		5.3	**Decisions on measures made in accordance with internal, legal, regulatory and other requirements, including ALARP principle** **a.** mutually ensure common understanding of requirements, expectations and cost and benefit between operator and contractor
		5.4	**Common understanding of the purpose of chosen treatments** **a.** clear communication between decision makers and parties performing operations regarding purpose of treatment

Figure 16: Evaluation criteria for the fifth activity - Risk treatment.

5.1 Identify measures based on risk assessment

Measures are identified and documented in the risk analysis tools based on identified risks. My impression is that there is a good process for identification and choice of measures based on input from relevant experiences and standardized measures. There is generally a low threshold for identifying proposals for measures that can reduce risk. Application of the ALARP principle as an element in risk reduction/treatment is not considered in this criterion.

5.2 Utilization of relevant expertise and competency (identification, evaluation of effect, applicability, costs)

a. utilization and involvement of relevant expertise including contractor

This criterion is related to the criteria 1.2, 2.1, 3.1 and 4.2, and is a criterion which seem to vary somewhat between projects, meetings and persons.

5.3 Decisions on measures made in accordance with internal, legal, regulatory and other requirements, including ALARP principle

a. mutually ensure common understanding of requirements, expectations and cost and benefit between operator and contractor

The overall impression is that decisions on measures are in accordance with internal, legal, regulatory and other requirements. However, direct use of the ALARP principle seems to be an exception. The ALARP principle has not been mentioned or dealt with in any of the risk assessments attended, nor in other risk related activities in the planning phase. This observation coincides with the all the responses from the interviewees regarding the ALARP principle.

The threshold for identifying and proposing well specific risk reducing measures seems however to be relatively low, and risk assessments are used as a tool to do this. Nevertheless, direct use of the ALARP principle including cost and benefit analyses are yet to be observed. The benefit aspect of the principle (risk before and after measure) is reflected in the project risk register, but there are no clear guidelines on prioritizing of proposed measures based on cost/benefit analyses. The ALARP principle may based on the mentioned be used more indirectly in the process without people being fully aware of it.

In my point of view, there seems to be a mutually common understanding of requirements and expectations between the operator and the rig contractor. This has been reflected throughout both project meetings and risk assessment meetings. However, cost/benefit is a topic which can be subject to discussion between the two parties. The impression is that involved parties want to save money, and measures are not implemented unless they *have to*. The financial aspect has the potential to cause discussions and is according to Proactima often a limiting factor for a good risk management process.

5.4 Common understanding of the purpose of chosen treatments

a. clear communication between decision makers and parties performing operations regarding purpose of treatment

Based on my participation in risk related meetings, there is a common understanding of the purpose of chosen treatments. Detailed explanations have been given regarding the treatments if someone has been doubtful regarding the treatment/measure. Statements from Equinor and the rig contractor in interviews reinforce this conclusion.

Except from what is mentioned in risk analysis tools and what is mentioned in the Detailed Operational Procedure (DOP) and accompanying DOP-meetings there seems to be limited communication in the planning phase between the decision makers and people performing the operations regarding the purpose of chosen treatment. However, in DOP-meetings, both risks and all operational measures are described, but in another format than in the risk register.

8.7 COMMUNICATION AND CONSULTATION

		#	CRITERIA
PARALLEL PROCESSES	Communication and consultation	6.1	**Common understanding of stakeholder, descision maker and contributor roles** **a.** two-way communication operator/contractor **b.** clarified expectations between parties on who communicates what and when
		6.2	**Ensure stakeholder interests are covered** **a.** involvement of stakeholders when applicable
		6.3	**Involve sufficient competence** **a.** utilization and involvement of relevant competency outside the project (e.g. earlier projects, HPHT-competency) **b.** consultation of relevant expertise when applicable
		6.4	**Inform decision makers** **a.** efficient communication channels across companies and management levels
		6.5	**Make sure contractor understands risks and decisions** **a.** informal updates on risk and risk treatment throughout project
		6.6	**Access to documentation and reporting - (contractor always updated on progress/agenda)** **a.** web-based collaborative document platform

Figure 17: Evaluation criteria for the sixth activity - Communication and consultation.

6.1 Common understanding of stakeholder, decision maker and contributor roles

a. two-way communication operator/contractor

b. clarified expectations between parties on who communicates what and when

Clearly, there is a common understanding of stakeholder, decision maker and contributor roles. Meetings have showed that the rig contractor contributes in relation to operational risks and matters regarding the rig and the performance offshore. This argument is supported by interview answers, where all involved actors stated that there is a common understanding of the roles and responsibilities.

The interviews show that the communication works well. My impression from meeting attendance is that the communication depends on who is involved in the project and communication lines. Equinor as the party controlling the whole planning phase always communicates towards the rig contractor, but it varies the other way.

6.2 Ensure stakeholder interests are covered

a. involvement of stakeholders when applicable

Input from the rig contractor is taken seriously. Meetings have shown that meeting participants pay attention to the rig contractor recommendations and interests. The rig contractor representative(s) in risk related meetings often have many years of operational experience and knows the rig well, and input from them is therefore considered valuable.

Stakeholders such as the rig contractor and service contractors are involved and invited to meetings by the operator when applicable. Their participation does however depend on the stakeholder's availability and prioritizing of time. My impression is that management on both sides are involved in important milestone decision meetings such as the final risk register meeting in the transition between the Concept selection and Detailed planning phase.

6.3 Involve sufficient competence

- **a. utilization and involvement of relevant competency outside the project (e.g. earlier projects, HPHT-competency)**
- **b. consultation of relevant expertise when applicable**

This criterion is related to the criteria 1.2, 2.1, 3.1 and 5.2, and is an area with room for improvement. This is explained by input from the risk management consultant from Proactima emphasizing this as a recurring issue in such projects. Based on own experiences, this seem to vary somewhat between projects, meetings and persons.

However, involvement of competency outside the project has been done, especially in the Detailed planning phase. In the risk assessment meetings in the Detailed planning phase, there were several drilling supervisors involved in order to investigate and evaluate the risks from other perspectives. Professional expertise such as well integrity competency have also been involved throughout the project.

6.4 Inform decision makers

- **a. efficient communication channels across companies and management levels**

For this criterion my knowledge strength is weak. The interviews gave me no experiences regarding this topic, but my own impression is that decision makers in Equinor are informed when important and new information arise. Based on own meetings participation (e.g. risk assessment meeting for the top hole sections), management personnel from Equinor were part of some meetings.

The communication channels across companies and management levels are considered to be efficient enough to communicate when applicable. Microsoft Teams and Skype for Business have been used throughout my participation period.

6.5 Make sure contractor understands risks and decisions

- **a. informal updates on risk and risk treatment throughout project**

In most cases, the contractor understands the risks and the associated decisions. The rig contractor has a broad understanding of the drilling-related risks, often better than the operator in terms of operational experience.

Updates on risk and risk treatment are usually given throughout the project, but it has been observed that this is done internally in Equinor up to several times without any informal update to the rig contractor.

6.6 Access to documentation and reporting – (contractor always updated on progress/agenda)

- **a. web-based collaborative document platform**

The fact that with the rig contractor only the Onshore Planner, who was co-located with the Equinor project organization, has access to Wellcom, the collaborative web-based platform with project specific information gives this criterion a low score. To be dependent on being sent documents upon request is not as efficient as it could have been.

However, there are platforms being used and constructed for collaboration between personnel across companies, but broader access should be considered.

8.8 MONITORING AND REVIEW

		#	CRITERIA
PARALLEL PROCESSES	Monitoring and review	7.1	**Well RM process in line with external requirements, RM100 - Manage risk in Equinor and DW100** **a.** Equinor follow-up of contractor process and vice versa
		7.2	**Common understanding of stakeholder, descision maker and contributor roles** **a.** common understanding ensured on management level between parties
		7.3	**Access to documentation and reporting - (contractor always updated on progress/agenda)**
		7.4	**Those responsible for RM follow up deliveries from contributors throughout process** **a.** make sure contractor knows and understands risks, decisions and required actions **b.** progress on deliveries (actions) systematically followed up across parties **c.** correspondance between operator/contractor risks ensured
		7.5	**Updating and revision of the risk picture according to ISO 31000 and objectives in the internal project phases**

Figure 18: Evaluation criteria for the seventh activity - Monitoring and review.

7.1 Well RM process in line with external requirements, RM100 – Manage risk in Equinor and DW100

a. Equinor follow-up of contractor process and vice versa

As mentioned already, the impression is that regulatory, external requirements are fulfilled. The internal Equinor processes such as RM100, DW100 and the risk management process in the well construction phase described in Chapter 5, however, are not always being followed. Both the Drilling Engineer and the Drilling Superintendent stated that the way the internal processes are interpreted varies from project to project and person to person – hence, the way the processes are applied is not standardized.

In the planning phase, the rig contractor follows the operator's planning- and risk management process completely – the rig contractor does not seem to run its own process. Whether authorities higher in the rig contractor system follows up the risk management process is more unclear.

7.2 Common understanding of stakeholder, decision maker and contributor roles

a. common understanding ensured on management level between parties

Clearly, there is a common understanding of stakeholder, decision maker and contributor roles. Based on meetings participation where management have been involved, my impression is that there is a common understanding on management level between parties as well. However, my knowledge strength is weaker on this criterion – medium knowledge strength is assigned to this criterion.

7.3 Access to documentation and reporting – (contractor always updated on progress/agenda)

As emphasized in 6.6, there is room for improvement regarding the availability of documentation and reporting. Documentation and reporting should be more easily accessible for the rig contractor. This is a criterion with room for improvement even though risk information and descriptions of measures are communicated throughout the DOPs. However, DOPs do not provide full overview of the risk picture and are included relatively late in the process close to operations.

7.4 Those responsible for risk management follow up deliveries from contributors throughout process

a. make sure contractor knows and understands risks, decisions and required actions

b. progress on deliveries (actions) systematically followed up across companies

c. correspondence between operator/contractor risk ensured

My basis for evaluation regarding the main criterion is relatively weak even though my impression is that Equinor follows up both the rig contractor and other service companies when it comes to risks and their

accompanied measures. This has been done throughout meetings where Equinor project members ask contractors about progress on their deliveries.

All five interviews from Chapter 7 in addition to my own experiences conclude that the rig contractor knows and understands risks, decisions and their required actions. Refer to criterion 6.5.

Weekly project meetings participated in went through the progress on deliveries (actions) systematically throughout the whole Concept selection and Detailed planning phase. However, the rig contractor did not always participate in these meetings, and all rig contractor personnel did not have access to the web-based platform informing about the progression of the actions. In that way, my impression is that progress on deliveries were not always followed up across companies.

The Quantitative Risk Analysis (QRA) for the rig performed by the rig contractor is reviewed by the operator in the beginning of the planning phase. In that way, the operator quality checks the risks mentioned in the document. Further on in the process, the rig contractor follows Equinor's risk management process completely. In that way, the process caters for correspondence between their risks to a certain extent.

7.5 Updating and revision of the risk picture according to ISO 31000 and objectives in the internal project phases

Participation in both the Concept selection and Detailed planning phase made clear that the risk picture is updated and revised throughout the project. The level of details increased the closer the operation was, a requirement that is also explicitly mentioned in the internal guidelines in Chapter 5. Involved project personnel interviewed supported this conclusion.

