About Geoservices

Geoservices provides services that support oilfield drilling performance and formation evaluation. Since its foundation in 1958, it has built an unrivaled base of expertise and specialist technologies in a range of essential areas that help optimize field exploration and development.

**Technology**
In addition to having access to the world-leading technologies of Schlumberger, Geoservices benefits from the specialized products and techniques delivered by its dedicated research and engineering facilities in Roissy-en-France, Paris. These facilities also enable experiments to be conducted on a range of upstream oil and gas activities. Key laboratories include:

- **Gas Systems Laboratory**
  Design and prototyping of gas analyzers used either for compositional or isotopic analysis of hydrocarbons flowing up the well with the drilling fluid. Analysis techniques include gas chromatography, mass spectroscopy, and laser absorption spectroscopy (isotopes).

- **Mud Laboratory**
  Development of techniques to maximize hydrocarbon extraction from the drilling fluid. This enables real-time monitoring of hydrocarbons flowing through the reservoir.

- **Advanced Cuttings Characterization Laboratory**
  Evaluation of advanced analytical techniques such as X-ray diffraction (XRD), X-ray fluorescence (XRF), and diffuse reflectance infrared spectroscopy to characterize cuttings while drilling. This is primarily used to characterize mineralogy, elemental composition, and total organic carbon (TOC) content to predict zones of interest in unconventional reservoirs.

**People**
Since its founding, Geoservices has recognized the importance of a highly trained, highly motivated, and culturally diverse workforce. Engineers are recruited from the best universities worldwide to build a workforce of different nationalities and a healthy gender balance. The structured career development program includes fixed-step training and relevant competence certifications.

**Health, safety, and environment (HSE)**
Geoservices has a long-standing commitment to the highest standards for the health and safety of employees, customers, and contractors as well as to the protection of the environment and the communities in which it works.

The global Schlumberger HSE Management System defines the principles by which operations are performed worldwide.

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**Products and Services**

**Surface logging services**
As the recognized industry leader in surface logging services, Geoservices has developed unique measurement technologies, data acquisition platforms, and analysis and reporting systems.

Accurate and timely monitoring of the lithology and pore fluid composition of the formations being drilled supports critical decisions that help drill wells more efficiently into potential pay zones.

Our specialized surface-located sensors measure mechanical, hydraulic, and engineering data while drilling, providing the basis for calculating parameters such as mud pit volumes, mud flow rate, mud weight in the shale shaker area, mud-gas level, and return flow rate.

This information helps detect unbalanced formation fluid pressures, optimize the drilling process, and maintain a safer operating environment.

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**Drilling services**
The direct alignment of our comprehensive offering of drilling-related products and services with the full range of our customers’ drilling functions and requirements reduces risk and improves performance across all drilling environments.

**Drilling performance**
A key part of drilling is managing risk in ways that make it possible to achieve high performance in wells and borehole sections where drilling efficiency is the priority. Drillers benefit from recommendations to improve downhole performance in real time based on measurement and analysis of surface parameters.

**Wellbore quality**
A range of drilling parameters related to pore pressure, hole cleaning, and wellbore stability are provided through 24/7 real-time surface monitoring and data analysis combined with predictive models. These help identify drilling risks and operational issues early, minimize NPT and invisible lost time (ILT), and increase drilling efficiency—with minimal reservoir interference and maximum returns.

**Rig operations surveillance services**
Geoservices offers the latest in digital surveillance technology. We provide a superior digital alternative to traditional analog instrumentation and driller’s consoles (primary instrumentation systems) that also functions as an advanced electronic drilling recorder with multiple built-in capabilities.

Our system enables drillers and their crews to increase the efficiency of daily rig operations by reducing NPT, lowering costs, and increasing operational safety. Built specifically as an automated system, it connects rig and onshore personnel, enabling the sharing of wellsite information such as real-time drilling data and reports in a variety of formats.

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Geoservices transformed the mud logging industry from the mere provision of geological technicians into a range of specialist services delivered by highly trained expert engineers. The company was among the first to introduce computers to the wellsite for mud logging and was one of the first oilfield service companies to have a role in the entire life of a well.

Today, Geoservices provides essential support from exploration to production at a time when drilling technologies are constantly pushing back the limits of developing resources in deep water and other challenging environments.
Surface Logging Services

Geoservices Surface Logging Services (SLS) comprise an acquisition system and geological laboratory to illuminate well stratigraphy and to monitor all events during the well construction phase for wellsite safety. Integrated with enhanced workflows, the surface logging service delivers accurate gas ratio, detection of string issues, and process performance assessment with a secured real-time transmission that enables data access from any location.

