PETROLEUMSTILSYNET

Audit report

Report	
Report title **Report of an audit of technology development and the use of digital well planning, automated drilling and digital twins – Equinor and *Transocean Enabler*, 11-15 October 2021**	Activity numbers **001532037** **402013003**

Security grading		
☒ Public	☐ Restricted	☐ Strictly confidential
☐ Not publicly available	☐ Confidential	

Involved	
Principal teams T-1 and T-F	Assignment leader Kristian Solheim Teigen
Members of the audit team Amir Gergerechi, Linn Iren Vestly Bergh and Kristian Solheim Teigen	Date 6 December 2021

1 Introduction

The Petroleum Safety Authority Norway (PSA) exercised supervision in the form of an audit of the implementation and use of digital well planning and automated drilling control (ADC) by Equinor and Transocean on the Johan Castberg field. The audit was conducted on the *Transocean Enabler* drilling rig from 11-15 October 2021.

Good preparations were made by Equinor and Transocean for the audit. A positive and open dialogue was pursued, along with informative presentations.

2 Background

We have intensified our follow-up of digitalisation initiatives in the industry by operator companies, vessel owners and suppliers. In that context, we have paid special attention in recent years to the development and implementation of ADC.

Introducing digital solutions and ADC is not just a matter of technology. In our follow-up, we are concerned about how the companies assess vulnerability and risk in a holistic perspective which includes human, technological and organisational (HTO) factors.

Automation leads to changes in roles and responsibilities for the players concerned, technical systems and people. Automated drilling systems can reduce risk and increase efficiency – because operations are planned executed more consistently, for example, and larger quantities of information are analysed faster and in more detail. At the same time, automation can also introduce new risk and uncertainty.

Industry players are adopting new technology and automated solutions at a rapid pace. However, we see through our follow-up that the industry does not always succeed in changing and adopting work processes in line with the introduction of automated solutions. The result can be a lack of correspondence between technology and work processes, which may in turn reduce the level of employee trust in the solutions.

To avoid increasing the major accident risk, it is important to understand how and in what ways humans interact with the system. Automation can lead to more complex systems, so that users do not always understand the underlying assumptions for actions performed by the systems. That in turn may make it difficult to take control and secure the operation when the systems fail. It is therefore important to give emphasis to human operators being able to intervene, have sufficient situational awareness and assume control when automation malfunctions.

The responsibility of participating players to meet requirements for prudent operation, continuous improvement and risk reduction also applies when upgrading technologies and introducing new solutions.

3 Objective

The objective of the audit was to monitor how Equinor and drilling contractor Transocean identified and followed up issues related to health, safety and the environment (HSE), and complied with regulatory requirements related to implementation and use of ADC and digital well planning.

When conducting the audit, we gave emphasis to the decision basis and criteria and processes, as well as to what risk assessments and analyses had been implemented, and to how these fulfilled and secured operations from a holistic HTO perspective.

Other key issues were how new technology was applied in drilling and well operations, what HSE effects this had and how risk was handled if the technology failed. We also wanted to investigate how implementation of the new systems had influenced work assignments and processes, and how those involved had been equipped to handle changes in technology, organisation and work execution.

4 Results

4.1 General

The audit's results are based on a review of relevant parts of governing documents at Equinor and Transocean, as well as of technical documentation, analyses and incident reports. In addition come presentations by and interviews with personnel on the facility. A total of 13 interviews were conducted for various positions on board. Certain areas of application for the technology were demonstrated, and we observed and conversed with operators in the plant. Random samples were taken from the management system related to the audit's subject, and processes and system for competence management were reviewed at Transocean's Stavanger premises.

Through the audit, we learnt that a number of workshops had been conducted to acquire input from operative personnel on shaping the user interface in an early design phase for the technologies. This is positive and important in relation to good technology design.