8.9 SCORING OF EVALUATION CRITERIA

A presentation of the scored criteria analyzed in the previous sub-chapters is presented below.

Note: Main criteria (in **bold**) and sub criteria (a., b., etc.) with same criterion number have been scored differently for some criteria numbers, e.g. criterion 7.2 and 7.2a. It is emphasized that the main criterion not necessarily covers the sub criterion even though they are connected – the sub criteria (a., b., etc.) are added in order to address aspects more relevant for collaboration.

		#	CRITERIA	SCORE
CONTEXT	Establishing the context	1.1	**Common understanding of the basis - scope, goals, roles and responsibilities**	5
		1.2	**Utilize available competence**	3
			a. involvement of relevant expertise/competence in start-up meetings	3
		1.3	**Everyone has access to all necessary information in order to understand and contribute to the context**	2
			a. shared platform containing essential information	3
		1.4	**Awareness of well/area specific conditions**	3
			a. Equinor (geologists, drilling engineers etc.) share important area/well information	3
			b. contractor(s) contributes with relevant experiences and knowledge of rig aspects/capabilities	3

		#	CRITERIA	SCORE
RISK ASSESSMENT	Risk identification	2.1	**Utilization and involvement of relevant expertise and competency in identification of risks** **a.** utilization and involvement of relevant contractor competencies in risk identification	**3** 3
		2.2	**Methodology for identification of new risks - both a systematic and creative process** **a.** preparations before meetings and discussions **b.** both operator/contractor contribute with experiences and identified risk aspects	**2** 3 3
		2.3	**Documentation - availability/sharing of identified risks** **a.** risks idetified in risk meetings are documented **b.** shared platform containing essential information	**2** 4 3

		#	CRITERIA	SCORE
RISK ASSESSMENT	Risk analysis	3.1	**Utilization of relevant expertise and competency - analysis is an interdisciplinary task** **a.** utilization and involvement of relevant contractor competencies in risk analysis meetings	**3** 3
		3.2	**Methodology used to break down, understand and describe the risk (meetings agenda etc.)** **a.** clear responsibilities in meetings (facilitator, expert panel, secretary). Expectations to contractor representative communicated and clarified	**3** 4
		3.3	**Quantification/agreement on likelihoods and impacts of risk contributions**	**3**
		3.4	**Risk analysis tools known and common for all parts** **a.** relevant parties must be familiar with tools before risk analysis meeting	**3** 3
		3.5	**Necessary assessments of uncertainty, including description of strength of knowledge** **a.** uncertainty reflected in risk analysis tools	**2** 2
		3.6	**Barrier managament - establishment and continuously use of barrier functions and elements in all project phases** **a.** common understanding of the purpose of barrier elements	**5** 4

		#	CRITERIA	SCORE
RISK ASSESSMENT	Risk evaluation	4.1	**Sufficient risk analysis and understanding of the risk established**	**4**
		4.2	**Involvement of adequate competence/authority** **a.** involvement of relevant competency/authority with contractor as applicable	**3** 3

		#	CRITERIA	SCORE
TREATMENT	Risk treatment	5.1	**Identify measures based on risk assessment**	**4**
		5.2	**Utilization of relevant expertise and competency (identification, evaluation of effect, applicability, costs)** **a.** utilization and involvement of relevant expertise including contractor	**3** 3
		5.3	**Decisions on measures made in accordance with internal, legal, regulatory and other requirements, including ALARP principle** **a.** mutually ensure common understanding of requirements, expectations and cost and benefit between operator and contractor	**2** 3
		5.4	**Common understanding of the purpose of chosen treatments** **a.** clear communication between decision makers and parties performing operations regarding purpose of treatment	**4** 3

		#	CRITERIA	SCORE
PARALLEL PROCESSES	Communication and consultation	6.1	**Common understanding of stakeholder, descision maker and contributor roles** **a.** two-way communication operator/contractor **b.** clarified expectations between parties on who communicates what and when	**5** 3 4
		6.2	**Ensure stakeholder interests are covered** **a.** involvement of stakeholders when applicable	**4** 3
		6.3	**Involve sufficient competence** **a.** utilization and involvement of relevant competency outside the project (e.g. earlier projects, HPHT-competency) **b.** consultation of relevant expertise when applicable	**3** 3 3
		6.4	**Inform decision makers** **a.** efficient communication channels across companies and management levels	**3** 3
		6.5	**Make sure contractor understands risks and decisions** **a.** informal updates on risk and risk treatment throughout project	**3** 3
		6.6	**Access to documentation and reporting - (contractor always updated on progress/agenda)** **a.** web-based collaborative document platform	**2** 3

		#	CRITERIA	SCORE
PARALLEL PROCESSES	Monitoring and review	7.1	**Well RM process in line with external requirements, RM100 - Manage risk in Equinor and DW100** **a.** Equinor follow-up of contractor process and vice versa	**3** 3
		7.2	**Common understanding of stakeholder, descision maker and contributor roles** **a.** common understanding ensured on management level between parties	**5** 4
		7.3	**Access to documentation and reporting - (contractor always updated on progress/agenda)**	**2**
		7.4	**Those responsible for RM follow up deliveries from contributors throughout process** **a.** make sure contractor knows and understands risks, decisions and required actions **b.** progress on deliveries (actions) systematically followed up across parties **c.** correspondance between operator/contractor risks ensured	**3** 3 2 3
		7.5	**Updating and revision of the risk picture according to ISO 31000 and objectives in the internal project phases**	**4**

9 CONCLUSIONS

The aim of the present research has been to examine the collaboration in risk management processes between the operating company and the drilling contractor in the planning phase of exploration well projects.

In this work, evaluation criteria for good collaboration are established, using the ISO 31000 risk management process as a starting point. Conclusions have been drawn from criteria with medium and strong knowledge basis. Criteria with weak strength of knowledge may have been equally important for a good process, but not concluded upon as the evaluation basis have been limiting and possibly inadequate.

Conclusions are drawn within two topics. The first topic covers aspects of the collaboration process, whereas the second topic relate to the risk management process itself.

Collaboration process:

The PSA regulations including guidelines and referred standards, such as ISO 31000, state that good collaboration including necessary communication must be safeguarded during planning, installation and operation – but not how this should be done. This work has therefore constructed criteria considered necessary for a good collaboration process.

The investigation has shown that the collaboration process between the operator and rig contractor in general fulfills the expectations to a good process, i.e. aligned with the definition of risk governance as defined by the International Risk Governance Council in Chapter 2.3 – but with some challenges:

- Gaps and improvement potential related to consistent involvement and utilization of relevant and correct competency (refers to the evaluation model criteria 1.2, 2,1, 3.1, 4.2, 5.2 and 6.3)
- Rig contractor's limited access to web-based document sharing platforms such as Wellcom Risk (refers to the evaluation model criteria 1.3, 2.3, 6.6 and 7.3)

Findings through my participation in project meetings revealed that involvement and participation of the rig contractor seems to vary somewhat between projects, meetings and persons.

Utilization of the competence in place throughout meetings is largely dependent on the person facilitating the relevant risk meetings. It is the job of the risk facilitator to invite suitable personnel and optimize and extract necessary information and input throughout discussions in risk related meetings.

The current access to digital project documentation from the contractor side seems to be a limiting factor for an optimized collaboration process. Documentation is only accessible for a very limited number of contractor representatives. Being forced to request Equinor for well specific information by e-mail has by the rig contractor been emphasized as a cumbersome form of information sharing.

The research has also shown that important elements regarding collaboration are fully aligned with requirements and expectations:

- Common understanding of scope, goals, risks, decision maker and contributor roles (refers to the evaluation model criteria 1.1, 5.4, 6.1, 6.5 and 7.2)

The investigation has indicated that there in general is a common understanding of the risks identified – no signs of different risk perspectives have been identified. In addition, there is a clear division of the roles and responsibilities between Equinor and the rig contractor. Equinor's main responsibility is visible throughout the well construction in planning phases whereas the rig contractor contributes in the form of practicality and handling of these risks in execution.

Risk management process:

The study has shown that the risk management process during planning of exploration wells in Equinor largely, with some exceptions, is in line with main requirements and expectations such as the PSA regulations, ISO 31000, the relevant NORSOK standards (D-010 and Z-013) and internal processes. The investigation has shown that Equinor is doing good on requirements regarding:

- Establishment and continuous follow-up on barriers and barrier elements (refers to the evaluation model criterion 3.6)
- Resources used and degree of focus in risk management activities iterating the process from risk identification to optimization and follow-up of measures through the project phases (refers to the evaluation model criteria 4.1 and 7.5)

Establishment and continuous follow-up of the barrier system, not only in traditional D&W technical planning, but also as an integrated part of risk management activities seems to be a well-implemented activity. Barrier solutions developed through well design and operational planning have been experienced as an important topic in risk analyses and management.

In line with ISO 31000 and Equinor's internal risk management guidelines, sufficient time was spent on risk analyses (often split into several meetings) and updating of the risk picture seems to be an established practice and integrated part of the work process.

In contrast, one of the more significant findings to emerge from this study is that two of the main elements in the requirements described are not being complied with as intended:

- Uncertainty treatment (refers to the evaluation model criterion 3.5)
- The ALARP principle (refers to the evaluation model criterion 5.3)

One possible explanation to this is that the two concepts in minor degree are facilitated for and emphasized in Equinor internal processes and analysis tools while another is minor focus on the concepts in the risk management activities.

Practical use of the ALARP principle is in my opinion not made sufficiently clear, neither in the risk management process described in Chapter 5 or in other internal governing documents in Equinor, at a higher level.

Concrete expectations including a concrete methodology on a detailed level relevant for drilling projects could increase focus on the principle. These risk assessments in D&W result in a higher number of risk contributions, each usually with one or more related risk measures, often summing up to more than a hundred measures. Performing complete assessments including cost/benefit analyses of all proposed risk reducing measures is an extremely comprehensive

process, probably not affordable and realistic to fully perform in practice. However, this should not prevent the ALARP principle from being used in a less formal way in decision regarding which measures to implement. I believe project personnel and management need more concrete input on how to proceed to me compliant. Maybe the PSA could also have a role in providing such guidance, as this is expected to be a challenge also outside Equinor.

A second possible explanation is lack of professional and theoretical knowledge and understanding of the elements. The latter explanation is strongly supported by both the comprehensive and less comprehensive answers from the interviews regarding the ALARP. This possible explanation does not fulfill basic expectations described in the introductory theoretical Chapter 2 regarding understanding of and communication of such elements. However, this conclusion is drawn with the proviso that interview answers could have looked different by interviewing risk specialists compared to D&W project personnel.

The explanation related to lack of professional and theoretical knowledge and understanding of the elements can also be related to the gaps observed on uncertainty treatment. The provided risk analysis tools include fields for description of uncertainty and knowledge strength, but these are rarely used. This seems to be related to lack of knowledge related to the concepts.

