Human Factors in Drill and Well Operations

Challenges, projects and activities

The report is written by DNV in cooperation with PSA in Fall 2005, based on input from the industry
Summary:
The report discusses the HF challenges in drill and well operations. It provides examples of HF projects in the industry. Drill and well operations consist of complex work operations that have a high risk for personal and major accidents. Feedback from the industry and from conducted investigations and audits indicate various challenges in this area:

• Management's role
• Manning/workload
• Design/equipment
• Standardization of equipment dimensions
• Human Machine Interface
• User involvement and HF competence
• Competence and Learning
• Procedures/work routines
• Communication
• Planning and cooperation
1.0 Introduction

During investigations of major accidents conducted in the last few years, it has become increasingly apparent that there is a lack of focus on the interacting factors between man, technology and organizations. On the Norwegian Continental Shelf (NCS), many of these incidents are related to drill and well operations. These operations are high risk potentials for personal injuries and major accidents.

The Petroleum Safety Authority (PSA) has evaluated the investigations conducted after major accidents related to drill operations. Information was gathered from investigations carried out by various companies in the past 6 years. The most common causes were related to management and organization, errors in execution and organization of the work, deficient communication and procedures and work instructions that are not familiar, understood, or easy to follow.

With goals to obtain a better understanding and overall perspective of the challenges in the industry, PSA sent out a letter requesting information on planned activities and improvements in human factors in drill operations. The target group were operators, ship owners, drill entrepreneurs, and equipment manufacturers. Feedback was requested on the following issues:

- Challenges related to Human Factors in drill operations from the industry’s perspective
- Information on relevant projects and modifications
- Examples of relevant classification and analyses connected to HF in drill operations through the years

The following industry sectors responded to the questionnaires:

- 11 operator companies
- 7 shipping and drill companies
- 4 service companies
- 3 equipment manufacturers

1.1 Human Factors approach in PSA

Human Factors (HF) is a systematic, holistic approach which includes the application of methods and knowledge that can be utilized to evaluate and improve the interaction between human, technology, and organization.

The goal of applying HF in a working environment is to optimally contribute toward achieving efficiency and prioritizing safety while taking into consideration abilities, limitations, and the needs of the people who function in them.

The interaction between human, technology, organization, and environment is a critical factor to achieve the goals of safe and effective drill and well operations. To do so, it is important that the following is assessed for development and improvement where necessary:
- Personnel: i.e. competence, abilities, needs, and limitations
- Technology; i.e. design, functionality, usability, overall integration and how it supports operators in their work.
- Organization; i.e. structure, support, manning and management

Figure 1-1 illustrates the HF approach and how the different disciplines cross and overlap one another. The HF perspective considers the different elements and disciplines as an integrated whole.

![Diagram showing the integration of Personnel, Technology, Organization, and Human centered approach.](image-url)

**Figure 1-1 Human Factors perspective**
2.0 Summary

Safety and working environment in operations related to drill and well operations have improved after the implementation of remote operated pipe handling equipment. Between 2000 and 2004, the frequency of serious personal injuries related to drill and well operations on production installations were significantly reduced. In addition, on floating installations, serious personal injuries within drill and well operations have reduced in frequency. However, when considering the overall injury records, this operations category continues to rank highly.

Between 2002 and 2004, the total amount of wells has reduced, but drilling frequencies from permanent installations have increased. The increase is based on work being conducted in new fields and maintenance of existing fields.

Operational tasks in drill and well-operations are inherently complex. In such operations, there is a high risk potential for personal injuries and major accidents. Records from 2004 indicate a reduced amount of well incidents in production drilling. However, the overall risk of incidents has increased. In the NCS, developments in the last few years indicate that well and drill operations in drained, mature reservoirs are becoming increasingly more demanding. Simultaneously, an increasing amount of operations on mature fields are reusing existing top hull sections. In 2004, well incidents were among the top five categories that contributed toward total indicators for loss of life in large accidents/04/. To reduce risk potentials in these types of activities, it is critical have a systematic view of interactions that influence risk levels. It is not sufficient to focus only on the improvements of technical solutions such as drill and well technology, but also pay attention to human and organizational conditions. The challenge is to optimize the interacting factors.

The following example may highlight the importance of the drill area as system, made up of various parts, and some of the cause effect relationships:

New pipe handling equipment was installed during upgrades. These new equipment reduced the level of manual pipe handling. The visibility from the drill cabin was not previously optimal, and the new installation, lead to a more limited visibility from the drill cabin. Additionally, there was less workspace. To compensate, cameras were installed on the drill deck. The related monitors were installed in the drill cabin for the drill operators to monitor. Drill operators work with high workloads and the additional information channels and monitoring activities lead to an even higher mental workload. This high workload can contribute toward human errors. There is a need for training for both drill deck workers and drill operators in relation to the use of new equipment. The risk conditions should be assessed, new roles must be defined and new procedures and work descriptions must be developed.

Section 5 presents the critical challenges related to Human Factors in drill and well operations. Challenges identified in the feedback from the industry, and PSA’s experiences from investigations and audits are described. The challenges are not new, but indicate that there are other critical areas in the future that require focus and input from the operators, drill entrepreneurs, and service companies.

- Generally, drill management (drill managers and drill supervisors) are not visible, nor do they participate in operational work. Active participation from the management is a pre-requisite for development and competence maintenance. This applies to both operational personnel and management. Experience and competency provides an advantage in understanding risk potentials in different work operations.
• Training and competence will play a more critical role in the future. Developments in technology and the steady increase in the level of automation intensify the complexity within the system. These increases require different categories of competency and training. For example, when manual intervention is required with an automated system in an unexpected situation, personnel are not familiar and are unable to step in. Drill and well personnel should have knowledge and training that allows them to understand automated operations and if necessary respond with manual actions.