**Geoservices Surface Logging Workflow**

**Drilling monitoring**

Wellsite surveillance is performed by monitoring drilling parameters, mud properties, and toxic gases. Surface drilling data monitored includes mechanical, hydraulic, and engineering parameters; downhole drilling data monitored includes parameters imported from other sources such as downhole pressure and gamma ray.

**Formation monitoring**

Geological data is obtained by physical examination of drilled cuttings. Hydrocarbon data is obtained by the analysis of mud hydrocarbon content.
Surface Logging Units

Geoservices surface logging units provide purpose-built, climate-controlled environments for onshore and offshore operations. The units house personnel, instruments, and data acquisition systems, irrespective of external climate conditions. Fully equipped, they serve as centers for collating and analyzing drilling parameters and geological data acquired while drilling. The standard unit can accommodate up to four people full time, and the combined services unit can accommodate up to six people full time. Both have room for temporary visitors.

Applications
- Purpose-built, climate-controlled environment, onshore or offshore
- Built to the highest standards and certified for hazardous oilfield operations

Benefits
- The surface logging units are fully equipped to serve as offices, laboratories, and data processing centers
- Construction may be adapted to specific local conditions, such as extreme cold, helicopterable rigs, tropical forests, and deserts
- Cabins are pressurized, enabling operations in hazardous environments
- Pressurization and shutdown control system are included

Features
- High-quality, secured electrical circuit
- Separate workstations and laboratory equipment
- Independent air-conditioning systems included (two for the standard unit, three for the combined services unit)
- Sample-processing equipment and heating modules
- Secured chemical storage

Standard Surface Logging Unit Specifications

<table>
<thead>
<tr>
<th>Ratings</th>
<th>ST2</th>
<th>ST3</th>
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</thead>
<tbody>
<tr>
<td>Fire</td>
<td>A60</td>
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<tr>
<td>Structural</td>
<td>DNV 2.7.1</td>
<td>DNV 2.7.1</td>
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<tr>
<td>Electrical and shutdown systems</td>
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<td>DNV 2.7.2</td>
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<td>Power Supply</td>
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<tr>
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<td>Three-phase 380 V, 415 V, 440 V, 480 V, 600 V, 50 or 60 Hz</td>
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<tr>
<td>Output</td>
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<td>220 to 240 V and 110 V</td>
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<td>Power Consumption</td>
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<td>18 kV A</td>
<td>18 kV A (three-phase power required)</td>
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<tr>
<td>Optional</td>
<td>36 kV A (with enhanced gas analyzer)</td>
<td>36 kV A (with enhanced gas analyzer)</td>
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<td>Water Supply</td>
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<td>0.6 MPa [87 psi]</td>
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<tr>
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Combined Services Surface Logging Unit Specifications

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<tr>
<td>Structural</td>
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<td>Power Supply</td>
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<tr>
<td>Input</td>
<td>Three-phase 380 V, 480 V, 600 V, and 50 or 60 Hz</td>
<td>Three-phase and single-phase 380 V to 240 V</td>
</tr>
<tr>
<td>Water Supply</td>
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<tr>
<td>Standard (Worldwide)</td>
<td>0.6 MPa [87 psi]</td>
<td>0.6 MPa [87 psi]</td>
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<tr>
<td>Optional</td>
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To find out more, visit the Surface Logging Units web page.
Acquisition System

The Geoservices acquisition system enhances drilling operations and decision making through high-frequency and accurate data acquisition. With a dynamic, flexible design, the system can be easily customized to meet individual challenges.

Accurate rig data—such as torque, standpipe pressure, cement unit pressure, and weight on hook—is vital to efficient and safe drilling operations. The acquisition system features contextual panels that provide information at a glance, enabling anomalies to be identified in a fast and accurate manner. This allows corrective action to be taken at the earliest opportunity, improving safety and minimizing downtime.