The research has also shown that there are weaknesses related to the methodology used in risk assessments:

- Methodology used in risk identification (refers to the evaluation model criteria 1.4 and 2.2)

The methodology used in risk identification has proven to be largely influenced by previous projects and so-called reference wells – a methodology which has the potential to overlook important well- and area specific risks. It is not necessarily wrong to use previous work, but risk identification processes should in my opinion to a greater extent focusing on well- and area specific new risks. Both meeting preparation, execution of meetings and quality control of the analyses are essential for the results of risk identification and may be improved. The practice seems to vary with the personnel facilitating the risk identification meetings. The DW100 describes the best practice in detail, and this is not always adhered to.

10 SUGGESTIONS TO FURTHER WORK

The findings provide the following insights for future improvement areas for collaboration in risk management processes during planning of exploration wells:

1. **Increase focus on involvement and utilization of the right competency in risk related meetings and discussions**
   Even though there are internal guidelines today provide advice on who should attend different risk assessment meetings, it is recommended that this is a focus area in future risk work. The investigation has shown that the Equinor project organization is conscious of involvement and participation, but not consistent enough in the long run from one risk assessment meeting to another. The rig contractor (and other contractors) can also be more conscious and critical about what personnel they are sending-to-the-different-meetings-and-discussions.

   In order to utilize competency available, risk related meetings rely on having a risk facilitator motivating the expertise available to contribute with experiences on topics discussed. Therefore, personnel having the responsibility of being risk facilitators must be aware of learnings from the risk facilitator course (which is a requirement for those acting as risk facilitators). In addition, a focus area should be to provoke the involvement of the competency present in relevant risk meetings.

2. **Enable for easier access to risk related project information on web-based document sharing platforms**
   The rig contractor in the followed project stated that they need easier access to project specific information throughout web-based document sharing platforms such as Wellcom Risk. A suggestion is to consider broader access and improve the exchange of project specific information between Equinor and the contractor(s).

Greater compliance with certain requirements and expectations is also suggested. A greater focus on the following risk management elements will fulfill the PSA's requirements and possibly improve the risk management process during planning of exploration wells:

3. **Highlight and implement the uncertainty aspect in line with the PSA guidelines**
   Even though there is a separate tab in the risk analysis log sheet considering uncertainty, it is not always used. An improvement potential is to highlight and clarify and prioritize for doing assessments on uncertainty. The uncertainty aspect of risk must be more visible, both in risk meeting's agenda but also in the analysis tools. A possible solution is to include an own color code in the risk matrix reflecting the degree of uncertainty affecting the risks. Another suggestion regarding assessment of uncertainty is to include a description of what is uncertain, the strength of knowledge regarding the topic, and what this knowledge is based upon.

4. **Actively apply the ALARP principle in work with risk reducing measures**
   Project organizations within drilling projects in Equinor should continue reducing the level of risk to as low as reasonably practicable even though set risk acceptance criteria are met. According to the definition of the principle, reducing measures should be implemented if the costs are not grossly disproportionate to the benefits gained by implementing the measure.

In order to assure this, assessments of all risk reducing measures should ideally be carried out for every risk included in the risk register and activity program. Such assessments should include documentation of all risk reduction proposals (both accepted and rejected) and being able to prove why a proposal not is implemented. In order to achieve this, the ALARP principle must in higher degree be highlighted, clarified and prioritized in the internal processes as a focus area.

However, this is as mentioned a comprehensive process. Clarified expectations regarding methodology on a detailed level tailored for application of the ALARP principle in D&W projects provided by the PSA can potentially improve the focus on this concept as a key element in the risk management processes.

5. **Being less dependent on reference wells in risk identification**
   A greater focus on being less dependent on previous projects and reference wells could possibly produce important findings that account more for area- and well specific risks and elements. As emphasized, this is not necessarily wrong, but a suggestion is to be conscious and aware of how gaps between reference wells risks and current well project risks can be identified. It is referred to compliance with internal processes in Equinor and course material for fulfillment of this suggestion.

11 REFERENCES

Anonymuous rig contractor. (2020). *INTERNAL: Directive - Risk Assessment*. Anonymuous rig contractor.

ARIS. (2019). *INTERNAL: FR08 Functional Requirements Risk Management*. Equinor.

ARIS. (2020a). *INTERNAL: DW100 - Construction of Exploration Wells*. Equinor.

ARIS. (2020b). *INTERNAL: RM100 - Manage Risk*. Equinor.

Aven, T., & Renn, O. (2010). *Risk Management and Governance: Concepts, Guidelines and Applications* (Vol. 16). Berlin: Springer-Verlag Berlin Heidelberg.

Aven, T., & Vinnem, J.-E. (2007). *Risk Management: With Applications from the Offshore Petroleum Industry*: Springer-Verlag London.

Equinor. (2018). *INTERNAL: Contract between Equinor Energy AS and Rig Contractor Marine Drilling Services NCS Mobile Drilling Unit X*. Equinor.

Equinor. (2020a). *INTERNAL: One Team Commitment Mobile Drilling Unit X*. Equinor.

Equinor. (2020b). *INTERNAL: Teamsite for the exploration well project*. Equinor.

International Organization for Standardization. (2009). ISO 31000: Risk management - Principles and guidelines. In: ISO.

National Research Council. (1989). *Improving risk communication*: National Academies.

Nilsen, T., Sørli, F., Røed, J. B., Strømsnes, K. B., & Stavseng, L. (2013). *INTERNAL: Facilitation of risk analysis in DW work processes*. Equinor.

Norges Rederiforbund, & Norsk Olje & Gass. (2015). *Handbook for Acknowledgement of Compliance (AoC)*.

Petroleum Safety Authority Norway. (2016). *Risikobegrepet i petroleumsvirksomheten*.

Petroleum Safety Authority Norway. (2017). *Principles for barrier management in petroleum industry: Barrier Memorandum 2017*.

Petroleum Safety Authority Norway. (2018). *Integrated and unified risk management in the petroleum industry*.

Petroleum Safety Authority Norway. (2019). All regulations. Retrieved from https://www.ptil.no/en/regulations/all-acts/

Standard Norge. (2010). NORSOK Z-013: Risk and emergency preparedness assessment. In (3 ed.): NORSOK Standard.

Standard Norge. (2013). NORSOK D-010: Well integrity in drilling and well operations. In: (4 ed.): NORSOK Standard.

Standard Norge. (2019). NORSOK standards. Retrieved from https://www.standard.no/en/sectors/energi-og-klima/petroleum/norsok-standards/#.XmjJkm5FwZ4

Veland, H., & Aven, T. (2012). Risk communication in the light of different risk perspectives. *Reliability Engineering and System Safety*.

Wellcom. (2020). *INTERNAL: Wellcom Risk - the exploration well project*. Equinor.

APPENDIX A – PARTICIPATION IN AN EQUINOR EXPLORATION WELL PROJECT

In order to investigate the collaboration in risk management processes in planning of new exploration wells (Concept selection phase and Detailed planning), this work follows an exploration well (kept anonymous) and use this as input for the evaluation in Chapter 8. The exploration well is planned to start operations (spud) the 15th of May 2020 and is located in the North Sea (Equinor, 2020b).

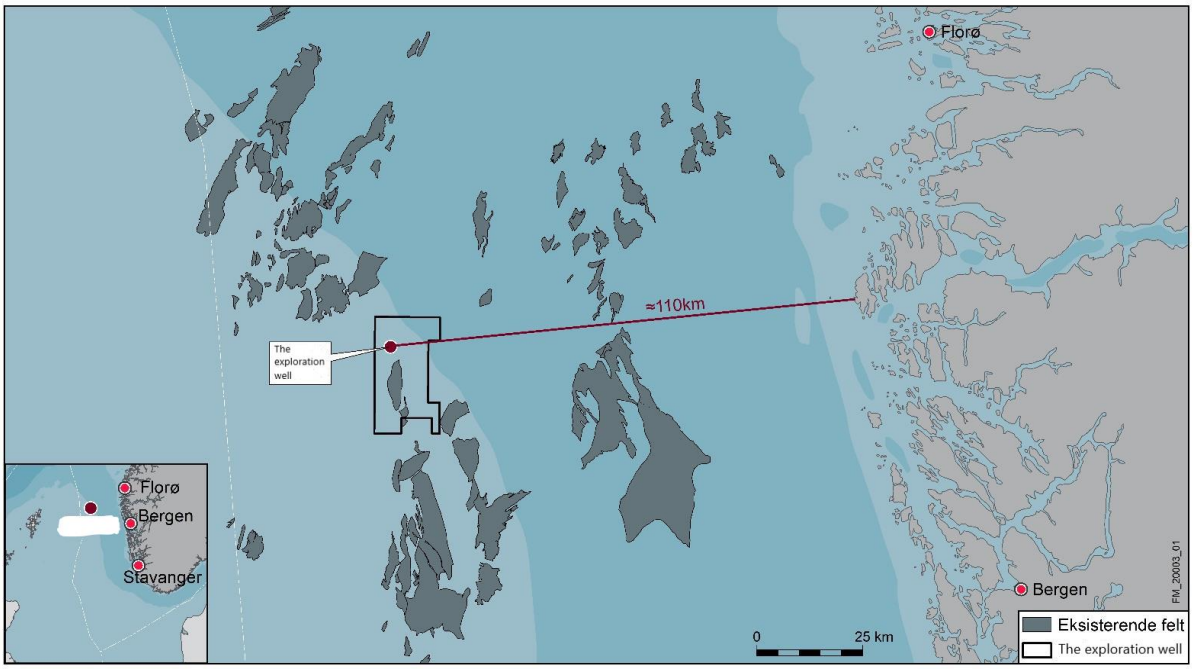

Figure 19: Location of the exploration well in the North Sea (Equinor, 2020b)

The exploration well is a high pressure and high temperature (HPHT) well, a term pertaining wells where the pressure and temperature are above normal. Therefore, the operation of drilling it is characterized as a critical activity/operation. A critical activity is an activity that potentially can cause serious injury or death to people, or significant pollution of the environment or substantial financial losses. Some further information about the well is provided in the table.

Well	[redacted]
Licence	[redacted]
Block(s)	[redacted]
Area	Northern North Sea
Partnership	Equinor Energy AS – 70% [redacted]
Well classification	Wildcat
Well category	Near HPHT Well head shut in pressure = 660 bar Temperature @ TD = 165°C
Water depth	142,1 m
Fluid type	Gas/condensate
Basin	[redacted]
Reservoir	[redacted]

Table 5: Information about the exploration well project (Equinor, 2020b)

Activities involved in

Following the project includes observations, involvement, discussions and participation in the listed risk related meetings:

- Weekly project meetings
- Risk assessment meetings
- Risk register meetings
- Main risks for activity program meetings

Date	Project phase	Meeting
3rd of March 2020	Concept selection	Risk assessment P&A section
10th of March 2020	Concept selection	Weekly project meeting
10th of March 2020	Concept selection	Risk assessment 8 ½ "section
24th of March 2020	Concept selection	Weekly project meeting
1st of April 2020	Concept selection	Main risks for activity program
7th of April 2020	Concept selection	Weekly project meeting
8th of April 2020	Concept selection	Risk register meeting
16th of April 2020	Detailed planning	Risk assessment 42", 26" and 17 ½ " section
21st of April 2020	Detailed planning	Weekly project meeting
23rd of April 2020	Detailed planning	Risk assessment 12 ¼ ", 8 ½ " and P&A section

28th of April 2020	Detailed planning	Weekly project meeting
12th of May 2020	Detailed planning	Weekly project meeting

In the following, a short description of the purposes of the different meetings involved in are provided.