• The fluctuations in activity levels on the NCS lead to a challenge for competence development in drill and well service companies. Manning is often reduced during periods of low activity. However, conflicts arise when activities are on the rise, and companies recruit insufficiently trained and inexperienced personnel.

• Co-operation in planning and operations between operators, drill and service companies is a prerequisite for successful drill and well operations. A main challenge in this area is the cooperation among the various installations so that consistent procedures, work descriptions and standards on pipes and equipment are applied. Personnel who work short periods on various installations find that there is insufficient time for planning. Often, there is limited time for planning and orientating oneself with the installation and well specific conditions. Another important challenge is planning for the management of unforeseen incidents. If something unexpected happens, an organization with a plan will be better prepared to manage the unexpected than one that applies an ad hoc solution. Having a plan will provide the supervisors and operators security and trust that the unexpected can be managed in a good and safe manner. Providing special competence training to drill and well service companies and early involvement of operational personnel in the planning phase will ensure that the operational challenges are addressed.

• The lack of or insufficient communication is often cited as a factor during unexpected incidents in drill and well operations. In particular, inaccurate radio use, cultural differences, and language barriers are considered as some of the important challenges. In the future, when planning is conducted largely on land, communication between land and sea will be an important aspect to manage efficiently.

• In the example described previously, challenges in new and old drill constructions include the lack of space, smaller work rooms, reduced overall perspective, difficult access to equipment, increase use of cameras and increased workload in other storage areas. The possible use of more equipment on the drill deck and supporting areas were not taken into consideration in the design of these constructions. The example illustrates that it is important to have a holistic approach during modification activities and installation of new equipment. A critical element in this process is to involve end-users with operational experience and personnel with HF competence, so that the practical challenges can be handled in a systematic and holistic manner. It is important to ensure that the equipment is considered as part of a larger system and not as individual units that have little influence on the other.
3.0 Objective

The objective of this report is to categorize, analyse, and summarize feedback on HF challenges in drill and well operations. Information to support these activities is provided by feedback data from the industry and PSA’s experiences from investigations and audits related to drill and well operations.

The aim of the report is to provide an overall perspective of projects from industry related to the theme. The projects that are presented are recently completed, ongoing, or planned for the near future.

Issues related to e-operation (integrated operations) are not analysed in this report. Although there will be significant developments within integrated solutions in drill and well operations in the future, minimal feedback on e-operation was received from the industry. E-operation issues are explored in other project reports. Please refer to the e-drift forums and consequence analysis directed by OLF on the implementation of e-operation /05/.

4.0 Method

The feedback data from the industry provided a good base to identify challenges. The raw data was preliminary categorized. This was followed up with specific identification of the main challenges in each category.

PSA and DNV participated in 2 meetings to discuss findings from the feedback and experience gained through audits and investigations of incidents. During the meeting, discussions were held on the specific challenges to address more closely.

In the report, citations gathered from the feedback data are used to illustrate important findings. In some instances, the citations have been edited to ensure anonymity.

5.0 Challenges

This section describes the critical challenges related to HF in drill and well operations. These challenges were identified through an analysis and summary of the feedback from the industry, and further supported by PSA’s experiences from investigations and audits related to drill and well operations. The challenges are divided into the following categories:

- Management’s role
- Manning/workload
- Design/equipment
- Competence
- Procedures/work routines
- Communication
- Planning and cooperation
5.1 Management Roles

It is important that the drill management (drill manager and drill supervisors) have a clear understanding of the overall system in drill and well operations. To develop a clear risk perspective of the various activities and phases in drill operations, it is important to have a holistic perspective and in-depth knowledge of the operations and well conditions. It is a challenge to obtain an overall risk understanding and in particular, to understand the hazards that may arise and the consequences of these. However, this understanding is important to lead and conduct safe operations. It is especially important when unexpected incidents arise and there is need to make quick adjustments to the planned drill programmes.

Feedback indicates that drill management are generally not visible and are seldom on the drill deck with the operators conducting operations. Operative presence is greatly reduced due to the administrative tasks that take a large amount of the working day. Drill management’s limited presence and participation in the operative work may contribute toward negative consequences i.e. reduced overall view over drill operations, reduced familiarity to daily challenges, lack of understanding of drill conditions (pressure, temperature, etc) and reduced knowledge of equipment that is utilized. There is less time for follow up and guidance to drill deck personnel and difficulty in identifying areas for competence development.

To maintain and further develop competence levels of drill deck personnel and management, it is important to have an active drill manager. It is also important for guiding personnel attitudes toward HSE in all phases of drill and well operations and all levels of the organization. Important characteristics for leading managers include presence, visibility in the field, trust, open attitudes, ability to have good dialogues and “chat with others”, ability to prioritize daily HSE plans, and provide a systematic and formal follow up of the daily HSE systems. The drill management priorities in regards to the workday schedule should be evaluated. Due to the overload of administrative tasks that managing personnel face, there is less time for active follow up of drill operation on the drill deck. This is a difficult and complex challenge.

Drill operators have management responsibility for activities that take place in the drill area and have a list of tasks similar to drill managers and drill supervisors. Work pressure is often high (drill operators’ work conditions are described in chapter 5.4.2) and this can lead to de-prioritizing certain tasks i.e. guidance and training of other drill personnel.

