NAVIGATING THE UNDERGROUND LABYRINTH

John Evans and Brian Jansky, Gyrodata, discuss the importance of accurate data in spatially complex oil and gas drilling operations.

Over the last decade, many oil and gas producing basins have matured into a competitive field of producers that demand fast work in crowded spaces. Technological development has allowed oil and gas companies to gain a better understanding of a reservoir's resource and production potential, as well as improve safety and increase operational efficiencies.

In this era of multi-well pad drilling, operators must adapt to drilling environments where tight wellbore spacing increases the concern that a wellbore collision could take place. Whether unforeseen drift occurs while drilling a surface hole or clusters of vertical wells with inclination-only surveys reside in a lateral corridor, the risk of a well collision is present in every phase of unconventional drilling. An unexpected collision can bring about catastrophic consequences, such as a blowout, which can lead to injury to operating personnel as well as other health, safety and environmental (HSE) issues. The precise placement of the wellbore is critical for safety reasons as well as a major factor in maximising profitability.

The precision of today's surveying technology has rendered yesterday's wells somewhat abstract. Producers cannot assume that wells exist precisely where previous surveyors (who used less accurate measurements) charted them. Operators must treat any potential wellbore collision as a high-risk event with grave consequences that must be managed systematically. When an operator or driller identifies a potential risk, they should implement processes to mitigate it. The adoption of precise gyro-while-drilling (GWD) surveying, precision steering with rotary steerable technologies, comprehensive survey management services, and remote operation centre (ROC) monitoring are means of reducing collision risks.

Surveyors and drilling engineers use the term 'ellipsoid of uncertainty' (EOU), which identifies the area a well is likely located. An EOU is the result of the accumulation of all the uncertainties related to the tool and reference used. An important aspect of EOU is that it does not consider gross errors and therefore, for it to be meaningful, procedures and checks need to be in place. For anti-collision and target sizing applications, it is crucial that uncertainties are kept within the modelled value. The Industry Steering Committee for Wellbore Survey Accuracy (ISCWSA), also known as the SPE Wellbore Positioning Technical Section, developed the framework for error models as a way to try to standardise the uncertainty of downhole surveys. The error model together with the well trajectory and location, given that the survey passes the quality control, provides an estimation of the uncertainty.

To respond to all of these factors and navigate today's spatially complex field of fossil fuels, Gyrodata has developed systems of advanced survey technologies that are integrated with robust operational support.