Weekly project meeting: The purpose of the weekly project meeting is to provide a weekly status to the project members on the progression of the project – update project plans, actions, milestones etc.

Risk assessment, Concept selection: The aim of the risk assessment in this phase is to identify all major risk factors requiring special attention and/or compensating measures.

Main risks for activity program, Concept selection: The purpose of this meeting is to agree on main risks to be included in the activity program.

Risk register meeting, Concept selection: The purpose of this meeting is to go through risks relevant for the project risk register prior to move the project from the Concept selection phase and onto the Detailed planning phase.

Risk assessment, Detailed planning: The risk assessment in this phase shall be carried out to analyze risks related to the draft Activity program and operational plans.

APPENDIX B – DETAILS FROM THE PSA REGULATIONS

Appendix A presents excerpts from the PSA's four regulations relevant for this work (Petroleum Safety Authority Norway, 2019):

- The framework regulation
- The management regulation
- The facilities regulation
- The activities regulation

The framework regulation

Last amended: 2019-04-26

The framework regulations are regulations relating to health, safety and the environment in the petroleum activities and at certain onshore activities (Petroleum Safety Authority Norway, 2019).

Chapter I – Introductory provisions (§§ 1-8)
The purpose of the regulations is to

1. Promote high standards for health, safety and the environment in activities covered by these regulations,
2. Achieve systematic implementation of measures to comply with requirements and achieve the goals laid down in the working environment and safety legislation,
3. Further develop and improve the health, safety and environmental level.

The regulations state that the operator and others participating in the activities are responsible pursuant to these regulations. The operator shall ensure compliance with requirements stipulated in the health, safety and environment legislation.

Chapter II – Basic requirements for health, safety and the environment (§§ 9-16)
The activities shall be prudent, based on assessment of all factors of relevance for planning and implementation of the activities as regards health, safety and the environment. Moreover, the regulations state that the risk shall be further reduced to the extent possible.

In risk reduction, the operator must choose the operational, technical or organizational solutions that, according to an individual and overall evaluation of the potential harm and present and future use, offer the best results, provided the costs are not significantly disproportionate to the risk reduction achieved. i.e. ALARP principle.

This chapter also states that risk assessments shall be carried out during all phases of the petroleum activities.

Chapter III – Management of the petroleum activities (§§ 17-19)
A management system shall be designed by the operator to ensure compliance with requirements in the health, safety and environment legislation. The system should be both established, followed up and further developed by the operator.

The management regulation

Last amended: 2019-04-26

The management regulations are relating to management and the duty to provide information in the petroleum activities (Petroleum Safety Authority Norway, 2019).

Chapter II – Risk management (§§ 4-6)

In reducing risk as mentioned in the framework regulations, the operator shall select technical, operational and organizational solutions that reduce the likelihood that harm, errors and hazard and accident situations occur. Barriers, which are described in more detail in the last chapter, should also be established. The barriers and solutions that have the greatest risk-reducing effect shall be chosen based on an individual as well as an overall evaluation.

When it comes to the management of health, safety and the environment, the operator shall ensure that the system comprises the activities, resources, processes and organization necessary to ensure prudent activities and continuous improvement.

Chapter III – Objectives, internal requirements and the basis for making decisions (§§ 7-11)

The operator shall stipulate and further develop objectives and strategies to improve health, safety and the environment. The objectives should be both short-term and long-term in various areas, at various levels and between various participants in the activities. It is also important to mention that the operator shall ensure agreement between its own requirements and between its own and other participants' requirements.

There should be an agreement between the operator and the party responsible for operating a mobile facility when it comes to acceptance criteria for major accident risk and for environmental risk associated with acute pollution. An acceptance criterion should be set for

1. The personnel on the facility, and for personnel groups exposed to particular risk,
2. Loss of main safety functions for offshore petroleum activities,
3. Acute pollution from the facility,
4. Damage to third party.

Chapter V – Analyses (§§ 16-18)

The operator shall ensure that analyses are carried out that provide the necessary basis for making decisions to safeguard health, safety and the environment. During the activity, the operator is responsible for carrying out new analyses and/or updating existing analyses as regards changes in conditions, assumptions, knowledge and definitions that, individually or collectively, influence the risk. These risk analyses, as well as something called emergency preparedness analyses should form the basis for making decisions. Necessary assessments shall be carried out of sensitivity and uncertainty. Throughout the activity, there should also be a comprehensive overview of the analyses that have been carried out and are underway.

Chapter VI – Follow-up and improvement (§§ 19-23)

The operator shall ensure that hazard and accident situations that have occurred and that may lead to or have led to acute pollution or other harm, are recorded and examined in order to prevent recurrence. Frequent situations or situations that have great actual or potential consequences, should be investigated.

The operator's own and other participants' management systems should be followed up by the operator to ensure that all elements have been established and function as intended, and that a prudent level exists for health, safety and the environment.

The facilities regulation

Last amended: 2019-12-18

The facilities regulations are relating to design and outfitting of facilities, etc. in the petroleum activities (Petroleum Safety Authority Norway, 2019). The regulations address requirements all the way from equipment, design of work and common areas, physical barriers, electrical installations, drilling and well systems, production plants, maritime facilities and diving facilities.

Chapter VIII – Drilling and well systems (§§ 48-54)

- Well barriers shall be designed such that well integrity is ensured, and the barrier functions are safeguarded during the well's lifetime.
- Well equipment control shall be designed and capable of activation such that it ensures both barrier integrity and well control.
- Floating facilities shall be equipped with a disconnection system that secures the well and disengages the riser before a critical angle occurs.
- The drilling fluid system shall be designed such that it mixes, stores, circulates and cleans a sufficient volume of drilling fluid with necessary properties safeguard the drilling fluid's drilling and barrier functions.
- The cementing unit shall be designed such that it mixes, stores and delivers the correct volume of cement with necessary properties to ensure proper anchoring and barrier integrity.
- Equipment in the well and on the surface shall be designed to safeguard controlled flow during production, injection and well testing.
- Christmas trees and wellheads shall be designed such that prudent well control can be performed through recovery, workover and well intervention.

The activities regulation

Last amended: 2019-12-18

The activities regulations are relating to conducting petroleum activities (Petroleum Safety Authority Norway, 2019).

Chapter VII – Planning and execution (§§ 29-32)

When scheduling activities on the individual facility, the responsible party shall ensure that important risk contributors are kept under control, both individually and overall. Moreover, the operator should ensure that matters of significance for prudent execution of the activities as regards health and safety, are always monitored and kept under control.

Chapter X – Monitoring the external environment (§§ 52-59a)

The operator shall monitor the external environment, and the monitoring must be adapted to the existing pollution risk, be able to prove and map pollution of the external environment and indicate development trends in the environmental condition. If there are more than one

operator, they must cooperate on monitoring. In order to map the environmental status in the areas to be drilled, the operator must carry out baseline surveys

1. Before exploration drilling in new and previously unserveyed exploration areas,
2. Before exploration drilling in areas where are proven vulnerable environmental values (species and habitats), or where their existence is likely,
3. Before production drilling.

Chapter XIII – Emergency preparedness (§§ 73-79)
The responsible party for operating a facility must have a strategy for emergency preparedness against hazard and accident situations. The emergency preparedness should be established based on results from risk and emergency preparedness analyses and the defined hazard and accident situations and barrier performance requirements. It is important that there is good collaboration between the involved parties, and it should be ensured that necessary internal and external notification and communication is always safeguarded during installation and operation, and during hazard and accident situations.

Chapter XV – Drilling and well activities (§§ 81-89)
There are several requirements regarding drilling and well activities. First of all, there must exist a well program which describes the individual activities to be carried out and the equipment to be used. Moreover, it is required to have a plan for handling of situations with shallow gas or other formation fluids. There are also regulations covering well barriers, well control and securing of wells in the activities regulations.

APPENDIX C – THE ALARP PRINCIPLE AND TREATMENT OF UNCERTAINTY

This appendix gives a brief introduction to two of the main concepts the PSA points towards in their regulations, namely the ALARP principle and treatment of uncertainty. The Appendix is based on the memorandum *Integrated and unified risk management in the petroleum industry*, published by the PSA in 2018 (Petroleum Safety Authority Norway, 2018).

Version: Ed. 1, June 2018

ALARP PRINCIPLE

The memorandum states that the risk reduction processes do not stop even though the risk acceptance criteria are met (Petroleum Safety Authority Norway, 2018). It is highlighted that risk is to be dealt with even further and reduced as far as possible. The ALARP principle is based on British legislation and is an established process in the industry.

The framework regulation § 11 Risk reduction principles says:

"Harm or danger to people, the environment or material assets shall be prevented or limited in accordance with the health, safety and environment legislation, including internal requirements and acceptance criteria that are of significance for complying with requirements in this legislation. ***In addition, the risk shall be further reduced to the extent possible****."*

"In reducing the risk, the responsible party shall choose the technical, operational or organizational solutions that, according to an individual and overall evaluation of the potential harm and present and future use, offer the best results, ***provided the costs are not significantly disproportionate to the risk reduction achieved****."*

ALARP means *as low as reasonably practicable*, i.e. risks should be reduced, and the proposals must be implemented unless there is an unreasonable imbalance between the cost and benefit of implementing the measure. In other words, the principle entails a reverse burden of proof.

NORSOK Z-013 states that both accepted and rejected risk-reduction proposals should be documented. The standard describes a "reverse burden of proof" – in other words, *being able to demonstrate why a proposal is not implemented.*

TREATMENT OF UNCERTAINTY

Like the ALARP principle, uncertainty is also mentioned as an important element in the memorandum regarding risk management. The memorandum states that uncertainty is a key component of the risk concept and taking account of uncertainty in selection of solutions and measures therefore is a regulatory requirement.

Uncertainty takes various forms, and it is uncertain which incidents will occur, how often, how they arise and what the consequences will be if they occur. Some of the most important implications from this work's point of view are whether uncertainty in knowledge assessments and assumptions influence decision making.

The management regulation § 17 Risk analyses and emergency preparedness assessments says:

*“Necessary assessments shall be carried out of sensitivity and **uncertainty**.”*

Uncertainty must be assessed, and these assessments build on a certain level of knowledge, based to a varying degree on data, information, testing, analyses, arguments, theory, models, assumptions and so forth. The knowledge can be both weak and strong. Taking account of uncertainty also means clarifying what this knowledge comprises and how good it is. By describing the knowledge, uncertainty will also be described. The strength of knowledge says something about what impact the assessments should have.

The knowledge and perceptions must be investigated with an eye to weaknesses, possible errors and potential surprises.

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APPENDIX D – MORE DETAILS ON ISO31000 RISK MANAGEMENT PROCESS

Version: Ed. 1, 2009-11-15

ISO 31000 is a risk management framework, including guidelines, principles, framework and a process for managing risk, and can be used by any organization regardless of its size, branch, activity or sector (International Organization for Standardization, 2009).

The standard states that risk is managed by identifying it, analyzing it and then evaluating whether the risk should be modified by risk treatment in order to satisfy a specific risk criteria. Every phase, part or stage of an operation brings with it individual needs, audiences, perceptions and criteria.