"Management must be visible, accessible, and be able to guide at the work site when needed." (Translated)

Drill entrepreneur

5.2 Planning, cooperation and change management

Thorough planning is a prerequisite for successful drill and well operations. Feedback from both the industry and investigations of incidents indicate that planning can be improved. Areas for improvements include work to incorporate sufficient planning, involvement of operational personnel and planning for changes during operations.
Feedback from the drill and well service companies indicate a clear challenge in the short deadlines imposed by the operator companies. The operator companies often call for operations personnel to come out to the installations immediately prior to carrying out the operations. Therefore, personnel have limited time for necessary preparation i.e. to familiarize themselves with installation specific HSE information, and simultaneously orientate themselves to the relevant procedures and work descriptions.

Another challenge in drill operations are the interactions among the different operators i.e. rig owners and the various service companies when planning and carrying out operations. Operator companies are often responsible for planning the work operations to be conducted. Each and every company has specific knowledge. The plans are quality assured to a certain degree by operating personnel. However, involvement in the planning phase should be more effective. Involvement of operations personnel and the inclusion of personnel with special competence in drill and service companies can ensure that operational challenges are considered early in the planning phase. The participation of operational personnel will become increasingly more important in the future when drill and well operations are planned from land.

"A challenge is to ensure that a contractor and operator have a common understanding of drill/well situations and work assignments." (Translated)  
Operator company

To a large extent, planning of operations is focused on work in progress. Experience indicates that unexpected changes are not properly managed and that there is a lack of proper planning for such instances. With plans not in place, insecurity is created leading to wrong decisions. Changes in planned operations demand that those involved have the competence and risk understanding to be able to evaluate the situation and the consequences related to ongoing work.

“Planning of work operations can be improved, especially in relation to what shall be done if something unforeseen takes place during operations. Earlier incidents show that the work can be well planned from the start, but a change could take place. Then, there is a challenge to get the organization to stop and design a new plan where the changes are considered in the planning for the ongoing work.” (Translated)  
Drill entrepreneur
5.3 Manning/workload

Due to optimization, manning has been reduced among drill workers and their assistants. However, the number of tasks has not necessarily reduced and the existing personnel have received more tasks and larger work areas. Personnel are asked to conduct tasks that they are not familiar with and have not received sufficient training to manage. Feedback indicates increased stress levels among personnel involved in drill and well operations that follow personnel optimization.

"Reduced manning among drill entrepreneurs creates changes for drill wash engineers. Drill entrepreneurs in the contract are pressured to steadily lower manning. Ass derricman and Mud Process Area (MPA) operators must train the drill deck workers – steadily increasing work area - gives increased stress!" (Translated)

Service company

Automation/remote operations of manual work operations does not automatically compensate for reduced manning. With the introduction of automation, new tasks are introduced. For example, this may include the monitoring of new systems and relevant alarms. In addition, work operations that are automated may have supporting tasks that still require manual operations. Even if a task is automated, this can lead to increased workload for the personnel. Therefore, prior to implementation of a new technology, a thorough analysis should be conducted on the tasks a person assumes to fulfill their function. Questions should address information on unnecessary tasks, new tasks and supporting tasks. In further analysis, questions should address what signifies supporting tasks i.e. simultaneous operations, criticality, need for technical support, and need for learning and competence.

During operations, the work pressure on drills may be high. In addition to overseeing the drill process, the drill operators must attend to i.e. diverse phone calls from drill wash engineers who need information and personnel who come to the drill cabin with questions. Disturbance during demanding work operations are everyday occurrences for drill operators and increases the stress level in this work group.

Conflicts arise when prioritizing tasks and dividing resources when there is low manning in drill and well operations.

"Drill entrepreneurs prioritize their tasks, while service companies defend theirs. Service companies are often dependent on drill entrepreneurs to get their work done. This creates a power struggle and takes away focus from the task at hand as personnel receive different instructions- this increases risks." (Translated)

Service company
5.4 Design/equipment

5.4.1 Layout – storage and lack of space

Extra equipment is installed in drill areas to meet new requirements for drill and well operations as technology develops. Older installations are designed for manual drill operations. Space for new and more equipment on the drill deck were not considered when these were first built. Modification of older constructions to make space for new and more modern equipment is complicated. If the new equipment is to be utilized as intentioned, there are often limited spaces as to where the equipment can be installed.

"Extra equipment and systems installed on drill deck to meet new demands have lead to a lack of space. This in turn leads to smaller workspace, increased workload on pipe deck and limited storage space, which in turn requires that equipment, must be moved from drill deck when it is not in use."

Operator company

The consequences of increasing equipment on the drill deck can contribute toward a lack of space, smaller work rooms, reduced accessibility to equipment, reduced visibility, increased use of camera and increase workload in other storage areas.

"New and more demanding wells require more and different chemicals to be used during an operation. This also happens on older installations where there is limited space. A multitude of simultaneous operations often gives space problems e.g. chemicals that are used by service companies (drill wash engineers). In some cases there is no place for the tanks on board and boats must be used as storage places "

Service company

During modification projects that involve installation of new equipment, it is important to have a clear holistic understanding and consider the various equipment as part of a system. It is not sufficient to only see the isolated advantages of new equipment. Evaluations should be conducted to see the influences of such modification and the use of the new equipment on the overall system. This also applies to risk evaluations. It is not sufficient to only conduct risk evaluations on the new equipment. Risk evaluations should be holistic in design, e.g. changes that affect other HF conditions and those that can affect the interactions. If the use of the equipment requires special training, this must be conducted prior to the new equipment is implemented for operations. It is important that those who participate in operations of new equipment receive a complete risk understanding.
5.4.2 Human Machine Interface

Manual work in drill and well operations has become more automated as a consequence of changes in regulations and technology development. Frequency of serious personnel injuries related to drill and well operations both on production and floating installations have had a significant reduction since the peak in 2000-2001 and up to 2004/04. Equipment failures and handling problems with different types of pipe with different dimension also lead to relatively heavy manual operations. This often leads to heavier workloads on muscle and skeletons. In addition, manual operations also put personnel in high risks zones for crushing hazards and exposure to falling objects. Despite the significant reduction of major personal injuries, drill and well operations still place highest on the injury statistic for major personal accidents in 2004/04.