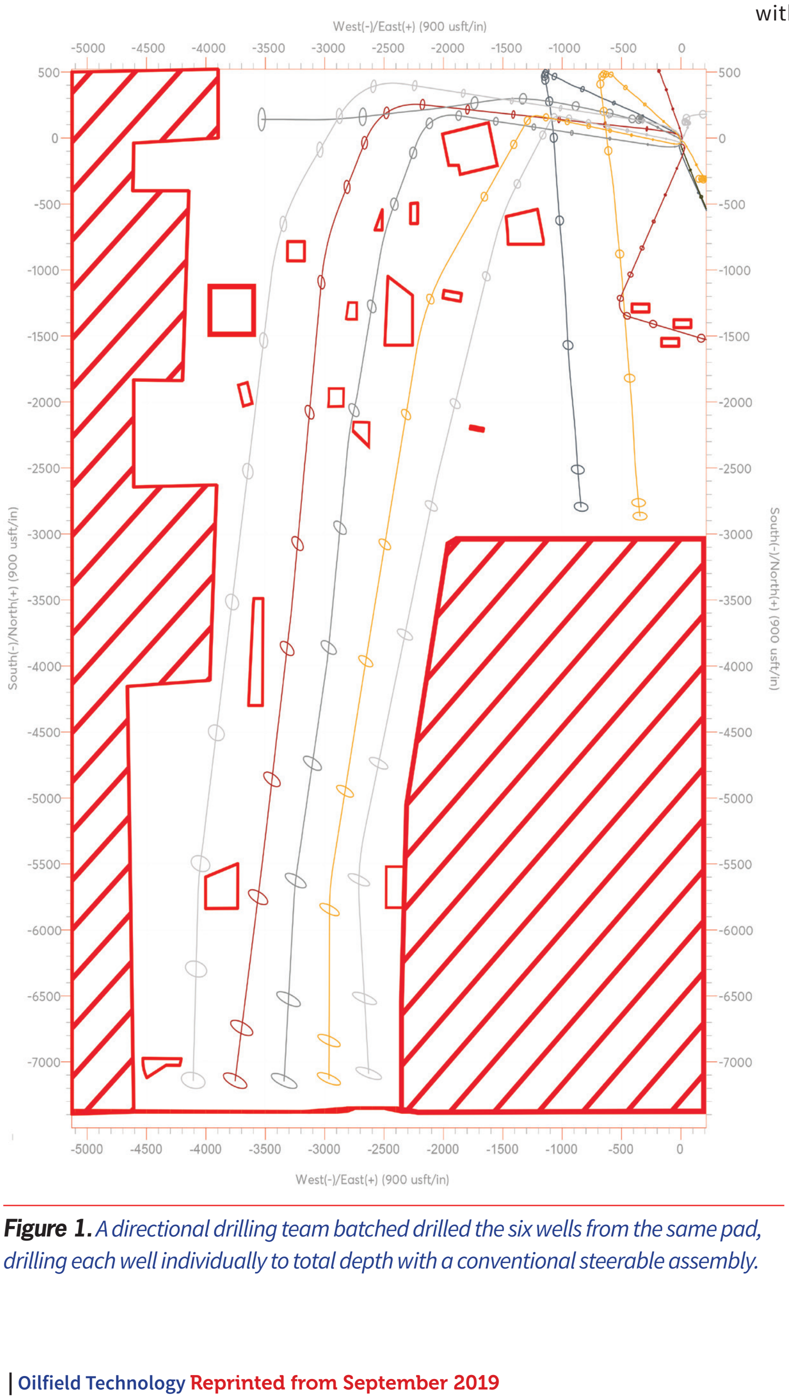

Figure 1. *A directional drilling team batched drilled the six wells from the same pad, drilling each well individually to total depth with a conventional steerable assembly.*

Tool comparison

When drilling a well, the actual trajectory of the well must be regularly measured to ensure that it is aligned with the planned trajectory. Historically, operators have relied on magnetic measurement-while-drilling (MWD) surveying technology as a solution for well path determination and its position in 3D space. MWD tools take measurements of the magnetic and gravity field and compute azimuth and inclination. In ideal conditions, this method works well, but difficulties arise in or near casing, where magnetic interference can induce significant errors in azimuth related to distortions of the Earth's magnetic field. Of course, there are ways to compensate for magnetic interference, but the corrections are hard to quantify and do not work in all scenarios.

Alternatively, drillers can utilise GWD technology, which is not impacted by magnetic interference. Operators can use GWD tools when magnetic interference is an issue and then switch to magnetic MWD tools once they are free of this interference. Gyro survey systems determine the direction of the wellbore (azimuth) by using measurements of the horizontal components of the Earth's rotation. This process is referred to as gyrocompassing. Gyros utilised in GWD tools use small rugged spinning mass electro-mechanical technology. Over the last few years, GWD technology has evolved from near vertical to high inclination systems of high accuracy. These systems offer improved reliability of the data, which allows drillers to have confidence that the resulting survey is representative of the true wellbore trajectory.

Data centres and the flow of information

ROCs are multidisciplinary collaboration hubs that combine the expertise of engineers, technicians, and managers who monitor wells in real time from offsite locations to take full advantage of operational potential. Before ROCs were introduced into the market, operators faced numerous performance challenges when they were drilling in crowded oilfields or in remote areas that had wellbore stability and service reliability issues. Drilling engineers and well planners who work within ROCs offer a solution-based approach to address directional control challenges, wellbore collision risk, and performance optimisation.

The company's ROC, (Guide Center), specialists use survey tool error modelling, axial interference correction algorithms, in-house multi-station analysis solutions (GMAS), and anti-collision monitoring to ensure safe and efficient drilling operations. Anti-collision and real time monitoring services provide clients with the safest recommended path to avoid offset wells and lease lines, as well as other potential hazards. Proprietary software technology is deployed within the Guide Center for real time data analysis. This provides clients with a higher level of confidence in wellbore placement. Tool error modelling helps clients make decisions regarding which survey tools to use to reduce the EOU, so they can safely navigate through populated pads or fields.