According to ISO 31000, the risk management process should be

- an integral part of management,

- embedded in the culture and practices, and

- tailored to the business processes of the organization.

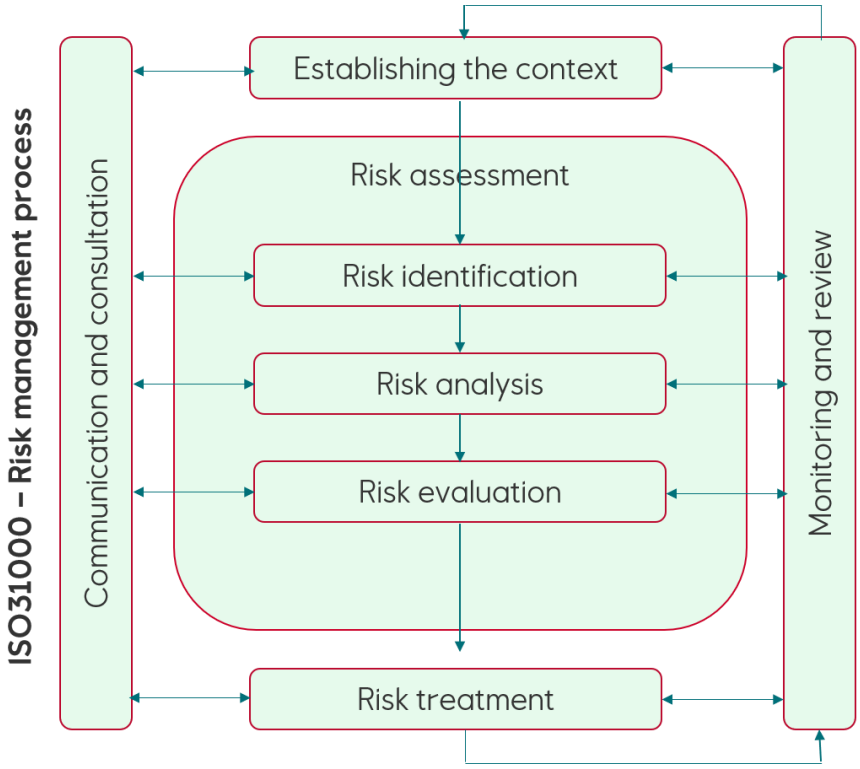

Figure 20: Illustration of the ISO 31000 risk management process (International Organization for Standardization, 2009)

In the following, a description of the different activities included in ISO 31000 are presented.

1 ESTABLISHING THE CONTEXT

In this stage of the risk management process, the organization must articulate its objectives. Moreover, the company must define the internal and external parameters and environment to

be considered when managing risk, and the scope and criteria for the remaining process must be set.

2 RISK ASSESSMENT

Risk assessment is the overall process of risk identification, risk analysis and risk evaluation.

3 RISK IDENTIFICATION

Risk identification is an important part of the process. Here, the organization must identify sources of risk, areas of impacts, events, their causes and potential consequences. Key in this phase is to generate a comprehensive list of all risks that might influence, either positively or negatively the achievement of the objectives. It is important to emphasize that risk identification should include risks whether their source is controlled by the organization – it may also be under control of other stakeholders, e.g. the contractor in our case. This yields even though the risk source or cause not is evident. People with appropriate knowledge should be involved in identifying the risks for the specific operation or activity.

4 RISK ANALYSIS

Risk analysis must develop an understanding of the risk found in risk identification. The causes and sources of the risks, their likelihood as well as their positive and negative consequences have to be considered. The analysis should provide an input to the risk evaluation and to decisions on whether risks need to treated, and if so, how.

The risk analysis can be undertaken with varying degree of detail, depending on factors such as the risk, the purpose of the analysis, and the information, resources and data available. Dependent on the circumstances, the analysis can be quantitative, semi-quantitative or qualitative, or a combination of these. The consequences and their likelihood can be determined by modelling the outcomes of an event or set of events, or by extrapolation from experimental studies or from available data.

5 RISK EVALUATION

Risk evaluation has the purpose of assisting in making decisions, based on the outcomes of risk analysis, about which risks need treatment and the priority for treatment implementation. Another important part of risk evaluation is to compare the level of risk found during the analysis process with the risk criteria established during the first stage, in “Establishing the context”. The need for treatment can be considered based on this comparison.

6 RISK TREATMENT

The last phase, called risk treatment, involves selecting one or more options for modifying risks, and implementing those options. It can be described as a cyclical process of:

- assessing a risk treatment;

- deciding whether residual risk levels are tolerable;

- if not tolerable, generating a new risk treatment; and

- assessing the effectiveness of that treatment.

7 COMMUNICATION AND CONSULTATION

Communication and consultation with stakeholders, both internal and external should take place during all the stages of a risk management process.

In that way, there should be developed plans, frameworks or procedures for communication and consultation at an early stage of a new activity or operation. These plans should include issues relating to the risk itself, its causes, its consequences (if known), and the measures being taken in order to treat it. Effective communication, both external and internal should take place to ensure that those accountable for implementing the risk management process and stakeholders understand the basis on which decisions are made, the reasons why particular actions are required, and maintain control underway in the ongoing activity.

A consultative team approach may among others:

- ensure that the interests of stakeholders are understood and considered;

- ensure that different views are appropriately considered when defining risk criteria and in evaluating risks;

- secure endorsement and support for a treatment plan;

- enhance appropriate change management during the risk management process; and

- develop an appropriate external and internal communication and consultation plan.

Communication and consultation should facilitate truthful, relevant, accurate and understandable exchanges of information, considering confidential and personal integrity aspects.

8 MONITORING AND REVIEW

The risk management process should include both monitoring and review, activities which involve regular checking or surveillance. This follow-up can be ad hoc or periodic.

Responsibilities for monitoring and review should be clearly defined, and the organization’s process should encompass all aspects of the risk management process for the purposes of:

- ensuring that controls are effective and efficient in both design and operation;

- obtaining further information to improve risk assessment;

- analyzing and learning lessons from events, changes, trends, successes and failures;

- detecting changes, including changes to risk criteria and the risk itself which can require revision of risk treatments and priorities; and

- identifying emerging risks.

The results from monitoring and reviewing should be recorded and reported as appropriate, and should also be used as an input to the review of the risk management framework.

APPENDIX E – SUMMARY OF PARTS OF THE PSA'S BARRIER MEMORANDUM

Barrier management is by the PSA defined as the coordinated activities which establish and maintain barriers such that they maintain their function at every time and is an important contributor in order to prevent major accidents (Petroleum Safety Authority Norway, 2017). The Barrier Memorandum 2017 is a recommendation that the PSA points towards, and it states that barriers are measures which early should detect errors, danger and possible incidents, and reduce the opportunity for these to be even more disastrous. The barriers should, with reference to the management regulations §5 (see Appendix B – Details from the PSA regulations), identify incoming events, prevent the development of an event sequence and reduce consequences. A traditional barrier diagram is shown in the figure. Barrier elements could be both technical, operational and organizational.

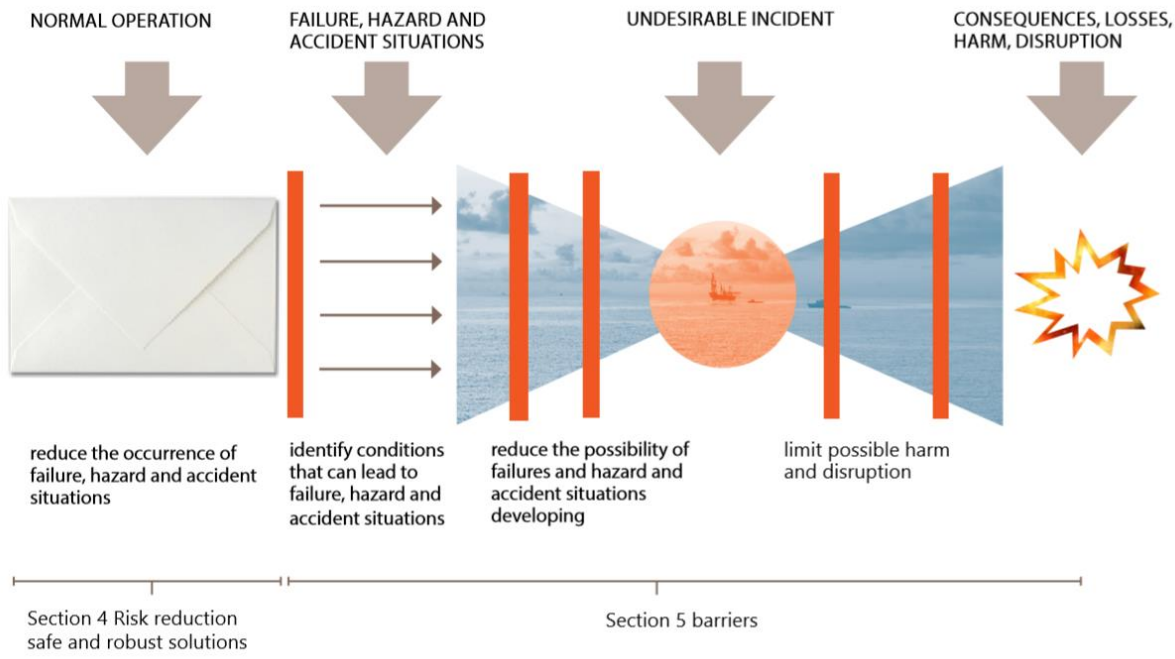

Figure 21: Traditional barrier diagram showing functions (in red) to handle failure, hazard and accident situations outside of normal operations (Petroleum Safety Authority Norway, 2017)

General principles for barrier management

Barrier management represents an integral part of the companies' risk management, which in turn forms an integrated part of their corporate governance (risk governance mentioned in Chapter 2.3) (Petroleum Safety Authority Norway, 2017). This is illustrated in the figure below.

Figure 22:: Barrier management - an integrated part of risk management (Petroleum Safety Authority Norway, 2017)

Based on regulatory requirements and ISO 31000, there are some main principles and steps for barrier management described in Barrier Memorandum 17 as seen from the figure below:

1. Barrier management should start with an understanding of the context in which the barriers are meant to function in.
2. Throughout risk assessment, identification of which failure, hazard and accident situations must be reviewed.
3. In order to protect against and combat these situations, the necessary barrier functions, elements and performance requirements must be established (Chapter II in the Management Regulations, see Appendix B – Details from the PSA regulations).

The Barrier Memorandum emphasizes that barrier management is a persistent process and that the management is continuously used in all phases of a facility's or project's life. This can also be seen from the figure below, where *Monitoring and review* + *Communication and involvement* like ISO 31000 yield throughout the whole process.