There are different sets of problems and challenges that arise on the individual drill installations due to the large variation in the layout of the drill work place. Feedback information from the industry indicates that there is limited possibility to vary sitting positions, and the shift between sitting and standing work positions. The same sitting position throughout the shift has negative consequences for muscle stress and may negatively affect the drill operators’ concentration. Controls and switches are often badly placed on the panels in relation to drill operators working position (the locations do not interact well with the stool’s movement and have bad underarm support) or simultaneous or sequential operations. During design of new operator stations, it is important to ensure that the equipment placement is not in conflict with operational tasks. Sufficient analyses should be conducted early in the planning stages.

The increasing level of automation leads to an increase in generated information. The information from the system is received mainly by the drill operators and these are presented on monitors. The drill operators should be able to work interactively on the screens that are designed with a good human machine interface that supports the execution of the various operations. There must be clear information on how to conduct operations and clear feedback on drill operator actions. In addition to the information from the automatic systems, the drill operator also receives information visually from the drill deck. Information is received from cameras that are placed in areas with no natural view and from radio communication with other drill personnel. An important aspect in a new and upgraded drill facility, is that the tower mans function is often moved to the drill cabin. The amount of information that drill operators must coordinate is significant. In addition, in certain periods, there are a large amount of activities in the drill cabin i.e. other personnel who come in to obtain information for the drill operator. Currently, PSA is not aware of any analyses documented on the mental workload of these drill operators. Feedback from the industry and PSA’s experiences indicate that the drill operators’ workload may be on the border of what is considered dangerous. Increased mental workload over the normal handling workload may increase the likelihood for errors.

"Due to lots of equipment and blocked views, cameras have been installed. On many occasions, this has helped the drill operator but it also increases the workload where the screens must be monitored for a thorough overall perspective."

Operator company
5.4.3 User participation

A design challenge is to get end users (personnel with operational experience on all levels) and personnel with HF competence sufficiently involved in new built and modification projects so that operational challenges are handled in a systematic and holistic manner. Regulations for petroleum work requires that analysis i.e. function analysis, task analysis, and job analysis are conducted in the different phases of a project. It is important that the analyses are conducted in a timely manner so that the results can be utilized as input to design. The analyses are tools to ensure that the solutions implemented are user friendly. For example, it is important to identify potential simultaneous operations which may be in conflict. According to PSA, experiences indicate that while analyses have been conducted, they are often conducted late in a project, and no actions are implemented.

In work processes where user involvement is part of the work, it is important that the end users are consulted and given an orientation on how certain processes are conducted and ensure sufficient information in good time.

User involvement in planning of drill and well operations is another important challenge that should be considered. These challenges have been discussed earlier in chapter 5.2 – Planning and cooperation.

5.4.4 Standardization of equipment

Today, there are relatively large differences in dimensions of pipe and equipment that are used in drill and well operations. Manual operations are required to integrate the non-standardized pipes and equipment. Manual work reduces efficiency and creates additional hazards. Drill projects should make an effort and reduce manual pipe handling in accordance with the guidelines and routines that are described in “Suggested Guidelines” to fulfil PSA requirements for remote operated pipe handling, described in The Facilities Regulations section 55 and The Activities Regulations section 80 (OLF/NR/081) /06/.

"It is difficult to operate pipe handling systems due to the various types of design and dimensions of pipes in use."

Operator company

5.5 Competence

Fluctuations in the activity levels on the NCS lead to a challenge for competence development in drill and well service companies. During high activity it is difficult for companies to provide sufficient personnel with adequate competence and experience. The short term solution is to provide an increasing amount of persons with less experience. When activities on the NCS reduce, the risk for retrenchments increase as it is not feasible for companies to hold on to extra resources. Those affected during retrenchment periods are often personnel who were employed last and have the least experience. And when the activity levels rise, most companies are not prepared and inexperienced personnel are employed.

“The cyclical activity on the Norwegian sector leads to a high level of new personnel during periods with high activities. The same is relevant for more
experienced personnel. They are often sent to various rigs during periods with high activities. Both new personnel and personnel that are shifted around rigs have a need for rig specific training. These rig specific training is difficult to coordinate and conduct both from land and offshore.”

Operator company

Personnel often lack installation specific training and experience due to large variations in layout, equipment, and work procedures on different installations. An additional factor is the large amount of drill and well service personnel who work for a limited time on each individual installation and have limited time to obtain installation specific information. Industry feedback indicates that many of the personnel feel uncomfortable with the tasks they are required to conduct due to limited competence. Steadily increasing new ad hoc teams and rotations between installations can influence the quality of the interaction between personnel. Risk may increase due to reduced quality in interactions. This becomes a more critical challenge when new manning with limited experience and time to prepare are hired in. Planning and cooperation is discussed in chapter 5.2.