Applications
- Monitoring of all well construction operations, onshore and offshore

Benefits
- Enhanced safety through quality assurance monitoring and alarms
- Reduced rig-up time with simplified sensor connection
- Reduced NPT with plug-and-play capabilities and full integration within a common database

Features
- High-frequency acquisition (up to 50 Hz)
- Automatic detection of system activity
- Linear and multipoint calibration
- Flexibility for engineering application plug-ins and hardware add-ons

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The acquisition system can connect and process data from up to 250 sensors at 1-Hz acquisition frequency, allowing full flexibility to connect different sensor types and to import and record parameters of any kind in a customizable database. This also allows acquisition at high frequency (up to 50 Hz) for a maximum of 8 sensors, selectable by the user. Analog signals are digitized directly by the field boxes located in key areas on the rig site, enabling connection to the system network with a reduced number of cables. Each field box is capable of connecting up to 12 sensors, allowing quick and noninvasive rigsite installations.

Sensors

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Advanced Monitoring Options

Using our well monitoring expertise, Geoservices tailors surface logging services to specific drilling challenges. Through early abnormal event detection and quick intervention, we can help minimize your recovery costs.

Easy Integration of Geoservices Advance Monitoring Options with the Core Acquisition System

- Pressure Integrity Monitoring
  - Real-time monitoring for pressure tests
  - Charts pumped volume versus time
  - Replay and superimposing method

- Advanced Drilling Pack
  ■ Vibrations
  ■ KPIs
  ■ Dual mast management
  ■ Mechanical specific energy
  ■ At-bit data tracking

- Torque and Drag
  ■ Pickup slack-off (PUSO) modeling
  ■ Automatic PUSO
  ■ Measurements versus model

- Fluid Displacement Monitoring
  ■ Real-time view on 2D well schematic
  ■ Pills monitoring and cement job simulation

- Automatic Flowback
  ■ Pop-up window
  ■ Automatic fingerprinting alarm

- D-Exponent
  ■ Real-time D-Exponent
  ■ Overburden and fracture gradient model
  ■ Pore pressure estimation
  ■ Fracture pressure estimation

- Automatic Flowback
  The Automatic Flowback application is fully automatic and enables close monitoring of potential well imbalance during critical operations when potential losses and influxes are likely to occur. This application is especially valuable for deepwater and high-pressure, high-temperature environments in which narrow mud-weight windows may be encountered.

Benefits
■ Provides faster detection of abnormal well balance events
■ Minimizes potential influx volume and recovery costs
■ Enables faster decision making

- Torque and Drag
  The Torque and Drag (T&D) application plots the pickup and slack-off points that are automatically recorded and detected depending on operation status. These records can be compared with a model established beforehand (T&D trend estimation) as a function of wellbore geometry, fluid, and downhole string characteristics.

Benefits
■ Optimizes wiper trips and pill frequency
■ Detects abnormal wellbore conditions
■ Enhances reaming programs and reduces ILT

Automatic flowback identification enables faster detection of well balance events.

Plot of pickup and slack-off points.
Advanced Monitoring Options

D-Exponent
The D-Exponent application provides overpressure evaluation and compaction trend estimation, interpreted by our engineers using drilling parameters acquired by the surface logging unit.

Benefits
- Ensures that mud-weight selection is appropriate for the formation being drilled
- Monitors for warning signs that indicate overpressure

Pressure Integrity Monitoring
This application closely monitors all pressure tests, including formation integrity, leakoff, and BOP tests.

Benefits
- Determines fracture pressure and equivalent mud weight (EMW) in real time
- Avoids unnecessary overpressuring during tests
- Provides accurate monitoring and recording of BOP stack tests in real time

Fluid Displacement Monitoring
The Fluid Displacement Monitoring application is used either to simulate a cement job or to evaluate the position of pills, lost circulation material (LCM), and cement plugs in real time.

Benefits
- Enables onsite premodeling of cement jobs in planning phases
- Minimizes the risk of incorrect positioning of pumped pills and plugs

Tech Report

The Acquisition System Flowback Feature Enables Fast Detection of Abnormal Mud Volume Return
Decision-ready information detects unwanted wellbore event and reduces NPT

Using the data acquisition system, Geoservices analysts observed the red profile was trending above the fingerprinted baseline for the same flow shut-off procedure. Having such a plot in real-time enabled quicker detection of abnormal well balance events, facilitated faster decision making, minimized potential influx volumes, and reduced recovery time and costs. The influx was suspected only three minutes after shut-off (10-bbl increase), and confirmation was received after five minutes (20-bbl increase).
Advanced Drilling Pack

The Advanced Drilling Pack provides a suite of tools and processes to monitor drilling parameters and process performance, enabling rig NPT to be minimized.