Subjects we have covered during the audit include the following:

- risk analyses for implementing new systems
- utilising experience data as part of the decision basis
- processes for completing detailed procedures for drilling and well operations (the drilling operations plan – DOP)
- competence requirements, education and training for personnel
- establishing work processes and procedures, and compliance with them
- HTO in technology development and implementation, with emphasis on human-centred design and user interfaces for ADC
- collaboration, involvement and organisation of work
- roles and responsibilities
- the companies' own follow-up.

The following six nonconformities were identified by the audit:

- lack of follow-up
- inadequate ensuring of competence
- failure to conduct analyses in choosing technical, operational and organisational solutions when implementing new technology
- inadequate workplace organisation
- inadequate procedures
- deficiencies in alarm management.

One improvement point was identified, relating to:

- inadequate updating of analyses in relation to software changes.

5 Observation

Our observations fall into two main categories.

Nonconformity: Observations where we *establish* a breach of/deficiency in complying with the regulations.

Improvement point: Observations where we *think we see* a breach of/deficiency in complying with the regulations, but lack the information to establish this.

5.1 Nonconformities

5.1.1 Lack of follow-up

Nonconformity
Equinor had failed to conduct and follow up internal verification or system audits to check that elements in its own and Transocean's management systems had been established and functioned as intended.

Grounds
Installation and utilisation of ADC technologies were a requirement and precondition for executing drilling operations set by Equinor for its drilling contractor.

How far Transocean fulfils the goals set in the contract is measured by several parameters, including speed and efficient use of ADC technologies in operation. This measurement included using a number of key performance indicators (KPIs).

At the audit kick-off meeting, Equinor explained that ADC technology is developed and delivered by a supplier, that the end-user is the rig owner (Transocean), and that a technology supplier collaborates with a classification society on testing and assessing the technology's internal risk. Furthermore, it was explained to us that change and operational risks were to be handled through Transocean's management of change (MoC/RMR) processes, and that it was Transocean which would assess operational risk. Identified risk would be followed up through the development of work procedures for ADC technologies.

We obtained confirmation during our audit that Equinor had not conducted its own verifications or system audits to ensure that Transocean had established processes which functioned as intended for identifying and handling operational risk related to implementing ADC. That applied to processes for identifying technical, operational or organisational weaknesses, and other faults and deficiencies related to implementation. Nor had Equinor established a verification plan for following up ADC on *Transocean Enabler*.

Follow-up was deficient in the following areas.

- Transocean's compliance with the regulatory requirements for competence, education and training in connection with introducing ADC technologies on the facility. See nonconformity 5.1.2.
- Transocean's analyses and assessments of local operational risk conditions when introducing the ADC systems on *Transocean Enabler*. Equinor had not followed up that Transocean's handling of change and operational risk was established and functioned as intended. See nonconformities 5.1.3 and 5.1.5.
- Risk associated with utilising KPIs. Equinor had not adequately assessed and followed up how the use of KPIs (scope, level and reporting of these) affected working environment factors for safe work. See nonconformity 5.1.4.

Requirement:
Section 21 of the management regulations on follow-up.

5.1.2 Inadequate ensuring of competence

Nonconformity
Transocean had not ensured that personnel on *Transocean Enabler* possessed system-specific competence with the ADC systems.

Grounds
- It emerged from interviews that deficiencies existed with regard to education, particularly equipment-specific. Personnel who were not part of the crew when the rig was new or the systems had been installed received little practical education and training – such as on simulators, for example.
- We were informed that the company's strategy for further development of system-specific competence and skills training was be met this through on-the-job training (OJT). Interviewees reported that OJT was not quality-assured. Nor were criteria established for when the training was to be conducted and what it should cover.
- Documentation of completed training was spread over several systems. Conversations with supervisors on board and reviews of the competence management system on land revealed that it was difficult to find and document the training received. This applied to both permanent employees and contract personnel.
- When temporary replacements were needed, availability of resources in Transocean's pool was often inadequate. Such temporary replacements were frequently recruited through agency hires. No requirements for system-specific competence were established for temporary personnel in Transocean. Agency hires were not systematically assessed against requirements for system- and

facility-specific expertise before being offered to the facility. The competence of temporary personnel was assessed individually from case to case by senior managers on board, with no systematic or quality-assured process related to these evaluations.

