This trajectory profile highlights how the ECD measurements along the string provided by NOV's BlackStream ASM tool helped in monitoring wellbore conditions, not only at the bit, but also in critical parts such as the casing shoe.

The time-based log shows the annular pressure, as measured at the bit by the LWD tool, and also by three BlackStream ASM tools placed along the string. If only using the LWD tool, the client would have to rely on modeled hydraulics calculations to estimate the ECD at the casing shoe. Using the BlackStream ASM tools the ECD is measured along the wellbore and at the casing shoe, eliminating uncertainties and allowing the client to make an informed decision. Images from NOV.

Visualizing downhole data

Melanie Luthi, Sanna Zainoune and Stephen Forrester, of NOV, discuss how streaming downhole data on a job in the Norwegian North Sea helped improve both the drilling process and decision making.

When tasked with a job that included complex reservoirs and conditions, NOV opted to utilize its eVolve Optimization Service, developed within NOV Wellbore Technologies. The system equips existing rigs and rig crews with an advanced toolkit that improves performance, enables real-time decision making, and enhances analytics capabilities. The premier tier of the eVolve service, AUTOMATE, enhances wellbore quality and makes drilling more efficient while reducing well delivery times and improving safety.

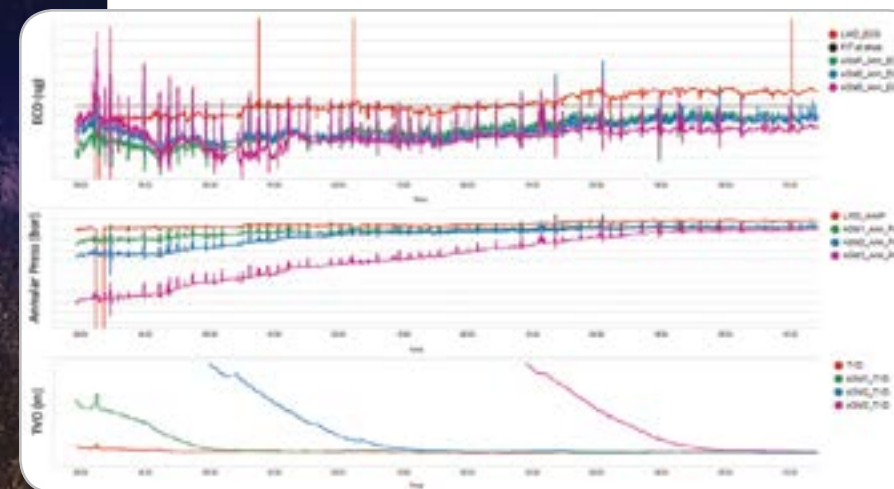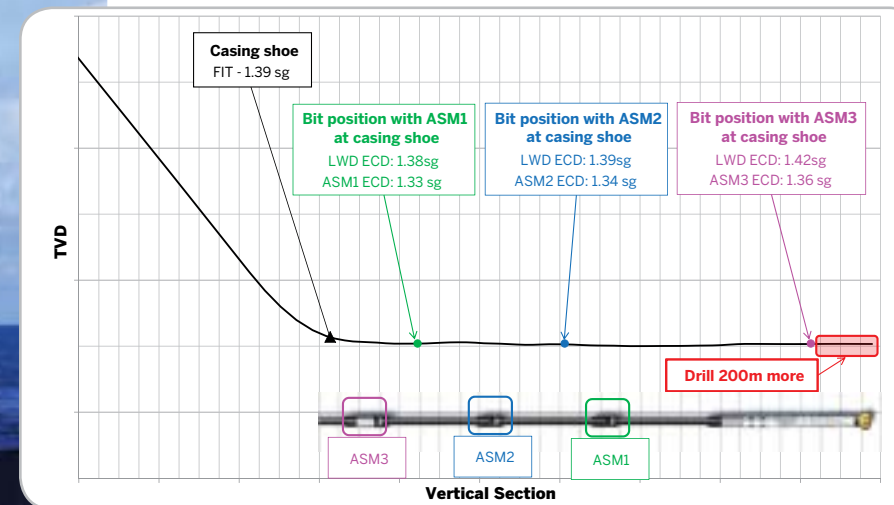Total E&P Norge is developing a Norwegian North Sea field that consists of an oil reservoir and several deeper, structurally complex, high-pressure gas and condensate reservoirs. Wells drilled in this operation have restricted pressure windows, necessitating a more complete understanding of the environment. NOV was tasked with providing Total E&P Norge with the downhole data to analyze the wellbore, which would improve decision making for more efficient and safer operations.