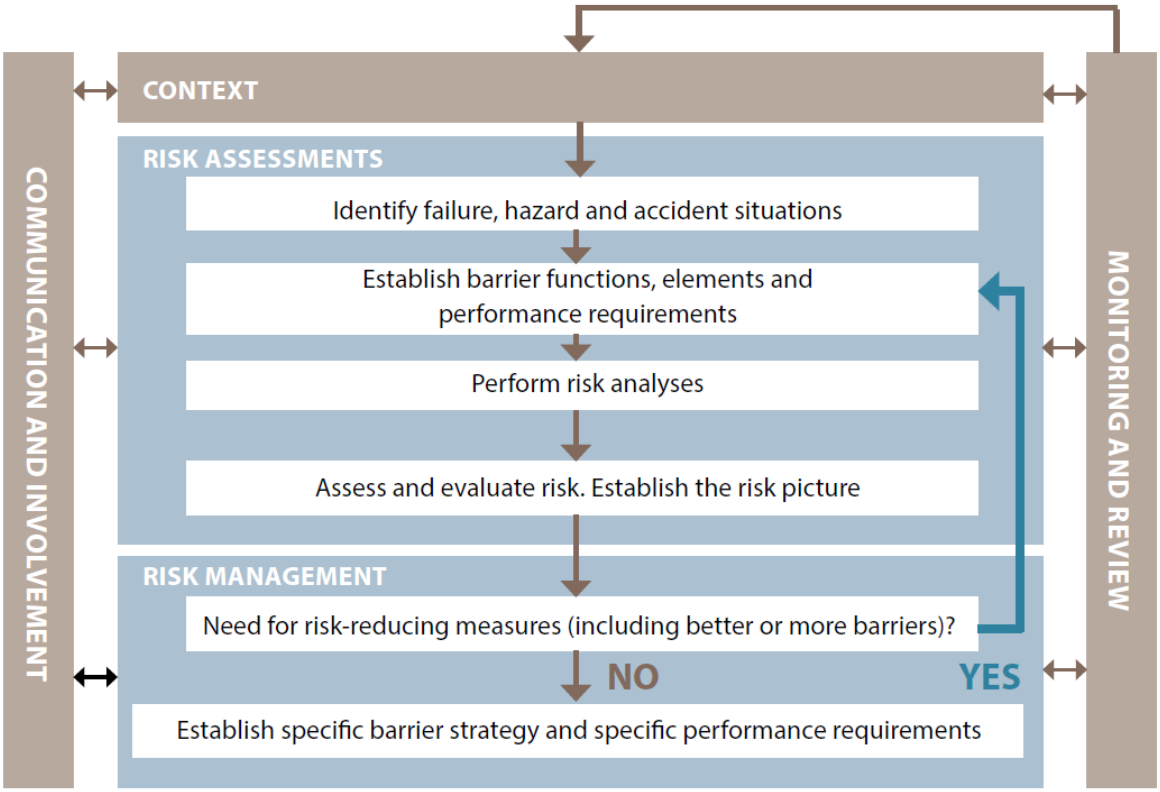

Figure 23: The process and foundation for barrier management (Petroleum Safety Authority Norway, 2017)

APPENDIX F – EXCERPTS FROM NORSOK D-010 WELL INTEGRITY IN DRILLING AND WELL OPERATIONS

Version: Ed. 4, June 2013

In the following, specifications regarding requirements in NORSOK D-010 are presented (Standard Norge, 2013). The requirements concern general principles and drilling activities.

GENERAL PRINCIPLES

1. Well barriers
    a. Well barriers shall be defined prior to commencement of an activity or operation.
    b. Well barrier schematics (WBS) shall be prepared for each well activity and operation.
2. Well design
    c. A well design shall be carried out for construction of new wells.
    d. There is a set of elements which should be assessed and documented in the subsurface well design basis. In addition, a drilling and well design basis shall be prepared.
3. Risk assessment and risk verification methods
    e. An assessment of well integrity risks associated with the intended operation shall be performed.
4. Activity programs and procedures
    f. An activity program as well as a Management of Change (MoC) procedure covering the life cycle of the well shall be implemented.
5. Blowout contingency plans
    g. A blowout contingency plan covering drilling, well, production and injection activities shall be established for area, field or installation.

DRILLING ACTIVITIES

1. Well barrier schematics (WBS)
    a. A WBS shall be prepared for each well activity or operation.
2. Casing design
    a. Casing, liner and tieback-strings shall be designed to withstand all planned and/or expected loads and stresses including those induced during potential well control situations.
3. Drilling location
    a. There must be performed a site survey in order to identify water depth, seabed and sub-surface hazards at the intended well location.
4. Shallow gas
    a. The risk of drilling into shallow gas shall be assessed for all wells. Risk reducing measures shall be applied.

APPENDIX G – EXCERPTS FROM NORSOK Z-013 RISK AND EMERGENCY PREPAREDNESS ASSESSMENT

Version: Ed. 3, October 2010

General requirements regarding the risk assessment and emergency preparedness assessment processes are extracted from NORSOK Z-013 in this appendix (Standard Norge, 2010).

GENERAL REQUIREMENTS FOR A RISK ASSESSMENT PROCESS

The risk assessment process shall always

1. Identify hazardous situations and potential accidental events,
2. Identify initiating events and describe their potential causes,
3. Analyze accidental sequences and their possible consequences,
4. Identify and assess risk reducing measures,
5. Provide a nuanced and overall picture of the risk, presented in a way suitable for the various target groups/users and their specific needs and use.

GENERAL REQUIREMENTS FOR EMERGENCY PREPAREDNESS ASSESSMENT

The emergency preparedness assessment shall always consist the following steps:

1. Establish context of assessment
2. Hazard identification (HAZID)
3. Establish defined situations of hazards and accident (DHSA) and analyze course of events
4. Identify governing performance requirements for emergency preparedness
5. Identify and evaluate
    a. Specific performance requirements
    b. Specific emergency response strategies
    c. Measures and solutions
6. Documentation of process and results.

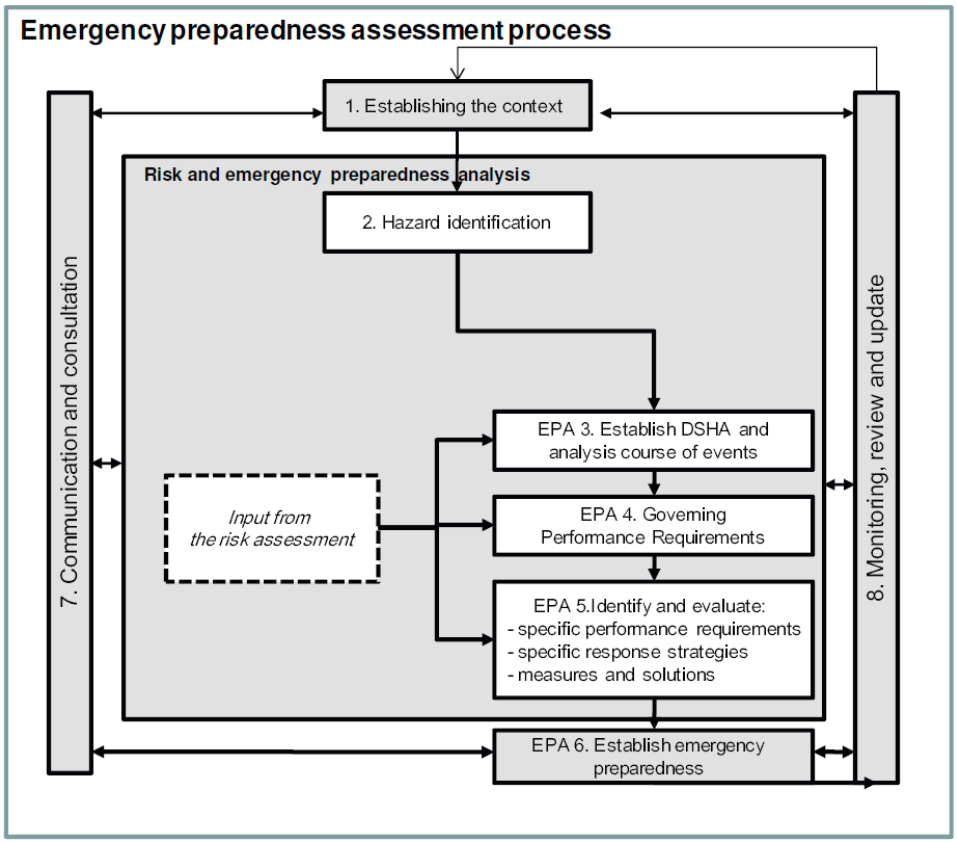

Figure 24: Emergency preparedness assessment (NORSOK Z-013)

Figure 24 illustrates the main elements and steps in an emergency preparedness assessment.

The risk assessment and emergency preparedness assessment processes have phase specific requirements, and they are prepared in different phases of a project. NORSOK Z-013 distinguishes the phases:

- Concept selection phase
- Concepts definition and optimization phase
- Detailed engineering phase/operational phase

The project life cycle phases are illustrated in Figure 25.

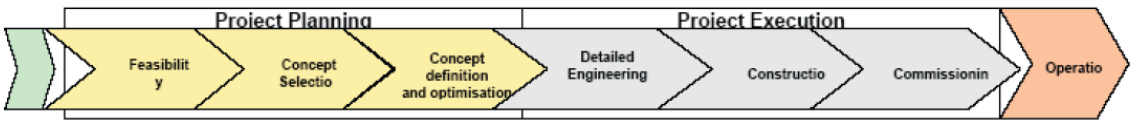

Figure 25: Project life cycle phases (NORSOK Z-013)

APPENDIX H – SUMMARY OF RIG CONTRACTOR GOVERNING DOCUMENT WITHIN RISK MANAGEMENT

Version: Ed. 1.03, April 2020

This appendix provides a short overview of some of the key contents from the rig contractor's directive *Risk assessment* (Anonymuous rig contractor, 2020).

The purpose of the document is to ensure that it is safe to commence a work and that all tasks are planned, hazards are identified and eliminated where possible. The directive is as mentioned in Chapter 3.5 applied offshore close to any planned operation. The rig contractor's planning of operations including risks takes place short time before the operation.