Competence is a pre-requisite for risk understanding in drill and well operations. Without risk understanding on all levels, it is difficult to conduct these activities in a safe manner. Training and actual competence is very important. In the future, this will become increasingly more important as technology development continuous and the level of automation increases. Complexity increases with increased automation and this creates a need for other types of competence and training.

5.6 Procedures and work routines

Procedures and work routines are influenced by installation specific conditions and by operators in the field. Due to the large variation in the layout and equipment between installations, there are relatively large differences in procedures and work routines. For drill and well service personnel that often shift work environments, it is a challenge to keep up with the different procedures and work routines. The danger of confusing or not using the relevant procedures and work routines is obviously higher for these types of personnel compared with a permanent workforce.

“There should be a focus on standardization of work routines and procedures across installations and operators. These are large challenges for under-entrepreneurs that shift work environments (installation) often and must keep up with a lot of safety and work routines.”

Service company

Procedures are tools to describe a work method to carry out tasks and ensure common understanding. According to feedback from the industry, there are currently many challenges related to procedures. After each new equipment installation or modification, procedural
documents have developed and become more detailed and difficult to understand. These developments have required much more of the average individual user. The often cited challenges include limited user friendly, not updated, and difficult to access procedures (procedure are often on the company’s intranet, but are difficult to find). Many of the personnel are not used to working with electronic data. Development of good procedures for work processes requires both grounding analyses and participation of end users who are familiar with real practice and conditions. In addition, the lack of common procedures among operators, and drill and service engineers are a challenge. It is especially difficult when there are direct disagreements between procedures.

"Over time, most of the procedures have changed to extreme detailed documents. Procedures must be simpler and more understandable for end users. Focus should be on “how” instead of why"

Operator company

5.7 Communication

Communication is a broad and extensive definition. However, in this context, the focus is on the challenges closely related to the execution of drill operations.

Incident investigations show that erroneous and/or inadequate communication is often a reason for unexpected incidents during drill and well operations. Feedback from the industry suggests that wrong use of radios and cultural differences are important challenges.

When utilizing the radio, it is important that all involved understand which channel and language to use, and be familiar with good radio etiquette. The sender should verify that the receiver has received and understood the content in the message. Often, there are unnecessary conversations and messages. In addition there is limited use of standard words and expressions.

When e-drift is implemented to a larger extent, there will likely be new communication challenges related to planning and decision making which will mostly be conducted on land.

"The improvement potential is to make everyone familiar with “good radio discipline” and at the same time focus on that the messages on the radio are confirmed." (Translated)

Drill entrepreneur
6.0 Summary and Future Work

We (PSA) wish to motivate the industry to take steps for improvements within HF in drill and well operations. Therefore, it is important for us to inform the industry on our (PSA’s) definition of HF. To raise awareness of work in this area, letters have been sent out to inform the industry. We have requested information on the challenges in drill and well operations and have enquired after information on current activities to improve HF in drill and well operations. We utilized internal competence development and obtained knowledge and experience both nationally and internationally. In addition, we have placed emphasis on the shared experiences from projects.

Feedback from the companies show that there are many HF challenges related to drill and well operations. Many of these factors are shown in the model below. The model illustrates how changes in one condition can influence the other. Therefore, it is important to evaluate how changes in one area affect another. This is best achieved through the timely involvement and application of HF competence. The end user must be involved in a practical manner.

We are in the midst of planning a seminar in cooperation with the industry to share experiences and to address the industry’s HF challenges. The seminar will be held in a PSA venue. We wish to create a better and more thorough understanding of the HF definition. In addition, the goal of the seminar is to build a good foundation for experience exchange between the multiple players in the industry through presentations of practical projects.

In the future, PSA will conduct audits in the industry to follow up of HF activities in drill and well operations. We will conduct these audits in various phases and include modification projects and operations to see that HF activities and plans are well implemented. We value the importance of meeting the multiple players in the industry during these audits.

We hope the work that PSA has begun and this report will contribute toward important considerations the industry gives to human abilities, limitations and needs in work design, planning and operations. This will contribute in increasing the HSE levels within drill and well activities.
### 7.0 Norwegian references

<table>
<thead>
<tr>
<th>Reference</th>
<th>Details</th>
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<tbody>
<tr>
<td>02</td>
<td>Oljedirektoratet (2003). Human Factors i kontrollrom – en revisjonsmetode</td>
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<tr>
<td>03</td>
<td>Statoil (2003). Human Factors – samspill mellom menneske, teknologi og organisasjon (hefte)</td>
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<td>04</td>
<td>Petroleumstilsynet (2004): Risikonivå på norsk sokkel (RNNS), Sammendragsrapport fase 5.</td>
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<td>05</td>
<td><a href="http://www.npd.no/Norsk/Emner/E-drift/Konsekvensutredning++e-drift/coverpage.htm">http://www.npd.no/Norsk/Emner/E-drift/Konsekvensutredning++e-drift/coverpage.htm</a></td>
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<td>06</td>
<td>Oljeindustriens Landsforening (OLF) &amp; Norges Rederiforbund (NR) (2003): Anbefalte Retningslinjer for å oppfylle ODs krav til fjernoperert rørhåndtering, fastsatt i Innretningsforskriftens § 55 og Aktivitetsforskriftens § 80</td>
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Appendix I – Relevant projects and activities in the industry.

In the questionnaire that were sent out to the industry, PSA also requested examples on relevant HF related studies and analyses on drill operations conducted by companies in the last few years. Table 6.1 gives an overall view on the relevant projects that were submitted to PSA. These input are presented “as is” from the information received. PSA hopes that this will be utilized as a point for experience transfer between companies. Please note that the input has been translated roughly into English.