Based on the specific parameters of Total E&P Norge's project, NOV incorporated the BlackStream along-string measurement (ASM) tools to meet the stated objectives. BlackStream ASM tools acquire temperature, annular pressure, rotation, and three-axis vibration data at high frequencies. When coupled with the IntelliServ high-speed Wired Drill Pipe telemetry network, the BlackStream ASM tools provided streaming visualization of the downhole data to enable substantially reduced nonproductive time, improved wellbore integrity, and sustained safety.

This project has the dual intent of providing significant and immediate value to the operator while developing lessons-learned for future operational implementation and continued engineering developments. We improved both access to wellbore pressure information and the support required to incorporate this new and additional information into performance improvements across multiple phases of the drilling operation. These phases included, but were not limited to, the following scenarios:

■ A relatively long drain with a restricted pressure window was successfully drilled using the BlackStream ASM tools as part of the AUTOMATE tier of the eVolve service. Operators have conventionally relied on annular pressure measurements at the bit and hydraulics models to estimate the equivalent fluid density at the casing shoe. By using the BlackStream ASM tools, an extended dataset was collected in real time, providing a detailed picture of the pressure and equivalent circulating density (ECD) distribution both in the open- and cased hole. This real-time data enabled timely and precise optimization of drilling parameters, fluid properties, and section length, resulting in the oil producer well's drain being extended by approximately 656ft (200m) measured depth. Total E&P Norge's use of this new method to acquire data along the drillstring gave them the confidence to safely drill ahead.

■ When total losses were encountered while drilling, the BlackStream ASM tools were used to monitor annular pressure trends. The information provided by the tools helped in estimating the relative height of the annulus fluid column. The flow-off information enabled continuous monitoring of the well, even while waiting on cement. The AUTOMATE tier of the eVolve service generated better information concerning wellbore conditions and stability, ultimately providing value for the client.

■ After Total E&P Norge encountered losses, a cement plug was pumped and the BlackStream ASM tools were run as part of the cement stinger. After an injection test was performed at a low flow rate, our BlackStream ASM tools were used to monitor annular pressure trends. This data, provided in real time with high accuracy, helped confirm that the losses were efficiently sealed off. The AUTOMATE tier of the eVolve service provided the data necessary to bring clarity to the total wellbore environment, and the real-time information describing the hole condition enabled the client to resume drilling operations without further delays.

■ When a packoff occurred, the annular pressure measurements provided by the BlackStream ASM tools helped Total E&P Norge understand where the string was stuck. A sudden annular pressure increase at the BlackStream ASM tool closer to the bit was not seen by the other tool placed in upper part of the drillstring. The difference between the two readings proved that the packoff was being seen in between the two sensors. The ability to identify the packoff location from this information helped find the optimal location to cut the pipe without having to run a wireline freepoint indication tool. The AUTOMATE tier of the eVolve service provided real-time information that described the hole condition, enabling the operator to safely manage a critical situation.

Acquiring data from distributed sensors along the drillstring in real time reduces lost time, increases performance, and enables real-time decision making. An improved understanding of ECD and equivalent static density distribution and fluid behavior along the wellbore is a vital component of the decision making process.

As the industry seeks to advance wellbore technologies through new developments in automation and optimization, NOV has successfully implemented the AUTOMATE tier of the eVolve service.

The value derived from this operation in the Norwegian North Sea is just one example of enabling clients to more efficiently and effectively address challenges and meet objectives. Moreover, NOV's commitment to ongoing development of software applications and processes for implementation in future projects ensures that the company will continue to learn how to better serve and add value to worldwide client operations. **OE**

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Stephen Forrester, a marketing and technical communications writer with NOV, worked as a contributing editor on this article.