Requirements:

1. All tasks at the rig contractor's installations shall follow the Task Process:

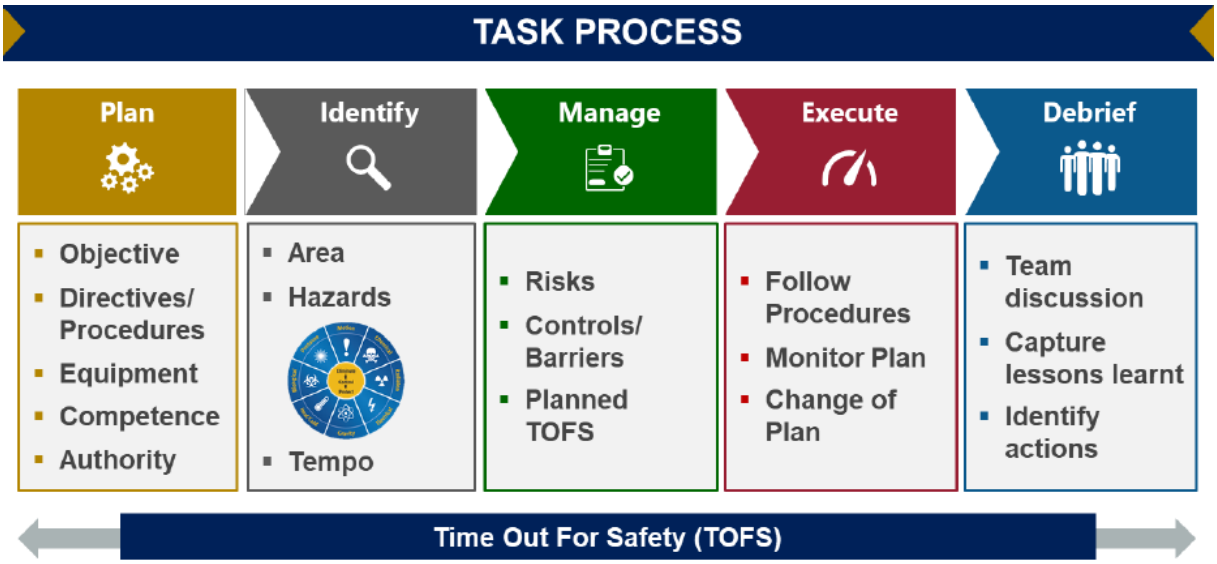

Figure 26: The TASK Process applied to offshore operations performed by the rig contractor (Anonymous rig contractor, 2020)

2. Risks must be evaluated and managed in the following order:
    a. Eliminate the hazards, where applicable;
    b. Control the risks (reduce to ALARP);
    c. Protect (mitigate consequences)
3. Regardless of the level of risk assessment, the Task Process shall be followed to ensure hazards are identified and risks managed:

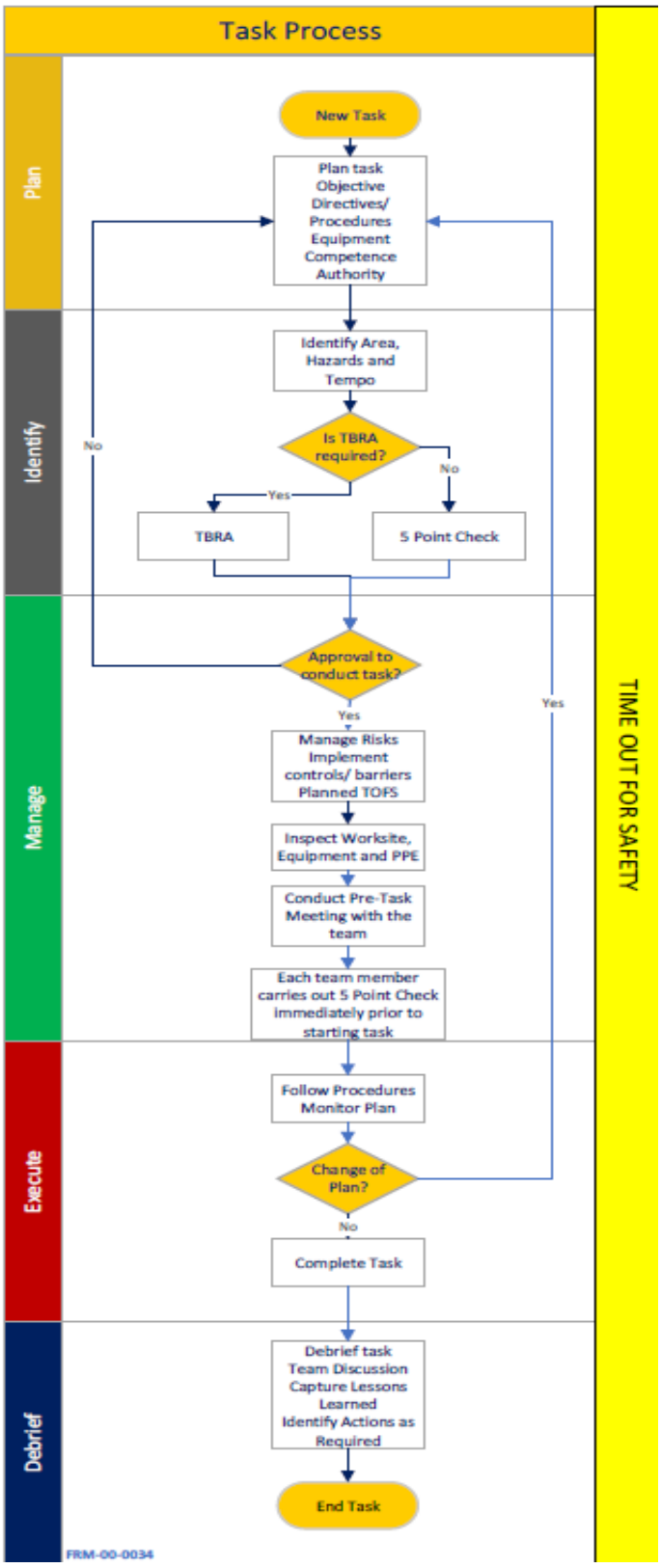

Figure 27: The TASK Process workflow (Anonymous rig contractor, 2020)

APPENDIX I – ON CONTRACTUAL REQUIREMENTS

Version: Contract entered 19.09.2018 between Equinor Energy AS and anonymous rig contractor

The contract which has been investigated regards marine drilling services at the NCS performed by the mobile drilling unit X (Equinor, 2018). The contract contains several topics and requirements, but this appendix presents requirements given to the rig contractor regarding risk management and associated collaboration relevant for the model in the thesis.

Risk management:

- Contractor shall have risk assessment process available for operator upon request
- Contractor shall implement a risk management system in compliance with ISO 31000
- Contractor shall implement management system regarding HSE
- Continuous risk assessment shall be performed in planning phase

Collaboration:

- Contractor shall communicate significant risks to operator
- Contractor shall have a documented process for monitoring and reviewing the risk management system
- Contractor shall participate in operator's well specific risk analysis
- Contractor shall identify/control interfaces between its own, operator's and third parties' management system
- Contractor shall participate in meetings requested by operator
- Contractor shall regularly report status to operator, including risk management covering identified areas of uncertainty.

APPENDIX J – ON THE EQUINOR ONE TEAM COMMITMENT

The One Team Commitment was signed and entered between Equinor, the rig contractor and a third party (service company) January 2020 and is presented below (Equinor, 2020a):

One Team Commitment

Our approach

We believe in collaboration to drive safety, efficiency, creativity and innovation. The way we collaborate in D&W operations is vital to our ability to achieve our objectives and reach sustainable safety and efficiency levels.

Objectives

- No harm to people - No well control incidents - No falling objects
- Sustainable low total well cost
- Step change in quality – Transforming the industry
- Collaborative win-win performance culture - Empowered people and teams

We are committed to

- Compliance to D&W Safety Standard in daily work
- Develop a culture that consistently delivers outstanding safety and operational performance
- Actively contribute in developing a One Team culture
    - An open, straight and honest communication between all parties
    - Problem solving, proactive and solution-oriented mindset
    - Ownership to common goals and adherence to decisions made
    - Establish a holistic well delivery mindset
    - Actively demonstrate values as open, collaborative, courageous and caring
    - Actively share experience across rig teams and engage suppliers' global competence

APPENDIX K – MORE DETAILS FROM EQUINOR DW100 PROCESS

Last amended: 2020-02-07

Below, an overview of the five defined project phases in Equinor's internal work process DW100 regarding construction of new exploration wells is presented (ARIS, 2020a). Each project phase has a purpose and a description of the output of the work phase.

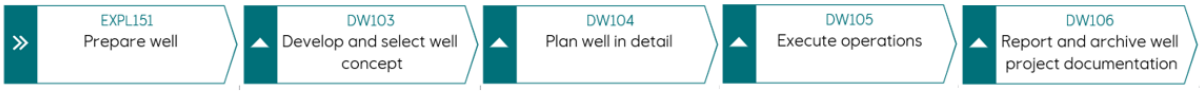

Figure 28: Overview of the five defined project phases in DW100 (ARIS, 2020a)

EXPL151 – PREPARE WELL

Purpose

Purpose

- To finalise design basis and a feasible well design as input to the Well construction process.
- To ensure quality, consistency, efficiency and compliance in execution of Prepare Well Projects
- To ensure integration between work streams and disciplines
- To ensure risk are assessed and integrated into design and time and cost estimates

To avoid risk

- To ensure time and resources are spend on the critical issues.
- To ensure quality in deliverables
- To ensure key risks are addressed

Output:

- Prepare well report
  - Shallow hazard evaluation
  - Final well locations and trajectories
  - Final geological and pressure/temperature prognosis
  - Blow-out and kill calculations
  - Data acquisition strategy and method
  - Feasible well design including time and cost estimates
  - Risk assessment

DW103 – DEVELOP AND SELECT WELL CONCEPT

Purpose

The solution identified in the feasibility phase is used as the basis. It is verified that the solution is within company standard solutions and that the bare-bone principle is applied.

The Develop and select concept phase can be customized to an individual well if some conditions are in place, such as standard well concept(s) are established and field proven.
The product of this phase is an approved Concept selection report. This is regarded as the formal decision to perform the operation, meaning that cost and time estimates must be as accurate as possible. The aim of the risk assessment in this phase is to identify all major risk factors requiring special attention and/or compensating measures. Before starting the concept selection phase, the well should be entered onto the D&W Master schedule.

The process ensures:
- That sufficient competence is appointed for the work
- Collaboration between GEOP, EXPL and D&W personnel
- That design basis for the well concept is established
- That risks are assessed and time and cost estimates are established
- That sufficient concept design is performed
- That sufficient documentation is completed
- That necessary verification and approval is done

The intended result (output) of the process is a document named "Well concept report exploration well". The work flow will be used by the nominated well construction project from GEOP, EXPL and D&W. The main users of the end result are participants in DW104-Plan well in detail.

DW104 – PLAN WELL IN DETAIL

Purpose

Based on the concept description, detailed planning shall be conducted. There should not be any changes to the described concept after approval of the concept report.

The process secures:
- That sufficient competence is appointed for the work
- Collaboration between GEOP, EXPL and D&W personnel
- That equipment is available
- That procedures and documentation ready to start operations are available
- That a complete risk register for the operation listing all identified risk with corresponding compensating measures are completed
- That the time and cost estimate is verified and prepared for reporting

The intended results (output) of this phase are activity programs and draft detailed operating procedures. The work flow will be used by the nominated well construction team from GEOP, EXPL and D&W. The main users of the end result are participants in DW105 – Execute operations.

DW105 – EXECUTE OPERATIONS

Purpose

Based on the well activity program and the draft operation procedures the DOPs are finalised and the operations executed accordingly.

The process secures
* That sufficient competence is appointed for the work
* Collaboration between GEOP, EXPL and D&W personnel
* That operations are executed according to the detailed operating procedures
* That the operations morning meeting, departure meetings and performance reviews will be performed
* After action review will take place after each DOP is executed and that DOPs and DBR will be updated for experience transfer
* Proper hand over of development well to operations

The intended results (output) of this phase are a well ready for hand over, well data according to the data acquisition program and transfer of relevant data from the operations. The work flow will be used by the nominated well construction team from GEOP, EXPL and D&W. The main users of the end result are participants in DW106 – Report and archive and future well planning teams.

DW106 – REPORT AND ARCHIVE WELL PROJECT DOCUMENTATION

Purpose

The process secures:
- That well data is compiled and quality assured
- That result are reviewed and that well reports are finalised
- The work flow further secures that documentation is archived and formal finalising and closing of the project.