- It emerged from interviews that perceptions differed on whether the company had a mentor scheme. Senior managers presented this as established practice, but the audit revealed that mentoring was not provided for a number of roles and functions.

Requirement
Section 21, paragraph 1 of the activities regulations on competence.

5.1.3 Failure to conduct analyses in choosing technical, operational and organisational solutions when implementing new technology

Nonconformity
Transocean had not conducted the analyses required to ensure a prudent working environment and to provide decision support when choosing technical, operational and organisation solutions. No assurance therefore existed that the design of screen-based equipment reduced the threat of errors which could affect safety.

Grounds
- The company could not present the requested analyses of screen-based equipment (human-machine interface (HMI) verifications) carried out in connection with the introduction of the systems on the facility.
- It was explained that the design of the beAware user interface was based on standards for eyes and alarms as well as research and work processes. Neither the norms applied in shaping the interface nor the way the chosen solution otherwise met the regulatory requirements was presented in the design-philosophy documents or other documentation which described the user interface design.
- No verifications or analyses were available which assessed local operational risk conditions when introducing the systems on *Transocean Enabler*. There was an expectation that the automated mode was the default for operations. However, some interviewees argued that the threshold for assuming manual control or choosing to conduct operations manually was high. Risk factors when changing between operational modes were largely not identified or handled in work procedures, risk registers and risk analyses. Interviews furthermore revealed that personnel on board were largely unaware of the risk related to changing between manual and automated operating modes.

Requirements
Section 18 of the management regulations on working environment analysis

Section 21 of the facilities regulations on the human-machine interface and information presentation

5.1.4 Inadequate workplace organisation

Nonconformity
Transocean had failed to ensure that the workplace was organised to ensure that undesirable physical and mental loads on the individual worker were avoided, and that the probability of errors which could lead to hazards or accidents was reduced.

Transocean could not refer to individual and overall assessments of the effects related to the various working environment factors.

Grounds
It emerged from interviews and document reviews that executing personnel experienced a heavy workload and great pressure. Little was done to assess and follow this up. Examples include the following.

- Executing personnel and supervisors found that the scope, level and reporting of KPIs contributed to excessive pressure of time, which affected safe working. A substantial number of KPIs and micro-KPIs were used in connection with drilling operations. We were, for example, shown 28 micro-KPIs which measured individual operations and sub-operations in minutes and seconds. The KPIs presented were largely directed at efficiency and speed. Status of and progress for KPIs were presented daily in various meetings on the facility.
- A number of people found that a lack of general and specific system competence among temporary personnel contributed to a high workload. Lack of competence meant that demanding jobs had to be reallocated to permanent employees, whose workload was increased by the scale of temporary hires.
- It emerged from interviews that long sessions in the operator's chair imposed a mental strain which could also affect vigilance when using the ADC systems. No guidance was established for how long at a time executing personnel should remain in the chair. We were informed that it was up to the individual and their supervisor to assess when they needed relief. We were told that executing personnel could remain in the chair for three-six hours, and in some cases throughout the shift. How long personnel remained in the chair depended on activities on board as well as available competent reliefs.
- During the audit, it emerged that parallel operations and coordination in order to be ahead of schedule was on such a scale that it could reduce vigilance in the ongoing operation.

- Personnel expressed a sense of insecurity over the scale and pace of all the changes made on board. In addition to adopting new ADC systems, for example, several other IT solutions were introduced.
- No assessment had been made on *Transocean Enabler* of such working environment factors as workload, pressure of time, use of temporary hires and available competence when implementing the ADC systems. During the audit, we received the hazard identification (Hazid) reports for 2017 and 2021 as well as a risk register from 2018. The Hazid reports were general and included little on human and organisational factors or descriptive measures where responsibility for execution had been assigned. Personnel on board were largely unfamiliar with assessments of operational and organisational risk.

