H&P Technical Paper Abstracts

SPE-IADC

March 2020

Galveston, Texas

IADC/SPE-199556-MS

Directional Drilling Automation: Human Factors and Automated Decision-Making

Bill Chmela, Helmerich & Payne Technologies; Sarah Kern, Helmerich & Payne IDC; Tyler Quarles, Sashmit Bhaduri, Randy Goll, and Collin Van, Helmerich & Payne Technologies

This paper was prepared for presentation at the IADC/SPE International Drilling Conference and Exhibition held in Galveston, Texas, 3–5 March 2020.

Abstract

Inconsistent directional drilling performance has cost the oil and gas industry billions of dollars in drilling costs, missed production potential, and increased lifting costs. While some directional drillers perform at a high-level, others often fail to properly compensate for multiple variables seen while drilling. Automation of the directional drilling service including automated decision-making is proving to be a viable solution to this problem and has been implemented in the drilling of thousands of wells in North America in recent years.

A joint industry project (JIP) affiliated with the IADC (International Association of Drilling Contractors), SPE DSATS (Society of Petroleum Engineers Drilling Systems Automation Technical Section), AUVSI (Association for Unmanned Vehicle Systems International), Southwest Research Institute, Energistics, and the OPC (Open Platform Communications) Foundation has created a *Drilling Systems Automation (DSA) Roadmap* to help the industry understand the direction of drilling systems automation. In this roadmap, the authors suggest that the transition from humans to automation in the general drilling space can occur across four cognitive functions: acquiring information, analyzing and displaying information, deciding action, and implementing action. They also suggest that there is value in partial automation.

This assessment is accurate when applied to directional drilling; over the past few years many individual directional drilling tasks have become either fully automated or partially automated, each bringing significant value to the operation. These individual automated tasks systematically link together, moving toward the fully automated rig.

Continuous real-time updating of the bit position is one of the many critical analysis steps that can be automated, driving steering decisions. The practice of accurately predicting bit position and trajectory is a skill that is artfully developed by expert directional drillers over many years. To demonstrate the value of partial automation, a specific example is presented where the continuous calculation of the real-time bit position and its trajectory is fully automated, showing that the analysis and decision-making performed by the automated system is faster and more accurate than performed by human directional drillers. Although the details of only a single automated task is the focus of the case study, it is important to realize that it is just one of many automated tasks currently implemented in the field on the path to full automation.

In the transition from human to automated processes, roles and responsibilities must change both on the rig and in the office in order to fully benefit from its value potential. With most of the heavy cognitive lifting performed by a machine, a single directional driller can now work remotely and manage the directional control of multiple wells simultaneously. This remote directional driler can perform data analysis in a structured scientific manner. Automation incorporates the science, integrates previously siloed best practices and individual knowledge, and allows for *continual consideration of the economic consequences to the asset from each decision*.

IADC/SPE-199574-MS

Foothills Drilling Performance Improvement – A New Transversal Approach

Carlos Augusto Rojas-Mendizabal, Total E&P Bolivie; Stephane Menand and Mahmoud Farrag, DrillScan; Cesar Villegas, Schlumberger; Leandro Vennier, Baker Hughes; Pierre Leclerc, Total

This paper was prepared for presentation at the IADC/SPE International Drilling Conference and Exhibition held in Galveston, Texas, 3–5 March 2020.

Abstract

Total E&P initiated a drilling campaign in 2018 near the foothills of Bolivia where wells can be extremely challenging and lengthy to drill. These wells mandate exhaustive planning due to the geological complexity and abrasive environment prone to severe wellbore instability. Through a unique and collaborative approach of competitive service companies, engineering resources were combined and leveraged to identify and mitigate risks of wellbore instability, losses and drilling dysfunctions. Combining service companies' resources and knowledge allowed to set up a new transversal approach to challenge old paradigms and implement new drilling tools (directional drilling and bits) adapted to this environment.

