Managed pressure drilling (MPD) has heralded an era of accurate and precise downhole pressure control. Not only can today's MPD systems operate in tight operational envelopes, but they, more importantly, provide dynamic real-time well control while drilling. This dynamic precision has directly enabled access to assets that were previously considered virtually "undrillable." But, how can MPD boast such success? One of the major reasons is automation. Automation can provide levels of functional control that are difficult, if not impossible, for human operators to achieve and maintain. MPD's inherent closed-loop setup, coupled with conventional methodology, naturally lends to automated applications. Furthermore, despite all the advancements in MPD automation within the past few years, there is a common misconception that current MPD systems can provide fully automatic control ("cruise control") of the entire drilling process. This is far from reality, as MPD systems today provide "supervised automation." Though there is a lot of material pertaining to the benefits and functionality of MPD automated drilling systems, there is very little technical information on how the systems actually function. The primary focus of this paper is to fill this disparate gap by examining the internals of such a system and, in turn, detailing how it actually works. The presentation will start by developing a generic framework, which is common to all MPD automated drilling systems (independent of the company). The components, technology, and architecture will all be presented in detail, which will be augmented by tracing the information flow through the system to clearly illustrate how the MPD process is actually carried out. Having established the technologies, capabilities, and limitations will become apparent. This will then be followed by examples of concrete implementations.

Co-Authors: Randy Lovorn, Kjetil Arne Knudsen

4 An overview of the successes and lessons learned using drilling automation in US land to improve efficiency, reliability, and wellbore quality.
Melanie Luthi, NOV

The growth in unconventionals, extended reach wells, and deepwater drilling is bringing about a need in the oil and gas industry for new land and offshore technologies. This technology should provide drilling optimization and efficiency, wellbore quality, repeatability, consistency, and safety while improving workforce efficacy. Drilling automation delivers these benefits by providing high-speed transmission of downhole measurements to enable closed-loop control of downhole drilling parameters and optimization algorithms. Drilling automation additionally provides a large data set useful for progressive understanding and data-driven decision making. This technology has been implemented on multiple projects in unconventional plays on US land. Field implementation has been successful saving time through faster on-bottom ROP, faster connections and survey transmission, improved well control, and a more stable BHA environment for improved tool longevity. Lessons learned from the technology utilization include log examples of time savings and performance improvements, change management approaches to support cultural adoption, and domain expertise. Optimization and control applications will continue to develop and evolve leading to significantly more efficient and safer operations, all while reducing the on-site personnel footprint. Case studies will be included in this presentation.

• Co-authors: Tony Pink, Andrew Coit

5 Real-time decision support in the automated future
Odd Erik Gundersen, Verdande Technology AS

The term automation when used about drilling ranges from fully automated rigs to automatically adjusting the commands given by the driller. Regardless, automation means giving more control to computers while taking it away from human experts. Computers can repeatedly perform tasks
consistently with a high precision seemingly forever. However, they do not have the creativity of humans to solve unforeseen problems. Thus, there exists situations in which humans will have to take the control from the computer system, similarly to how the pilot takes the control from the autopilot when critical tasks are performed. In such situations, the human decision maker must be able to acquaint themselves with the situation in very short time and gain situational awareness immediately. This require the computer system to describe the current situation as well as suggest possible actions, which are not the strengths of control theory or statistical machine learning methods typically used for automation. We predict the need for real-time situational awareness and decision support for as long as human intervention is required for any portions of the drilling process. None of the proposed automation solutions that exist in the literature and is suggested by the industry will change this need.

- Co-Authors: Frode Sørmo, CTO, Verdande Technology AS

6 A performance study of the new generation 100ton advanced technology rig
Maximilian Trombitas, Bauer Deep Drilling GmbH

More and more shallow drilling projects, especially for CBM, get more common for operators worldwide. There are only a small number of highly automated rigs on the market in the range of 500 - 750HP, which would fit for such drilling depths. To drill the high number of new shallow wells, which are in the pipeline of the operators, the new generation of high spec rigs has to proof the advantages regarding HSE and performance vs. the old conventional rigs.

This case study should show the performance and HSE results of the first CBM wells, which were drilled with the forerunner model of the TBA 100 in Botswana. Therefore the performance results of four multilateral wells in the Kalahari Desert will be discussed in a first step.

In a second step, the findings of the TBA 100 prototype, will be rolled out, based on a benchmarking of critical processes without automation during tripping, running casing and rig up/down, with a special focus on manipulating of pipes on the rig. In the end, an overview of possible automated solutions for all critical processes will be discussed and further developments to overcome some HSE issues will be presented.