Requirements
Section 33, paragraphs 1 and 2 of the activities regulations on organisation of work
Section 35 of the activities regulations on psychosocial aspects

5.1.5 Inadequate procedures

Nonconformity
Transocean had not ensured that procedures related to ADC systems were designed and applied in ways which fulfilled their intended functions.

Grounds

- Deficiencies existed in work procedures describing processes and instructions for using new technologies. We were given a local procedure which described the use of ADC technologies for driller's assist (DA) and the configurable automatic drilling system (Cads) with subsidiary functions. The document review showed that the early kick detection (EKD) and digitalised overview of drillstring length (eTally) sub-systems were not described in the local procedures.

- It emerged from the interviews that understanding differed over who had ownership of and responsibility for eTally. Transocean earlier used manual entries in an Excel spreadsheet to keep track of the tally (drillstring length), with responsibility for it allocated to a dedicated person. After the introduction of ADC on *Transocean Enabler*, both spreadsheet and eTally were in use without ownership of and responsibility for the latter being clearly defined and placed.

- It emerged from random sampling that the description of the performance assistant driller role had document status as a draft and was incomplete.

Requirement
Section 24, paragraph 2 of the activities regulations on procedures.

5.1.6 Deficiencies in alarm management

Nonconformity
No provision was made for alarms given in the drilling control system at any time to be accessed and actioned within the time required for safe handling.

Grounds
Transocean could not produce proof that alarm analyses or alarm rationalisation measures were conducted when implementing ADC or during regular operation, and therefore could not ensure that the alarms shall be issued could be perceived and responded to within the time required for safe use of equipment, plants and processes.

Requirements
Section 34a of the facilities regulations on the control and monitoring system
Section 31 of the activities regulations on monitoring and control

5.2 Improvement point

5.2.1 Inadequate updating of analyses in relation to software changes

Improvement point
Deficiencies existed in executing and updating existing analyses in the event of software changes which affected the risk associated with the activity.

Grounds
In the period between the installation of ADC on the rig until the time the audit was conducted, about 300 large and small software updates, fixes and improvements were carried out. It emerged from the document review and in conversations that risk assessment of software changes in the system was largely conducted in relation to the internal risk of the upgrade/change. Documentation submitted on one-off responses and conversations with personnel failed to clarify how operational and system risk for a number of these changes had been handled, either individually or collectively.

Requirement
Section 16, paragraph 4 of the management regulations on analyses.

6 Participants from the PSA

Kristian Solheim Teigen, process integrity (assignment leader)
Linn Iren Vestly Bergh, occupational health and safety, organisational safety
Amir Gergerechi, drilling and well technology

7 Documents

The following documents were used in planning and executing the audit.

BEAWARE - FUNCTIONAL DESCRIPTION
BEAWARE - DRILLVIEW GO - FUNCTIONAL DESCRIPTION
BEAWARE - WELLAWARE - FUNCTIONAL DESCRIPTION
BEAWARE - WELLREPORT - FUNCTIONAL DESCRIPTION
ETALLY - FUNCTIONAL DESCRIPTION
OPTIWOB- CONTROL SYSTEM- OPERATING INSTRUCTIONS
DEAL CONTROL SYSTEM - TECHNICAL DESCRIPTION
Z-TORQUE CONTROL SYSTEM - FUNCTIONAL DESCRIPTION
CADS CONTROL SYSTEM - FUNCTIONAL DESCRIPTION
DRILLERS ASSIST CONTROL SYSTEM - FUNCTIONAL DESCRIPTION
EARLY KICK DETECTION (EKD) - FUNCTIONAL DESCRIPTION
DCMS - DRILLVIEW - FUNCTIONAL DESCRIPTION
DRILLVIEW - DRILLVIEW ALARM SYSTEM FUNCTIONAL DESCRIPTION
CONTROL SYSTEM - DRILLVIEW - ALARM PHILOSOPHY
DCMS - DRILLERS CONTROL AND MON
DrillTronics Functional Description
DrillTronics on Songa Enabler - Rheosense test - 2017.12
DrillTronics on Songa Enabler - Songa Enabler experience
DrillTronics Topology Diagram
DT Heave & Rheosense Adaption - Functional Description
DT Heave a Rheosense Adaption- Technical Specification - IRIS report
ENA - ADC Drillers Assist Dynamic DDM Min Torque Protection
ENA - eTally Pilot Project incl beAware
ENA - Integration of DWT in CADS
ENA - OptiWOB Implementation
ENA - Replace DrillTronics PLC
ENA ADC Audit 2021.10.11.pdf
First use plan beAware
First use report TO Encourage pilot
Functional Description CADS
Realtime Rheology Test Report - DrillTronics
First use plan eTally
beAware_CoreTeam_WS1_Summary