The present paper reflects the approach taken to solve these technical challenges: Adaptation of new drilling technologies based on local experience with downhole tools. New fluids strategy based on operator's knowledge/experience with transversal geology and geomechanics interactions. Rate of Penetration (ROP) improvement roadmap based on data analysis and engineering implemented through the processing of offset wells drilling data, real-time monitoring of Mechanical Specific Energy (MSE) and drilling dysfunctions avoidance. Team spirit-based approach where all actors of the execution embarked on board.

As a result, the first well was finished ahead of the projected authority for expenditure (AFE) (87 days) without technical or geological sidetracks (which are common in the Bolivian foothills due to the geological complexity). Overall ROP was improved in most sections of the well and considerably less bottom hole assemblies (BHA) trips were required to complete the well. Wellbore quality improved in comparison with offset wells with less overgauge (OVG) and tortuosity. Customization of downhole tools for specific hard-abrasive-intercalated formations in foothills along with optimum drilling parameters were critical to achieve this success and is discussed in this paper.

Thanks to this new transversal approach and unique collaboration among all the competitive service companies, an overall reduction of drilling dysfunctions was achieved. Optimization efforts were successfully implemented by following a roadmap which focused on mitigating dysfunctions based on MSE and lithology. All this was possible through the creation of spaces and opportunities for open dialogue with contractors and service companies (training, meetings, workshops, debates) and information exchange with proper documentation, action planning, follow up and debriefings, valuing ideas, embarking everyone and encouraging to avoid silo thinking by taking care of good integration and interfaces.

IADC/SPE-199632-MS

Automating Anti-Collision Calculations for Autonomous Drilling Systems

Marc Willerth, Andrew McGregor, Sashmit Bhaduri, and Joshua Eaton, Helmerich & Payne Technologies

This paper was prepared for presentation at the IADC/SPE International Drilling Conference and Exhibition held in Galveston, Texas, 3–5 March 2020.

Abstract

The complexity of calculation along with the high stakes of error has traditionally meant that efficient implementation of anti-collision procedures required an experienced operator at the drill site. This is not ideal, as the expertise is only truly needed in isolated high-leverage situations. With the advent of automated drilling systems, more expertise is being moved from the drill site into the office. A system is proposed capable of balancing the efficiency of automated systems while retaining the safety afforded by expert supervision. Changing the way collision avoidance is conducted enables the full realization of the benefits of autonomous drilling systems.

The varied nature of collision avoidance operations makes it unlikely that the entire process will be completely automated in the foreseeable future. Sawaryn, et. al. (2018) outline eight elements required for a successful collision avoidance system. These elements are analyzed for the extent to which they can be automated. Historically, wellbore collisions are caused by operational shortcomings rather than a failure of calculations. The ideal system design would minimize any delay to the drilling process by focusing human efforts on validating the operational processes prior to drilling while automation handles the routine collection of data and application of calculations during drilling.

An autonomous drilling system can safely and efficiently execute in a collision avoidance scenario with the supervision of a remote monitoring center and appropriate risk-based escalation rules. Remote experts ensure that operational setups are valid prior to the start of drilling and that escalation conditions are clearly outlined. Separation-based cost functions are used to enable the autonomous drilling system to proactively steer away from escalation events. Mechanisms are defined that automate updates to provisional wellbore trajectories based on the automatic validation of survey data, projection of future possible well paths, and execution of separation calculations against separation rules. At necessary intervals human review confirms definitive wellbore trajectories, survey programs, and convergence plans. This moves tasks that require heavy human involvement outside of the critical drilling workflow. At appropriate risk levels, escalation occurs to increase the immediacy of the supervision, up to and including a stop-drilling condition requiring full management of change.

As more autonomous drilling systems are introduced in dense drilling environments, there is an increasing need to harmonize the requirements of these systems with collision avoidance workflows. By leveraging the ability of automation to identify critical points in the process, it is possible to move expertise to remote centers without sacrificing efficiency. Effective use of computer-assisted well planning can enable quick approval an optimal way forward leaving the execution to the automated drilling system.