**Mechanical Specific Energy**
This monitoring process provides the ability to detect changes in drilling efficiency or lithological drillability variation. Generally, mechanical specific energy (MSE) increases when drillability and the efficiency of the drilling process decrease. MSE is always measured from surface, but it can also be computed on bottom to eliminate all friction effects from the borehole.

**Benefits**
- Enables cost savings through bit-replacement optimization
- Enhances bit efficiency with optimized drilling parameters

**Vibrations**
The Vibrations application provides severity assessment of axial and torsional vibrations based on high-frequency surface data.

**Benefits**
- Optimizes drilling parameters to avoid harmful drillstring resonance effects during drilling and coring operations
- Maximizes opportunities for integral core recovery
- Avoids mechanical failures and reduces cost of delivery caused by potential tool replacement and extended operations time

**At-Bit Data Tracking**
At-Bit Data Tracking uses a unique synchronization process in which lagged data measured at surface is projected to when it was at the bit. The data can be compared in real time with surface events or activities.

**Benefits**
- Enables immediate gas peak characterization
- Provides direct synchronization of “in” and “out” data for lag-time accuracy
- Enhances and speeds up the decision-making process, avoiding imbalance events and associated recovery costs

**KPIs**
Using the automatic detection of rig activity, the duration of each operation (such as slip-to-slip time) is logged and made available for time analysis, enabling the tracking and monitoring of KPIs.

**Benefits**
- Enables ILT to be quantified to detect efficiency-improvement opportunities
- Provides metrics for postwell evaluations, enabling process-optimization analysts to consistently and cost-effectively improve performance

**Dual Mast Monitoring**
The Dual Mast Monitoring application provides a dedicated process to monitor and log all operations occurring simultaneously on a rig equipped with two-derrick systems.

**Benefits**
- Enables simultaneous and flexible monitoring of all operations occurring on both masts
Vibrations Monitoring Maximizes Core Integrity

Real-time analysis and control of drilling parameters prevents breaks and fractures in core samples.

Background
During core sampling, drillstring vibrations were adversely affecting the efficiency and quality of core recovery.

Using high-frequency acquisition and dedicated processes within the vibrations monitoring service of the GN4 acquisition system, vibrations were monitored from the surface. This enabled the operator to manage drilling parameters and minimize drillstring vibrations, ensuring the recovery of a clean and undamaged core.

Technology
■ Vibrations monitoring service of the GN4 data acquisition system

Tech Report

At-Bit Data Enhances Geological Interpretation

Combined real-time technologies help correctly assess the volume of mud system, detecting deviations from theoretical calculations.

Background
While drilling a well in West Africa, the client needed to ensure lag time was accurately calculated without interrupting operations.

Accurate lag-time calculation is vital since it provides the true depth for all data conveyed to the surface, such as hydrocarbons and cuttings. Incorrect lag-time calculation may lead to geological misinterpretation and increased well costs.

Technologies
■ Real-time At-Bit Data Tracking service of the GN4 data acquisition system
■ Coriolis mud weight sensor

Tech Report
Gas Portfolio

PIONEERING THE STANDARDIZATION OF GAS SAMPLING

Today’s challenging drilling environments, coupled with the increased complexity of reservoirs, introduce factors that affect mud-gas measurements at the surface.

The Geoservices portfolio covers surface logging challenges in alignment with well complexity, providing answers in high vertical resolution to enable efficient and rapid onsite extraction and analysis of hydrocarbons.

Data standardization in any environment
Flexible and fully adaptable to meet your needs, modern gas analysis chains from basic safety gas monitoring to highly advanced solutions provide data standardization—even in harsh environments.

Geoservices industry-leading fast gas analyzers, such as the Reserval qualitative C1–C5 gas measurement service, and solid quality-control processes help to ensure data quality at all times.

Gas sampling under constant conditions
The constant-volume gas extractor enables mud to be sampled very close to the wellhead. This minimizes the degassing effect on the light components (C1–C2) of the gas into the atmosphere. The conventional positioning of gas traps in the shaker enables the degassing effect to adversely alter the gas ratios between components when using standard methods of sampling.

The gas extractor is characterized by constant gas-air volume in the degassing chamber, constant mud flow through the system, and constant agitator speed. The gas sample is therefore taken under constant conditions, delivering the same gas sample extraction efficiency and enhancing comparability of the data measured. The gas measurement results can be easily standardized versus the drilling parameters, providing a powerful interpretation tool for comparing different sections of the wellbore or comparing with a reference well.