beAware_CoreTeam_WS2_Summary
2017 - Summary - Field study 4-7 September
2018 - Summary - Field study 6-9 August final
2018 01 31 Workshop CoreTeam Summary
2018 03 15 Workshop CoreTeam_Summary
2018 04 26 Workshop CoreTeam eTally - Summary
2018 04 27 Workshop CoreTeam Release 3 - Summary
2018 06 18 Workshop CoreTeam eTally Summary
2018 06 18 Workshop CoreTeam Release 3 Summary
2018 09 10 Workshop CoreTeam Summup - AJ
2018 11 26 Workshop CoreTeam eTally - Summup
2018 11 27 Workshop CoreTeam summup
2018-01 Report user testing - CADS - Final version
2018-02 Report user testing - beAware
2019 02 - Report - Field study - Enabler
2019 02 26 Workshop CoreTeam Summup
2019-01-21-22 Workshop eTally pre-test - Summup
2019-09 Report user test - beAware pilot
2019-10-01 Workshop core team sum-up
Report after ADC 2.0 workshop
Report user testing - DrillersAssist and DrillTronics - Second UserTest
Report user testing - Integration of Drillers Assist and DrillTronics v.1.0
Report_PreStudy_SituationalAwareness_Final
Product specification 2018_04_beAware
Product specification 2018-01_Soft Torque-Z
Product specification _eTally_OnePager
Product specification CADS
Product specification Deal
Product specification drillersAssist
Product specification Soft Torque
Usability test report, eTally pilot
RP-ENA-159 Tripping by use of CADS.pdf
RP-EQU-252 ADC.pdf
JOB DESCRIPTION Assistant_Driller
JOB DESCRIPTION Chief_Electronic_Technician
JOB DESCRIPTION Derrickhand
JOB DESCRIPTION Driller
JOB DESCRIPTION Drillers Assist
JOB DESCRIPTION Drilling_Superintendent
JOB DESCRIPTION Electrical_Electronic_Supervisor
JOB DESCRIPTION Floorhand_Craft
JOB DESCRIPTION Sr_Maintenance_Supervisor_
JOB DESCRIPTION Mechanic

Competency Assessment Program.pdf
Competence Assurance Risk Matrix.pdf
Norway Offshore with ADC
Barrier mapping log sheet - TO Enabler v4.xlsx
Risk assessment - ADC.xlsx
ADC HAZID Form
HAZID Record Sheet.FINAL
HAZID report ADC implementation
HAZID Report_beAware eTally_FINAL_r02
Oversikt Hendelser og interne avvik
CCN Status Report closed and implemented Enabler
Software Register Enabler
- Presentation to the audit meeting on technology development and use of digital well planning, automated drilling and digital twins - *Transocean Enabler*/Johan Castberg
- Presentation on ADC by Transocean 11 October 2021 - status technology development *Transocean Enabler*

Appendix A Overview of personnel interviewed