<table>
<thead>
<tr>
<th>Company</th>
<th>Project</th>
<th>Description</th>
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<tbody>
<tr>
<td>Odfjell Drilling</td>
<td>Symbolizing danger</td>
<td>The company is working on new suggestions on how to make personnel aware of the hazardous zones on the drill deck. A concrete plan that has been reviewed is to lay mats that have colours to define hazardous zones. The colour/mats should indicate areas on the drill deck that are especially hazardous during operations.</td>
</tr>
<tr>
<td></td>
<td>zones on the drill</td>
<td></td>
</tr>
<tr>
<td></td>
<td>deck.</td>
<td></td>
</tr>
<tr>
<td>Odfjell Drilling</td>
<td>Reducing manual</td>
<td>It is not a high priority for automated cleaning and lubricating of drill pipes. Odfjell Drilling has developed equipment for this function and is currently installed on certain installations. Use of movement function on the adjustable table and hydraulically operated power grinder (currently utilized on certain installations). The equipment reduced the need for personnel to a certain degree in hazardous areas.</td>
</tr>
<tr>
<td></td>
<td>handling, amount of</td>
<td>Entry limitations/control to the drill deck is an action that is meant for personnel who do not have a permanent work space on the drill deck. Area classification in exposed areas is classified according to danger zones under certain operations.</td>
</tr>
<tr>
<td></td>
<td>personnel on drill</td>
<td>Polishing of all glass windows in the drill area is conducted with success against slitage.</td>
</tr>
<tr>
<td></td>
<td>deck.</td>
<td>Rig poles and adjusting methods have been picked as areas for standardization. Here the weight balance is used on certain installations. It is viewed as an old-fashioned and not very effective system.</td>
</tr>
<tr>
<td>Hydro/</td>
<td>Safe Drill Deck</td>
<td>Projects are implemented by Hydro. The objective is to work out a plan and implement best practice methods for good planning and management of activities on the drill deck. It is also about the correct use and proper follow up on the drill deck and deck, correct communication and use of radio. There is a special focus on the proper feedback and confirmation on messages. A permanent colour coding system of lose pipe handling system.</td>
</tr>
<tr>
<td>Odfjell Drilling</td>
<td></td>
<td>The focus is now on work management in the drill area - development of best practice and training on these issues. Odfjell Drilling has implemented safe drill decks on 2 of its floating rigs that is currently operated by Hydro.</td>
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<tr>
<td>Company</td>
<td>Project Description</td>
<td>Details</td>
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<tr>
<td>Hydro</td>
<td>Work with crane lift</td>
<td>Hydro has had discussions with management and employees in the drill companies. The goals of the project are to describe expectations, discussions of experience transfer and identification of risk elements in crane-lifts. This has been conducted on installations. The themes are work management, competence, and job observations.</td>
</tr>
<tr>
<td>DONG</td>
<td>Radio connection in hearing protection for drill deck workers.</td>
<td>DONG E&amp;P have conducted research in 2000 with the workforce on the drill deck on the drill rig ENSCO 70. The study was to provide the workforce the possibility to speak with loudspeakers and microphones built into the earphones. It is not new for microphones and loudspeakers to be built in the earphones or helmet. It is often used by process operators, crane operators, and helicopter deck personnel but it is not used by the drill workforce. Since DONG wished that all personnel in noisy areas to protect their hearing with the help of from specially designed hearing protectors, we designed the loudspeakers and microphones into the hearing protectors themselves. Part of the specification was that this was Ex-ensured and could be utilized with standard UHF-radios. We bought UHF radios along with charging stations and connection switches to put on chest belts.</td>
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<tr>
<td>Weatherford</td>
<td>“All in one”</td>
<td>Weatherford is working with developing remote controlled systems to remove humans from direct contact with equipment during operations. An example of this is our “All in One” system that uses remote operated equipment to screw various pipe connections and other equipment that is used in the well.</td>
</tr>
<tr>
<td>National Oilwell</td>
<td>“Safety Brick”</td>
<td>With the increasing levels of automatic equipment on the drill deck, we saw the need to construct a system to register machine movements and a person’s position in relation to this. The idea was to build a sensor that would prevent the moving machine from colliding with a person who was not paying attention to the hazard. The system has been designed, is available and has been demonstrated in a full scale test on Ullrig in 2004.</td>
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<tr>
<td>National Oilwell</td>
<td>Electronic marking of drill pipes</td>
<td>For a period of time, National Oilwell has been working with a system for electronic marking of drill pipes. This will provide the possibility for automatic registration of drill pipes during checking in and out of the well. In addition, an operator could simply register the drill pipe by holding out a “reading meter” to register the information. He will seldom have a need to go into the drill pipe to check up serial numbers etc., but obtain this through the automatic reader. Similarly, the drill operator will have the possibility to monitor use-time intervals on each drill pipe. Drill pipes that have reached the defined limits for inspection and casing can be easily identified. The system is expected to be available in the 3 quarter of 2005.</td>
</tr>
<tr>
<td>National Oilwell</td>
<td>C-Cube</td>
<td>We have a total concept in connection with e-drift from land for a land centre where the operator can monitor the rigs operations audio visually, and integrate a two way audio visual communication. The Land Centre can see the rigs operations via a CCTV (monitor), and simultaneously follow operations via data animated logs, plots and other types of informative screen visuals. The concept includes all AV equipment, software, specially made to fit and ergonomically designed furniture and other necessary equipment and the connection of these to the rig.</td>
</tr>
<tr>
<td>National Oilwell</td>
<td>“SdiDA”</td>
<td>The Drill Information System “SdiDA” is a drill data information system that reduces the need for personnel on board a rig. In connection to the evaluation conducted in 2003, we conducted a user evaluation. All users in the field were asked how the system influences their work routines, and how SdiDA contributes toward easing their work tasks. Each user could also give his/her improvement suggestions. The results from these investigations are the basis for the next version of SdiDA. We feel that we have received valuable feedback so that we can focus on the elements in the system that needs improvements from the users’ point of view.</td>
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| Conoco-Phillips | Actions to reduce manual operations and the amount of personnel on the drill deck | All large tools will be put together on land. Use of remote operations and multi diameter grip thongs. The pipe is washed, painted and is greased on land. The use of the pipe without a need for greasing.