In deepwater operations, the low mud temperature out (caused by the riser-cooling effect) does not allow efficient gas extraction. Such conditions affect gas measurements and can mislead interpretation.

The constant-volume heated degasser from Geoservices enables better extraction in the traditional surface logging gas spectrum (C1–C5) in cold mud, mitigating incorrect interpretation. The constant-volume heated degasser can be used in all geological, drilling, and mud environments.

Better extraction in cold mud (right) in comparison with a standard degasser’s extraction performance (left).

Contamination-free chromatography
The polar components in standard analyzers can affect C4 and C5 measurement, resulting in standard chromatographic analysis gas readings that may be biased by contaminants. Complex drilling fluids can also affect the quality of mud-gas data by introducing contaminants such as complex amines or alcohols in the extracted gas.

Additionally, the heat that is generated at the bit when drilling in hard and abrasive formations can induce thermal cracking of the hydrocarbons downhole and produce artificial components that directly contaminate the C2 measurement—especially on fast-response chromatographs.

Geoservices technologies prevent gas data from being contaminated, providing reliable gas results that are unaffected by synthetic chemical components and bit metamorphism effects.

Effect of contaminants on standard fast-response chromatographs.
Gas Portfolio

PIONEERING THE STANDARDIZATION OF GAS SAMPLING

Recycling Indication Options

Gas in

Correction for recycled gas at bit
- Safety indicator for gas-cut mud effect
- Improved control of rig degassing system efficiency
- Indication of drilling fluid capability to retain hydrocarbons from drilling processes

Gas out

InterACT Visualization

MODULAR REAL-TIME DATA DISPLAY

The InterACT Visualization display provides globally accessible and fully integrated drilling-parameter visualization. It incorporates an interactive Geoservices viewer, which displays cuttings descriptions, interpreted lithology, gas data, a driller’s console, MWD and LWD measurements, and recorded events through specific screens. Information is displayed as a function of time or depth, or in numerical format, with real-time comments.

The InterACT Visualization display enables secure, two-way communication of drilling and gas parameters, geological data, and comments and recommendations in real time, worldwide. No special software or dedicated communication infrastructure is required, enabling users to securely monitor multiple rig operations simultaneously through a web browser whenever they are connected to the Internet, intranet, or a minimum 3G network.

Users can monitor multiple wells simultaneously in a single viewer, using the real-time data displays in the InterACT Visualization display to compare data, including key indicators, depth data, and surveys.

Applications
- Real-time drilling-parameter visualization
- Rig-to-office file exchange
- Secure data sharing and collaboration between the entire team, including the rig crew

Benefits
- Enables informed and timely drilling decisions
- Reduces risk and costs
- Monitors multiple rig operations simultaneously

Features
- Real-time access to drilling, geological, and gas data
- Secure access and file transfer from anywhere via the Internet
- Fully integrated and customizable visualization
- Simultaneous monitoring of multiple wells
- Compatible with wellsite information transfer specifications

Real-time data display of drilling, geological, and gas data, including real-time comments.
InterACT Visualization

Customizable real-time data display

The InterACT Visualization display’s log viewer offers intuitive customization of displayed parameters, header positions, curve positions and formats, track properties, and scales. Users can modify displays to suit individual preferences and then share them with others to ensure that the information is seen consistently by all parties. Collaborative capabilities include online chat for timely and efficient interaction. A patented technique for monitoring connection status buffers data if communication to the rig is temporarily interrupted and automatically resumes data flow without gaps when the connection is restored.

The display also provides a comprehensive project work area. Team members can upload and share any type of file, and files uploaded by anyone on the project are automatically downloaded to the user’s desktop. The service includes an application that ensures synchronization of the system with the user’s Microsoft® Windows® desktop.

Predefined viewing windows that enable log display on tablets and mobile devices.

InterACT Visualization display for tablets and mobile devices

Viewing logs via predefined viewing windows is as simple as clicking a link. The fully customizable viewer enables users to:

- modify the presentation format to view additional data
- change the vertical scale to see smaller features or a larger interval
- zoom in and out of the log
- display and track data values.

To find out more, visit the InterACT Visualization data display web page.

The operations control room.

Geological Operations Services

The Geoservices wellsite geologist drives our geological operations services and is a key contributor to the drilling process. All our wellsite geologists have advanced technical skills and broad field experience.