IADC/SPE-199644-MS

Automated Sliding: Efficiencies Achieved in the Next Stage of Drilling Automation

Aaron Hausher, Helmerich & Payne IDC; Sarah Kern, Helmerich & Payne Inc.; William Chmela, Jeremy Cantwell, and Kevin Mims, Helmerich & Payne Technologies

This paper was prepared for presentation at the IADC/SPE International Drilling Conference and Exhibition held in Galveston, Texas, 3–5 March 2020.

Abstract

In the current drilling climate, efficiency is king: do more with less. This motivation drives disruptive technological innovations in automation of the drilling process. Drilling automation can contribute to this efficiency specifically by automating the sliding process. The paper discusses a case history involving one operator's deployment and results of an automated sliding system.

The goal for automating the sliding process was to reduce personnel on location, drive consistency, increase wellbore quality, and shift the focus from an ROP-focused mindset. The operator had initially used bit guidance software for approximately one year, which was a significant backbone component of the automated sliding system. The automated sliding software was installed and tested on the rig, and then deployed on a six-well pad for initial observation and analysis.

After deployment, the automated sliding system successfully completed slides in all four surface sections on the pad. The first complete well on the pad, drilled to total depth, successfully completed slides in the vertical, curve and lateral sections. The rate of automated sliding exceeded initial goals, and the rig proceeded to drill several more wells at near-100% utilization rates. The automated decision-making system compiled detailed drilling set points and specifications used to form the most consistent and efficient method to drill the well, formation by formation. The total number of third party directional drillers was reduced, increasing overall safety and lowering costs.

Automating the sliding process, with this degree of accuracy and lack of human intervention through automated decision-making, represents a significant step change in the drilling industry milestones on the road to full automation. Best practices regarding adoption and deployment of automation technology will contribute to ensuring success in the ever-increasing field of drilling automation.

IADC/SPE-199660-MS

Automated Geosteering with Fault Detection and Multi-Solution Tracking

Stefan Maus, Timothy Gee, Alexander M. Mitkus, Kenneth McCarthy, Eric Charney, Aida Ferro, Qianlong Liu, Jackson Lightfoot, Paul Reynerson, and David M. Velozzi, H&P Technologies; Rocky Mottahedeh, United Oil & Gas Consulting Ltd

This paper was prepared for presentation at the IADC/SPE International Drilling Conference and Exhibition held in Galveston, Texas, 3–5 March 2020.

Abstract

Development of autonomous drilling technologies requires the automated analysis and interpretation of Logging While Drilling (LWD) data to optimally land the well in the target formation and keep it in the pay zone. This paper presents a fully automated geosteering algorithm, which includes advanced LWD filtering, fault detection, correlation, tracking of multiple interpretations with associated probabilities and visualization using novel stratigraphic misfit heatmaps.

Traditional geosteering uses manual stretch, compress and match techniques to correlate measurements along the subject wellbore against corresponding reference type logs. This results in a crude representation of strata by linear sections with offsets at fault locations. Instead of automating this manual process, we instead determine the possible interpretations as solutions of a geophysical inverse problem in which the total misfit between the subject and reference data is minimized. Interpretations are parameterized as discontinuous splines to accurately follow curved strata interjected by fault offsets. To account for ambiguities, multiple possible interpretations are continuously tracked in real time and assigned probabilities based on the misfit between the latest measurements and the reference data. Unrealistic solutions are suppressed by penalizing strong curvature and large fault offsets. Viable interpretations are simultaneously visualized in real time as paths on a novel stratigraphic misfit heat map, where they may be corroborated against valleys of minimal misfit between the subject and reference data. The user can guide the interpretation by setting control points on the heat map which the automated solutions must respect.

The algorithm has been validated using wells from different regions across North America for which previous manual geosteering interpretations are available. The automated spline interpretations represent the actual curved strata more accurately than manual interpretations. Operationally, the automated interpretations can be provided within minutes compared to typical manual turn-around times of hours. Automation leads to more consistent and repeatable results, removing the subjectivity of manual interpretations.