Use remote operated elevators and grinders with inbuilt positive feedback and dog collar. Use of remote operated mudcoating. Use of remote operated system for greasing. Use of casing pipes with integrated centering of pipe connections. A handling drill waste designed to minimize personnel exposure. Lifting system to handle BOP and marine riser. |
| Conoco-Phillips | Onshore Drilling Center (ODC) | Drill operations can be monitored from onshore in the near future. Operations can be replayed later to closer identify problems or used during training. The common discussion base and better access to information despite geographical location can lead to better decisions. |
| Statoil, Norsk Hydro, Conoco-Phillips og Total E&P | “Top 10 Network” | Statoil, Norsk Hydro, ConocoPhillips and Total E&P together have established the "Top 10 Network" forum. In this forum, operators, drill companies, and equipment manufacturers meet to discuss and exchange experiences. Drill entrepreneurs are focusing on the improvement potentials of equipment manufacturers in "down time" on equipment, "human factors"- elements and other factors such as equipment user friendliness, learning programmes for operators, equipment, documentation, service, availability of reserve parts, mobilization time of service personnel, general support in own organization and securing falling objects.

Drill entrepreneurs give grades and evaluations to equipment manufacturers. The results are presented and followed up annually by operator companies. Two meetings are held annually with every equipment manufacturer. In these meetings, improvement potentials on equipment and companies are discussed. The 2 most important subjects are noted and followed up by operator companies and equipment manufacturers. |
| Statoil, Norsk Hydro, Conoco-Phillips, and Viking Technology | Pipe handling | Through the OLF system, a revision has been conducted on OLFs Guideline 081 on pipe handling. The aim with this work is to automate manual work and unnecessary presence on the drill and pipe deck in relation to the handling of all types of pipes. The process is closely related to work conducted in "Top 10 Network".

An example of such equipment is the newly developed tool from Viking Technology that delivers tools to connect and screwing of pipes in drilling or connecting of wells. UniRough is a combined iron roughneck and casing tool that handles all types of drill pipes and all |
types of casing- and tubing pipes. In addition, the tool has an integrated mudcoats and an integrated greasing method. The tool has a unique design that makes it possible to place it around the pipe during normal operations. One can also skip moving the toll back and forth for every pipe connection that needs to be done. With this machine, one can remote operate the whole operation of connecting and un-connecting the pipes from the drill deck.