Case study: Barnett Shale

Gyrodata recently worked with a leading global private equity investment firm that develops oil and gas assets. The customer's project, located in Texas, US, was in an urban neighbourhood that included homes and buildings. A team within the Gyrodata Guide Center analysed the data that the firm had compiled to drill six wells on a single pad in an area that already contained 14 existing wells. They had identified several limitations with regard to well placement due to the risk of well collisions. They also dealt with the issue of drilling around land tracts that were not leased by the operator. To further complicate the planning within the site, there were a total of 20 smaller restricted zones with multiple locational discrepancies regarding wellhead location and five plugged wells that were still under pressure.

To navigate the area, well planners and engineers ran numerous scenarios to identify which survey equipment was best suited to give the directional team the best chance for success. The well trajectory needed the smallest ellipses possible in order to navigate this maze of obstacles. The final drilling and survey plan included:

- Full directional service with 24-hour support.
- MWD – MagGuide, which enabled real time monitoring of survey parameters based on magnetic measurements.
- GMAS, the company's MWD with multi-station analysis corrections.
- GyroGuide GWD, which collected real time survey data at all inclinations based on gyro measurements.
- Anti-collision monitoring – real time monitoring.
- Drop multishot – GyroGuide Memory survey drop at total depth.
- Wireline gyro surveys for post drilling uncertainty reduction.

24-hour anti-collision monitoring was mandatory to ensure that the well trajectory was followed and drilling into an unleased parcel was prevented. Onsite personnel and Guide Center support specialists analysed every survey to ensure that they followed an accurate approach. The onsite directional team also helped ensure that anti-collision procedures and practices were followed and that there was strict adherence to the well plan. Due to the vast development of the field, offset wells containing steel casing caused magnetic interference through many parts of the well paths. As a result, survey specialists needed to deploy gyro tools to mitigate the magnetic interference affecting the MWD tool and provide a reliable EOU.

Survey specialists took raw data from the MagGuide MWD tool and ran it through GMAS algorithms, which provided multi-station analysis. They utilised GMAS to make magnetic corrections where possible, which reduced the number of gyro runs and saved the operator time by increasing the efficiency of the operation. It also helped to reduce costs. They also used a drop multishot survey (through the GyroGuide Memory) and continuous multishot survey (by employing the GyroGuide Real Time). These two survey solutions were used to confirm the survey data that they had compiled, reduce the survey uncertainty, and serve as quality control for the MWD system and GMAS corrections.

This process helped the onsite survey specialists provide the most accurate data possible. As a result of these factors, the onsite directional team was able to ensure accurate wellbore placement in reference to the well plan. This enabled the well to be drilled in a safe and efficient manner, and precisely land it on target.

A directional drilling team from Gyrodata batched drilled the six wells from the same pad, drilling each well individually to total depth with a conventional steerable assembly. A gyro survey was performed on the conductor to verify accurate tophole wellbore positioning. For each well, the directional team used a directional bottomhole assembly (BHA) with GWD. The directional drilling team used the GWD's gyro toolface to start the nudge away from casing, as per the well plan. The paths of the wells were very complex. Some wells had trajectories that built more than 90° from vertical. The six wells required inclination and azimuth directional control in the upper section of the well in order to place the bottomhole location within the planned lateral target formation, while also optimising collision avoidance and drilling performance.

Gyrodata was able to successfully drill this challenging six-well pad in close proximity to existing producing wells, future planned wells, and hard lines associated with the unleased tracts of land. Experts from directional drilling, measurements, and survey management collaborated to execute this extremely complex project in a safe and precise manner.

Conclusion

Oil and gas drilling operations typically entail a wide range of complex and challenging scenarios, as there continues to be an ongoing push to maximise reservoir economics. For complex scenarios, there is rarely a one-size-fits-all approach. Instead, oilfield service providers and operators must provide customised, comprehensive drilling solutions, which require a lot of collaboration to ensure operations run smoothly. Solutions, such as gyroscopic surveying tools, MWD tools, mud motors, and real time operation monitoring services, can contribute to successful drilling under challenging circumstances. These solutions also allow operators to manage costs more effectively. As operations become even more complex, it will be interesting to see how the overall drilling industry continues to change and respond to obstacles. Technological advancements will surely contribute to the persistent pursuit of innovation.