With extensive activities worldwide, our wellsite geologists form a unique pool of highly trained personnel. They work mostly onsite (offshore or onshore) but can also work as operations geologists in customer offices.

Core expertise

Our wellsite geologists are competent in the following disciplines:

- wellsite geology
- geological interpretation
- reservoir evaluation
- reporting procedures
- supervision and quality assurance
- wireline logging.

In addition, our operations geologists are experienced in tasks including well planning, well supervision, and the provision of wellsite and shorebase services.

Combining knowledge of logging services (surface logging, LWD, and wireline) with an understanding of oil and gas geology, our wellsite geologists are able to quantify and QC geological data. This enables them to determine reservoir architecture and compartmentalization, hydrocarbons in place, and lithology or facies distribution via a single- or multiwell dataset.

As well as studying rock cuttings from oil and gas wells to determine what rock formations are being drilled into, wellsite geologists also:

- supervise every stage of the drilling process
- ensure that correct health and safety procedures are followed
- identify critical strata from rock cuttings, sidewall core, and conventional core sample data
- compile drilling reports and logs, including a final well report.

Our wellsite geologists also liaise with drilling and petroleum engineers during the course of projects, conveying information fluently, interpreting and clarifying details, and explaining the rationale.

The wellsite geologist following up the drilling process with the surface logging crew.
Drilling Services

Wellbore Quality
CLEAR Hole Cleaning and Wellbore Risk Reduction Service

FLAG Fluid Loss and Gain Detection Service
PreVue Pore Pressure Analysis Service
Drilling Geomechanics Services

Drilling Performance
Thema Drilling Operations Support and Analysis Service
Drilling Analyst

CLEAR

HOLE CLEANING AND WELLBORE RISK REDUCTION SERVICE

The simple, reliable, and robust CLEAR service monitors hole cleaning effectiveness and wellbore stability, providing real-time data to help the drilling team continually improve drilling performance and reduce NPT.

Applications
- Extended-reach drilling and highly deviated wells
- Horizontal and multilateral wells
- Deepwater wells

Benefits
- Increase safety by monitoring wellbore stability with drilling practices based on cuttings flowmeter (CFM) measurements and indicators
- Drill faster by ensuring good wellbore cleaning and condition
- Reduce NPT and stuck pipe risk by optimizing monitoring, analysis, and hole cleaning recommendations
- Optimize pill program and identify best practices for future wells

Features
- Digital measurements for improved cuttings evaluation accuracy
- Real-time dashboard with a simple, intuitive interface
- One-click report generation
- Transparency in data delivery
- Automatic alarm to signal when operational integrity of the equipment is compromised

Applications
- Extended-reach drilling and highly deviated wells
- Horizontal and multilateral wells
- Deepwater wells

Benefits
- Increase safety by monitoring wellbore stability with drilling practices based on cuttings flowmeter (CFM) measurements and indicators
- Drill faster by ensuring good wellbore cleaning and condition
- Reduce NPT and stuck pipe risk by optimizing monitoring, analysis, and hole cleaning recommendations
- Optimize pill program and identify best practices for future wells

Features
- Digital measurements for improved cuttings evaluation accuracy
- Real-time dashboard with a simple, intuitive interface
- One-click report generation
- Transparency in data delivery
- Automatic alarm to signal when operational integrity of the equipment is compromised
Using the CLEAR service, the weight and volume of cuttings are continuously measured at surface and compared with theoretical data to provide early detection of inadequate hole cleaning and wellbore stability issues. This helps confirm that the mud and drilling parameters are effectively removing and bringing cuttings to surface, mitigating problems such as bit balling, cuttings bed, stuck pipe, and packoff, which could lead to formation damage or loss of circulation.

**Multiple sensors and digital signals**
A CFM located at the end of each shale shaker incorporates a weighing tray positioned to catch cuttings as they fall off the screen. The tray is locked in position for a fixed interval, and cuttings that accumulate on it are weighed via strain gauges.

Digital outputs are sent to the acquisition system, which performs the computations. At the end of the adjustable preset period, the tray swings down and discharges the wet cuttings. The tray then returns to a horizontal position for the next measurement. The pneumatically controlled device is powered by the rig air supply.

The CLEAR service is compliant with the European Union’s Atmosphères Explosives directive as well as rated by the European Conformance (CE) and by the International Electrotechnical Commission Explosive Scheme.