The intended results (output) of this phase is a Final well report and a "Declaration of well construction project finalised". The work flow will be used by the nominated well construction team from GEOP, EXPL and D&W. The main users of the end result are participants in future well constructions, the client and authorities requiring end of well data.

APPENDIX L – SELECTED EQUINOR D&W RISK ASSESSMENT TOOLS AND ORGANIZATION OF RISK ANALYSES

Different risk analysis tools are being used in risk assessment dependent on which phase the project is in (Nilsen et al., 2013). This section will present tools used to document risk analysis in D&W processes; the Feasibility risk analysis template, the Risk analysis log sheet and the Project risk register. The purpose of the risk analysis templates is to document the risk analyses, while the project risk register provides a final overview of the risk picture at the end of each phase, including decided risk treatment actions. In addition, the D&W Risk matrix will be presented.

FEASIBILITY RISK ANALYSIS TEMPLATE

In *Prepare well*, the Feasibility risk analysis template, also called a checklist is being used as the main risk analysis tool . The template is broken down into topics and sub-topics with guidewords that may be relevant when assessing feasibility risks. *Yes, No* and *N/A* are simply ticked off, where descriptions are to be added for checkpoints checked off with checkpoints checked off with *Yes.* This is a simple tool used to document the main risk analysis in the feasibility phase. Figure 29 is an example of a checklist – this one extracted from the Drilling activity section on the exploration well project followed (Wellcom, 2020).

Topic		Checkpoints	Feasibility risk identified			Risk description	Comments
			Yes	No	N/A		
	4.01	Well trajectory *(Multiple targets and side-tracks etc.)*	☐	☑	☐		
	4.02	Side tracking *(Casing exit point etc.)*	☐	☐	☑		
	4.03	Drilling window *(Pressure margins, depths, formations and hole stability etc.)*	☑	☐	☐	Narrow drilling window, well classified as HPHT.	Focus area for concept phase and detailed planning. Reduced margins after changing from liner to casing design.
	4.04	Technical drilling solution *(Conventional, MPD, UBD etc.)*	☐	☑	☐		Plan conventional operations.
	4.05	Casing design *(Design parameters, long lead items, material choice, casing wear, life time evaluations, side-tracks etc.)*	☑	☐	☐	Uncertainty regarding status on contingency liner strings.	
	4.06	Cement design	☑	☐	☐	Change from liner to casing design increases risk on 9 7/8" cement job (no rotation, increased ECD).	Need to perform engineering for HPHT cementing.
	4.07	Wellhead fatigue *(Rest fatigue life, expected fatigue load etc.)*	☑	☐	☐	Could be risk, pending weather / winter operations.	Wellhead fatigue simulations initiated, no issues during summer operations
	4.08	Mud design *(WBM, OBM etc.)*	☑	☐	☐	Need to evaluate mud selection vs. data acquisition objectives. Reduced margin due to change from liner to casing design.	Plan to have Peer Assist on mud selection for reservoir.
	4.09	Well integrity	☑	☐	☐	Well classified as HPHT, narrow drillng window. Reduced margin due to change from liner to casing design increases probability of well control incidents. Contingency solution with 11 3/4" liner and 9 7/8" slick casing has increased risk on insufficient cement job.	HPHT manual will be established.

Figure 29: Example of a feasibility risk analysis template (Wellcom, 2020)

RISK ANALYSIS LOG SHEET

The Risk analysis log sheet is used in *Develop and select well concept* and *Plan well in detail*, has the purpose to document findings in the main risk assessment session and is tailored for use in formal risk assessment meetings. The tool is broken down into sections (e.g. 17 ½" section) to simplify and structure the risk identification and analysis process. Each risk element is described by the columns in the Risk analysis log sheet:

1. ID
2. Hazard
3. Causes
4. Consequences
5. Existing safeguards
6. Probability
7. Impact
8. Proposed measures

Figure 30 is an example of a risk analysis log sheet extracted from the exploration well project followed (Concept selection phase and the 8 ½ " section) (Wellcom, 2020).

ID	Hazard	Causes	Consequences	Existing safeguards	Risk before measures				Proposed risk reducing measures	Comments
					Prob	Impact				
						HSE	OBJ	TC		
1.6-03	Rig heave / weather	Rig schedule results in drilling reservoir section in fall/winter season.	WOW to allow for safe drilling when heave is taken into consideration.	The plan is to drill the reservoir section during summer season. Based on current well schedule the P is set higher than summer season.	P3	I1	I1	I3	Evaluate to shift wells on the drilling schedule to secure drilling reservoir section during summer.	
1.6-04	Losses.	Incorrect FG-model. Formations weaker than expected.	Sidetrack. Having to run 7" liner -> 6" hole -> lack of data aquisition.	TD strategy on 12 1/4".	P3	I1	I4	I4	Liner design, DP and mud selection to have low ECD. Active use of electronic popoff on the mud pumps to avoid unintentional fracture if pack offs. Define max surge pressure on trips and max ECD during circulation. Balance performance against margins to expected fracture gradient / minimize surge and ECD to ALARP.	
1.6-05	Wellbore breathing	Too high bottom hole pressure / ESD supercharging formation resulting in small amount of gas being bled back on pump off events.	High gas response in well. Potential for misinterpretation of gas response.	Fingerprinting.	P3	I1	I1	I3	Secure competency on pore pressure estimation offshore and onshore (24/7). Reduce ECD and surge to As Low As Reasonably Possible (ALARP).	

Figure 30: Example of a risk analysis log sheet (Wellcom, 2020)

PROJECT RISK REGISTER

The project risk register will be updated throughout the project, one for each phase. When the main risk assessment and any detailed studies are performed, the main results from the assessment will be transferred to the risk register for further treatment and follow-up. The risk register contains the final evaluation of the consolidated risk picture and the plan for dealing with the risks in terms of risk reducing measures.

When the final project phase risk register is completed, it will be included in and approved as a part of the project milestone document. Figure 31 is an example of the project risk register for the exploration well project followed (Detailed planning phase and the 8 ½ “ section) (Wellcom, 2020).

ID	Hazard	Causes	Consequences	Existing safeguards	Risk before measures				Measures				Risk after measures				Risk status	Cov. by ref data	Comments
					Prob	Impact HSE	Impact OBJ	Impact TC	Description	Status	Responsible	Deadline	Prob	Impact HSE	Impact OBJ	Impact TC			
8.0-03 WI-PB	Well control incident	Marginal drilling window Swabbing Confirmation bias due to high stress level.	Well control incident		P3	I3	I1	I2	HPHT seminar and simulator training	In progress	DSI	DW105	P2	I3	I1	I2			Activity Programme.
									HPHT brief upon arrival on rig.	Proposed	DSI	DW105							
									Evaluate OBE training sessions / well control forums focusing communication routines and listening skills.	Proposed	DSI	DW105							
									Check competence and composition of each team/crew.	In progress	DSI	DW105							
8.0-04	Rig heave / weather	Rig schedule results in drilling reservoir section in fall/winter season.	WOW to allow for safe drilling when heave is taken into consideration.	The plan is to drill the reservoir section during summer season. Based on current well schedule it's a risk that the reservoir will be drilled late autumn	P3	I1	I1	I3	Evaluate to shift wells on the drilling schedule to secure drilling reservoir section during summer. Performed.	Verified	DSI	DW 104	P2	I1	I1	I3			
									Align with management that Atlantis should drill reservoir section during summer season. Management prioritazion of wells. Atlantis is moved on rig schedule and is no put up to be drilled after Helleneset and Gabriel with planned spud late May.	Verified	DSI	DW103							
8.0-05	Losses.	Incorrect FG-model. Formations weaker than expected. ECD spikes due to packoff/poor hole cleaning etc	Lost time to cure losses. Worst case: Sidetrack or having to run 7" liner -> 6" hole -> lack of data aquisition.	TD strategy on 12 1/4".	P3	I2	I3	I3	Liner design, DP and mud selection to have low ECD.	Verified	Project	DW 103	P1	I2	I4	I4			Activity Programme.
									Active use of electronic popoff on the mud pumps to avoid unintentional fracture if pack offs.	Proposed	DSV	DW105							
									Define max surge pressure on trips and max ECD during circulation. Balance performance against margins to expected fracture gradient / minimize surge and ECD to ALARP. Limitiation to be described in DOP-	In progress	Drilling Eng	DW105							

Figure 31: Example of a project risk register (Wellcom, 2020)

After probability (P1-P5) and impact (I1-I5) have been assigned to the risk elements in the Risk analysis log sheet, the elements are placed in a D&W Risk matrix. The Risk matrix ranks and prioritizes the different risk elements, and uses three impact categories to define risks (HSE, Well objective and Time and cost). Such a risk matrix increases the visibility of risks and assists in management decision making. Figure 32 is the Risk matrix used in Equinor (Wellcom, 2020).

Risk matrix - Drilling

Show other HSE details / Show Upside details / Show Description		Monetary		Health, safety & environment (HSE)		Increasing probability (per well project) →				
		Well objective (OBJ)	DW time and cost (TC)	Well integrity	Other HSE	P1	P2	P3	P4	P5
						< 1 %	1 - 5 %	5 - 15 %	15 - 30 %	> 30 %
← Increasing impact	I1	No impact (<10 MNOK)	No impact (<10 MNOK)	No impact	No impact					
	I2	10-30 MNOK	10-30 MNOK	-	Moderate (Lost time injury/ moderate spill)					
	I3	30-100 MNOK	30-100 MNOK	Loss of one well barrier (well control situation)	Serious (permanent functional impairment/ serious spill)					
	I4	100-300 MNOK	100-300 MNOK	Challenging well control situation. Limited release from well.	Severe (1-3 fatalities/severe spill)					
	I5	>300 MNOK	>300 MNOK	Loss of well integrity (loss of both well barriers, blowout)	Major (>3 fatalities/ major spill)					

Figure 32: Risk matrix used in D&W in Equinor (Wellcom, 2020)

ORGANIZATION OF RISK ANALYSES

In risk analyses meetings, the following roles are defined:

- Risk analysis Facilitator
- Expert panel (the group of participants)
- Risk analysis Secretary

The facilitator has two roles in the risk analysis session: the person will act both as a meeting leader and as a facilitator. As a meeting leader the meeting must be managed according to agenda and schedule. As a facilitator, it lies a responsibility in order to prepare the meeting. In addition, the facilitator must ensure that the meeting runs according to plan and that consensus is achieved among the participants and the session results are optimized.

The secretary is the scribe throughout the risk analysis session. This includes documenting and filling in in the risk log sheet as the meeting progresses. Comments, recommendations and actions should be noted in the risk Comment column in the Risk analysis log sheet underway in order to keep track of relevant input.

The expert panel is the group of meeting participants and in sum their competence is the source of input to risk analysis. What is referred to as the expert panel is described in more detail as there is a lot of expertise involved in an exploration well project, all sitting on different competence and experiences contributing to the project in one way or another. The expert panel must be a cross disciplinary group consisting of all relevant expertise both from internal and external parties. The most important roles of the participants involved are:

- To use their experience, knowledge and judgement in identification of issues or topics discussed
- To ensure that all relevant risks and hazards are addressed and express their thoughts and concerns throughout the meeting
- To be active and supportive regarding reaching a consensus in the group
- To listen openly to suggestions and ideas from other participants and try to build on these.