<p>| Statoil Oceaneering Kværner and Saipem | Visualisation of work operations | On Kristin, for drill operations, a 3D animated film has been developed for connections. We have a DVD with such animations. At the beginning, the most important work operations are evaluated and visualised. The work begins with ROV-operations and is used in connection with movement of heavy equipment. There are plans for further developing the tool. The tool is used in learning, work preparations, training and for common understanding of challenges on Kristin B&amp;B and external contractors. We also use the tool for work meetings on board Scarabeo 5. Feedback has been positive. Thoughts of applying the same methods on Snøhvit. |
| Statoil Smedvig | Falling objects –pictures with explanations. | Statoil in cooperation with Smedvig has developed a CD. It contains descriptions with illustrations on situations where one needs to be careful of falling object and how to avoid them. |
| Smedvig | “Operations planning” | A position to better implement planning, actions, and follow up of procedures and programmes. |
| Smedvig | “Red Zone Entry Control” | A entry control “red zone” has been implemented on the drill deck to minimize personnel exposure to hazards. Furthermore, a security roof has been built over the operators who drive the stored away equipment on to the drill deck. Such operators include: csg tong operator, iron roughneck operator and the man rider operator. |
| Smedvig | Pipe Handling and &quot;Dog holder&quot; | An extra hook on the pipe handling crane has been installed on the Pipedeck (West Venture) to better grip the pipes with various dimensions. An electronic “Dog Holder” has also been built to operate from the drill cabin to minimize the use of the manual types. |
| Maritime Well Service (MWS) | Modification of BOP control panels | A huge modification has been done on our BOP control panels. The focus for the modification was improved human machine interface. This will contribute to safer use and reduced risk for errors. |
| Maritime Well Service (MWS) | Protection against Falling Objects | The tool is developed in cooperation with various tool manufacturers to offer security during work at heights with hand tools. This includes special holders for hammers, locking ring for six edged key, etc. so that all the tools have double protection when it is lifted up from the deck. Experience transfer: Information with pictures of potential falling objects and how these can be secured can be found on our net based HSEQ supervisory system. Hand saver: Newly developed product that will stop a falling lubricator from crushing hands/arms. The Handsaver provides a safe environment to work under a hanging lubricator. It will also hold the tool holder in place during the changing of the down hole string. Work Backpack for carrying in stairways: A simple backpack has been developed. It is designed to carry small tools on the back. It allows for both hands to be free when going up the stairs. |</p>
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<thead>
<tr>
<th>Company</th>
<th>Training/Modification</th>
<th>Description</th>
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<tbody>
<tr>
<td>Dolphin</td>
<td>Training on work processes</td>
<td>Dolphin has seen the need to provide better training on the supervisory systems related to individual work processes both offshore and onshore. In this context, Dolphin is currently developing its own training module for drilling. All who work within drilling shall participate in the course and complete an exam. The training module related to drilling is based on various cases and will provide training on planning work where the relevant supervisory systems are central. The training will begin in August 2005.</td>
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<tr>
<td>Dolphin</td>
<td>Good management</td>
<td>Dolphin has seen the need to define what companies mean with real and good work management. In this context, a film has been developed to communicate the message well. The film has been shown on one of the company’s rigs. The theme is a typical work operation and the management is in the focus.</td>
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<tr>
<td>M-I Norge</td>
<td>Modification of Procon Machinery</td>
<td>The Procon machinery has reduced the contact with chemicals for the derrick man and drill wash engineer. As drill wash engineers, they have the responsibility to transport the Procon tankers, so that the use of sacks can be avoided.</td>
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<tr>
<td>M-I Norge</td>
<td>Reduction of contact with mud</td>
<td>We have adapted the &quot;Zero Hole Philosophy&quot; i.e. shaker screen. This has lead to far fewer screen than before which leads to less contact with mud for the current drill deck worker who is in the MPA. Furthermore, less lifting of screens and less assembly of shakers etc., that in turn reduce individual strains.</td>
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<tr>
<td>Kunnskapsparken</td>
<td>Lifting equipment for Grinder</td>
<td>The product is a construction to ease the lifting operations on the drill deck on an oil platform. It is meant to make lifting and placement of grinders round the drill poles and move it out of the rotary bush, simpler and easier. Grinders are very heavy and are lifted manually about once per day out of the rotary in a difficult and stressed position. Besides the stress to the body – especially the back, - hands and arms can also be caught in between the grinder and elevator during a temporary, uncontrolled manoeuvre of the top drive. In these days, when safety and work conditions are in high focus, this is a relevant supplement for simpler and safer work. With the use of this construction, one is able to lift the slip out of the rotary bushing at the same time as the elevator lifts up the drill pole. This is done without any effort on the persons. The construction can be handled by one person.</td>
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<tr>
<td>Kunnskapsparken</td>
<td>&quot;Mud Cube&quot;</td>
<td>Since the 1930’s the use of “shale shakers” has been the dominating method separate the particles from the drill mud. The method is tedious and requires supervision and manning and is there are health risks due to gasses from the chemicals and it is noisy. The Mud Cube is an invention that represents a new type of viewing apparatus and a successful method for viewing materials that contain solid material (drill cuttings) and a fluid (drill mud). This material is deposited on the top side by a rotating viewing element where the material is influenced by vibrations caused by acoustic noise sources. Pressure waves loosen up the bindings between the solid particles i.e. drill cuttings and fluids,, so that the drill waste can be separated and handled in a careful and appropriate manner, but the drill mud can re-circulate in the well.</td>
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<tr>
<td>Company</td>
<td>Product/Feature</td>
<td>Description</td>
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<tr>
<td>Offshore &amp; Marine</td>
<td>Navigator Drill Cabin</td>
<td>Offshore &amp; Marine produces modern drill cabins of high quality. The drill cabin optimizes safety and work conditions for the cabin personnel. Each cabin is tailor made for the individual installations. During construction, special focus was given to Human Factors. Some of these factors are: Optimizing the view from the operator’s seat, high-quality window wipers, lighting can be adjusted in different zones and good noise and vibration damping. The Navigator-TP Drill Operator Stool is a new generation stool that is developed and delivered by Offshore &amp; Marine. The combination of long experience and new design has resulted in a whole new product. The Navigator-TP uses a touchpad technology with intuitive control. Intuitive control is logical for humans, where logic and control interacts. It is an important factor that can contribute toward reducing risks for operator error. In addition, the Navigator-TP has ergonomic advantages, where the stool can be raised and lowered to optimize operator views when the processes are underway.</td>
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<tr>
<td>Offshore &amp; Marine</td>
<td>Drill Control System-DDS</td>
<td>The Drilling Display System for Offshore &amp; Marine is developed with the thought on how a person receives and processes information (Human Factors). DDS has simple and safe navigation in the screen. Intuitive control ensures faster operation and less chance for operator failures. In addition, DDS has the possibility for personal adaptation of the screen, adapted for each user via using a password and username in the logging phase. Inbuilt report generator informs the system’s situation. It ensures operation, simplifies service and reduces downtime. Today, DDS for Drilling operations and for Wire Line operations are available.</td>
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<tr>
<td>Offshore &amp; Marine</td>
<td>AC-Wire line Control Cabin</td>
<td>Offshore &amp; Marine has developed advanced wire line cabins. Wire line cabins, the first in the market that are 100% electrically driven. During development of wire line cabins OM knowledge was used in cabin design, ergonomics, human factors, intuitive control, and AC-technology. Deep Well has contributed with operational experience from the wire line industry during the entire design phase. The working environment to the operator is optimized with the use of the DDS software, Navigator-TP operator stool and modern cabin technology. AC drifts gives far better detailed control of wire speed, faster acceleration and faster stops. Furthermore, it requires far less service and maintenance of an electrical system. The first 2 wire line cabins will be delivered to Deep Well during the first quarter of 06.</td>
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