- Co-author: Stefan Hackl

7 Robotic drilling
Kenneth Mikalsen, Robotic Drilling Systems

Robotic Drilling Systems AS (RDS) has since 2007 developed robotic technology to facilitate an unmanned drill floor. This has included the development of a new generation of pipe handlers, iron roughnecks, elevators, slips, control systems and man-machine interfaces, and a new machine, the drill floor robot. The drill floor robot will replace manual tasks carried out on the drill floor today. RDS presented a full-scale prototype of a robotic drill floor in 2010, and did run a numerous tests until 2012. In 2013 RDS presented an industrial version of the drill floor robot. RDS is now in a phase where they are designing and building industrial versions of all the machines and the entire system. This will conclude with an upgrade of an existing drilling rig with following test period. All machines are fully electrical robots with autonomous capabilities; designed to operate on higher-level command inputs in the form of "what to do" contra todays remotely controlled hydraulic machines "how to do". RDS would like to present the results and status from their research and development and discuss how this can be implemented in the industry in order to reduce the manning and increase efficiency in drilling.
8 Using Hardware-In-the-Loop testing to increase confidence in the control system delivery of Drilling Vessels
Tom Pedersen, Marine Cybernetics

The drill-floor is increasingly dependent on automated processes. With a number of different machines and systems cooperating in semi-automated tripping and drilling operation, the operator relies on a fully functional and fault tolerant drilling control system. It is well known that software errors may lead to delays and non-productive time and compromise safety. While the testing and verification regime for structures and machinery systems is well established, most of the computer control systems on today’s MODU’s are put into operation without independent testing and verification. Hardware-In-the-Loop (HIL) testing is a well-established test methodology in other industries such as automotive and aerospace, where high-performing and robust control systems are essential. It is a systematic and effective method for assessing the control system software in terms of functionality and robustness, and is an important tool in a technology qualification process. During HIL testing all stakeholders have the opportunity to participate in a live review of the control system, including a detailed walkthrough of all software functionality, user interface and HMI’s, robustness towards errors and integrated functions between systems and vendors. This paper will present Hardware-In-the-Loop testing as a methodology for drilling systems. This includes how independent HIL testing can be used to improve control system robustness as well as foster increased understanding of and confidence in the control system delivery between end user, owner, operator, yard, class and vendors, ultimately leading to a better, safer control system.

- Co-Authors: Øyvind Smogeli, Marine Cybernetics

9 Pre-implementation of an automation system on a North Sea platform: challenges and solutions
Benoit Daireaux, IRIS

We present the experience gathered during the pre-implementation phase of an automation system which interfaces real-time downhole simulations, thus accounting for the drilling process dynamics, to the drilling control system for subsequent semi-automatic control of the draw-works, mud-pumps and top-drive. The involved actors are therefore the automation system supplier, the drilling contractor, the drilling equipment manufacturer and the operator. All the partners were part of the pre-installation process, and we will present the challenges encountered and how those were tackled. We list below the preparatory aspects that received a special focus.

- Personal training: the drilling crew is not familiar to automation systems, therefore simulator based training sessions were performed beforehand to accustom the end-users to the final product.
- System testing and validation: the introduction of such a system is a new challenge to the industry. Specific testing and validation procedures had to be designed to ensure the readiness of the system prior to the installation.

Work procedures: the complexity attached to automation systems make it necessary to design work procedures especially dedicated to the system. The system configuration received particular attention, and special tools were developed to facilitate this crucial task. All those points will be discussed during the presentation.

12. Down hole autonomous robotic intervention systems
John Keith, Welltec UK

Interventions have been proven to extend and optimize reservoir production whilst extending the life cycle of wells. However, operating costs along with rig schedules, accommodation constraints, vessel availability, etc., can often limit the regularity that interventions are performed on.
In 1993 Welltec introduced the game changing Well Tractor to the industry. This enabled operators to move away from more conventional heavy and expensive conveyance methods such as drill pipe, snubbing units, and coil tubing. This was further enhanced by introducing an expanding portfolio of e0line conveyed mechanical solutions for intervention applications.

In 2009, BP and Welltec collaborated in a project to further develop Welltec’s patented conveyance system into an autonomous unit. The project aligned both company’s goals to establish an increased, robotized means of intervention—i.e. carrying out activities without any physical links to surface, while providing data from the tools to surface, and ultimately being able to optimize the tool from an onshore desktop. Further development could result in robots “living” within the well space, to be activated as and when they are required to undertake either mechanical or surveillance functions.

This presentation gives an insight to the project and the advantages that the technology can bring to the industry.

Kate Yuill
May 14, 2014