**Comprehensive, real-time data dashboard**
The CLEAR service provides comprehensive, real-time cuttings flow information integrated with drilling parameters, cuttings geology, drilling fluid properties, and MLWD data. Results are visually displayed through the CLEAR service dashboard, accessible online whenever and wherever it’s needed—at the rigsite or at remote offices for analysis by well construction engineers. The accessibility and ease-of-use of the dashboard allows the drilling team to more efficiently assess hole cleaning effectiveness and to minimize wellbore stability risks.

**Flexible service delivery**
Advanced services are available in addition to the CLEAR service dashboard and CFM equipment, providing next-level analysis through expert-level interpretation and evaluation of hole cleaning, lessons learned, and best practices for future use. Automated solutions improve data integrity and quality control as well as reduce the workforce required on the rig. With multiple service delivery options, the CLEAR service provides the flexibility to choose which services and deliverables are most appropriate for the operation.

**Cuttings Flowmeter Specifications**
- **Length**: 1.85 m [6.08 ft]
- **Width**: 0.50 m [1.64 ft]
- **Height**: Minimum 1.04 m [3.42 ft], Maximum 1.10 m [3.62 ft]
- **Minimum free space required under shaker**: 0.11 m [0.36 ft]
- **Weight**: 145 kg [320 lbm]
- **Strain gauges**: 4
- **Paddle volume**: 28 L [7.4 galUS]
- **Sensor nominal sensitivity**: 2 mV/V ± 1%
- **Sensor nominal load**: 100 kg [220 lbm]
- **Minimum air supply**: 0.6 MPa [87.02 psi]

To find out more, visit the CLEAR service web page.
CASE STUDY

**Operator Saves 16 Rig Hours and USD 194,000 Using CLEAR Service**

Optimized hole cleaning and pill strategy helps improve drilling performance and minimize risk, Southeast Asia

**CHALLENGE**
Mitigate wellbore instability suspected during an extended-reach drilling (ERD) operation that poses safety concerns and threatens to the operator’s schedule and budget.

**SOLUTION**
Use the CLEAR* hole cleaning and wellbore risk reduction service to monitor cuttings removal from the hole and to analyze the efficiency of the hole cleaning strategy.

**RESULTS**
Obtained continuous measurement of hole cleaning and stability, allowing the drilling team to adjust the drilling parameters, equipment, mud rheology, and pills.

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**CASE STUDY:**
Operator saves 16 rig hours and USD 194,000 using CLEAR service

Improved drilling performance, saved time and expenditures
Using the CLEAR service, the hole cleaning and pill strategy was successfully optimized. The frequency of the pills used was decreased without detrimental effect on the hole cleaning, improving the net ROP and decreasing hidden time spent on mud treatment.

Through correlation and systematic benchmarking on the impact of cutting lifting of the pills, the size, frequency, and type of pills used were revised according to the data to optimize efficiency and control time dedicated for a secondary hole cleaning. These results decreased the invisible lost time. High-viscosity pills were maintained for the larger-OD slant hole, and tandem pills were assessed and measured as having optimal performance in smaller ODs.

The solution led to an overall improvement in drilling performance. The average time spent per stand for circulating and pumping pills decreased by 11 minutes compared with previous wellbores. Due to a more systematic approach, the operator saved 16 hours of rig time and USD 194,000 in direct costs.

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**Wellbore Quality Services**

- Optimized hole cleaning strategy, minimize risk
- Use the CLEAR* hole cleaning and wellbore risk reduction service to monitor cuttings removal from the hole and to analyze the efficiency of the hole cleaning strategy.

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FLAG

FLUID LOSS AND GAIN DETECTION SERVICE

The FLAG service, delivered by Geoservices analysts, detects influx or loss in the well faster than sensors monitoring the mud pits.