IADC/SPE-199669-MS

Early Identification of Drilling Collision Risk Using MWD Survey Quality Data

Nicolas Cosca and Marc Willerth, Helmerich & Payne Technologies

This paper was prepared for presentation at the IADC/SPE International Drilling Conference and Exhibition held in Galveston, Texas, 3–5 March 2020.

Abstract

By identifying changes in the error characteristics of magnetic surveys while drilling, crews can be alerted early on to a potential close approach with an offset well. This alert does not require expert analysis prior to trigger, enabling safer deployment of remote monitoring and drilling automation systems.

That magnetic interference can be used to identify offset wells has been long known, however identification of the interference pattern is not always straightforward. Safe operation in close-approach situations currently requires proactive monitoring by an expert. This new method uses a conditional expectation of survey quality parameters ("marginal sigma") trained on previously accepted surveys to identify new errors. Quality control data from several wells with known close approaches are analyzed with this technique alongside traditional survey quality assessments. Automatic flagging of high-risk surveys for review would enable proactive monitoring workflows to be replaced with "management by exception" workflows making more efficient use of expertise.

Survey quality data from several close approach scenarios were analyzed using traditional QC methods along with the marginal sigma method. Traditional QC measures are not readily adapted to automated identification of offset wells. Problematic situations include cases where:

1. Surveys are already failing QC for a known reason,
2. External interference temporarily improving QC data masks the problem,
3. The onset of interference is too small to cause an immediate QC failure.

In light of this, traditional QC parameters still require proactive monitoring by an expert individual. Using the marginal sigma estimation, even small changes in magnetic measurement patterns are identified and escalated for review. These changes are often detected with even a single outlier survey, implying that escalation would occur as quickly as with the most vigilant observer. This system would be of particular value in situations where a limited number of experts are used to oversee a high volume of work, such as remote monitoring in North America Land, or in the future, supervising autonomous drilling systems.

The proposed system changes the drilling supervision requirements for what has previously been a high-risk scenario (collision avoidance drilling). Proactive monitoring by an expert can be safely transitioned to a "management by exception" system enabling better utilization of resources.

IADC/SPE-199675-MS

Nonlinear Dynamics of a Drillstring Immersed in a 3D Curved Well, Simulations and Experiments

Khac-Long Nguyen and Mohamed Mahjoub, DrillScan; Quang-Thinh Tran, Marie-Ange Andrianoely, Lionel Manin, and Régis Dufour, Univ Lyon, INSA-Lyon, CNRS UMR5259, LaMCoS, France; Stéphane Menand, DrillScan

This paper was prepared for presentation at the IADC/SPE International Drilling Conference and Exhibition held in Galveston, Texas, 3–5 March 2020.

Abstract

During drilling operations, the bit-rock and drillstring-wellbore contacts with stick-slip phenomena, fluid-structure interaction, and mass unbalances distributed along the drillstring yield nonlinear dynamics coupling axial, torsional, and lateral vibrations. Excessive and uncontrolled vibrations may induce drilling equipment damage due to fatigue, cracking, and ruptures. Understanding and predicting the drilling dynamics become necessary to avoid those harmful vibrations.

The drillstring dynamics is modelled in the time domain using the beam finite element method. The contact between the drillsting and borehole is accounted for using radial elastic stops and the fluid effect on the drillstring dynamics is considered by two models. The initial position is obtained from a static equilibrium computation that takes into account the drillstring pre-load. The dynamics is then calculated by applying a time-integration scheme.

The dynamic model is applied to a real case of a quasi-vertical well with field measurements of downhole vibrations along with surface data. Numerical simulations are carried on a drilling assembly of several kilometers length. The obtained results are compared to the experimental data to analyze the structure vibrations such as forward and backward whirling and stick-slip. Knowing the various uncertainties of some physical quantities like the friction factor and fluid damping, a series of simulations varying the model hypotheses are conducted and the results are compared to clarify the importance of each phenomenon.

The novelty of the proposed dynamics model is its ability to consider a realistic geometry of drilling assembly in 3D curved wells with fluid flows, and to give a complete study of the coupling phenomena between axial, torsional, and lateral vibrations.