Applications
- Rapid kick and loss detection
- Flowback fingerprinting
- Pump efficiency measurement
- Drilling fluid displacement monitoring
- Cement displacement and free-fall monitoring
- Wellbore ballooning characterization
- Tripping and casing run monitoring

Benefits
- Improves well safety
- Reduces NPT
- Lowers environmental risk
- Optimizes drilling procedures

Features
- Reliable differential flowout alarm corrected for heave, flowline effect, mud compressibility, and reciprocation
- True assessment of flow from the wellbore
- Accurate monitoring under various operating conditions—drilling, circulating, pipe connection, tripping, or cementing
- Intuitive visual displays, alarms, and quality controls
- Suitable for deepwater, HPHT, slimhole, and conventional wells on any type of rig
- Dedicated support technician for supervision of design, installation, and commissioning
- Stand-alone capability

Features

Accurate differential flowout under various operating conditions

The FLAG service is calibrated for the rig circulating system to compute the theoretical return flow from the well in real time. The streamlined interface minimizes user dependence. A Coriolis flowmeter† installed in the return flowline continuously measures the actual return flow. By comparing the measured and theoretical values, the FLAG service can detect an influx or loss almost as soon as it occurs, even under conditions that may make detection difficult by conventional means. Monitoring losses and gains in the flowline instead of the mud pit ensures faster detection and gives a true picture of downhole conditions, unaffected by surface actions such as the addition of chemicals to the mud pit or mud transfers.

In addition to visual and audible alarms activated by preset thresholds, computed and measured data and the alarm status are continually displayed in log format on the Schlumberger monitors. When used as part of the Thema drilling operations support and analysis service, depth- and time-base data from the FLAG service and a number of other sensors are used to display decision-ready information on drilling performance and safety via customizable screens in real time.

† An electromagnetic flowmeter is used when space constraints do not permit installation of a Coriolis flowmeter and a water-base mud is in use.

Significant reduction in risk

Fluid influx or loss is a potential hazard that can lead to loss of control of a well, with potential loss of life and damage to property and the environment. As deepwater and other increasingly complex drilling programs multiply, the magnitude of the possible risks continues to grow.

The FLAG service aims to meet these challenges with an essential early warning system that is highly sensitive to fluctuations but sufficiently intelligent to help prevent false alarms, making it an ideal primary well control device.

The FLAG service provided on a drillship using a Coriolis flowmeter.
FLAG
FLUID LOSS AND GAIN DETECTION SERVICE

Rapid system response
Quick and reliable detection of fluid influx or loss in the well is crucial, especially when drilling a slim hole or when drilling under high-pressure, high-temperature conditions. The FLAG fluid loss and gain detection service, delivered by Geoservices analysts, detects gains and losses 5 to 10 minutes faster than conventional systems. This provides significantly earlier warning of any abnormalities, thus allowing more time for remedial action. In addition, this automated early kick detection system gives a valuable advantage during drilling operations by accurately indicating influx or loss at very low volumes and by reducing the number of false alarms that result in time-consuming flow checks.

To find out more, visit the FLAG service web page.

PreVue
PORE PRESSURE ANALYSIS SERVICE

The PreVue service provides real-time monitoring and prediction of pore pressure and fracture gradients at the wellsite using LWD (gamma ray, resistivity, and sonic), MWD (annular pressure), drilling (ROP and torque), gas (C1–C5), and other surface logging data, including cutting and caving morphology diagnosis.

Abnormal pressure events—such as kicks, mud losses, and other well control problems—can lead to the loss of the entire well, life, and property. The PreVue service can play a decisive role in minimizing these risks and improving drilling performance.

Applications
- Estimation and monitoring of pore pressure and fracture gradients in any environment:
  - Exploration wells
  - Deepwater wells with narrow mud-weight windows
  - High-pressure, high-temperature environments
  - Presalt
  - Complex geologic environments

Benefits
- Safer well trajectory and better well control through proactive and actionable pore pressure recommendations
- Enhanced drilling efficiency and reduced NPT through informed selection of drilling parameters such as mud weight

Features
- Real-time evaluation of normal hydrostatic pressure, overburden, pore pressure, and fracture gradients
- Discrete pressure compartment analysis to better understand pore pressure envelope shifts at bedding interfaces (e.g., sand and shale)
- Corrected D-Exponent analysis for evaluation of pore pressure gradient

Resistivity used as porosity-dependent curve used by experts to estimate pore pressure.
PreVue

PORE PRESSURE ANALYSIS SERVICE

Predrill planning
Before drilling starts, pore pressure experts at the Geopressure Technical Center analyze offset data such as results from leakoff tests (LOTs), engineering and geological reports, well logs, and mud weights. The experts use this information to model the pore pressures likely to be encountered along the proposed wellbore trajectory. Potential hazards are identified and analyzed, and contingency plans are recommended.

Real-time monitoring
During drilling, two Geoservices analysts specialized in the PreVue pore pressure analysis service provide 24-hour service at the wellsite, using real-time pressure monitoring software, evaluating data, and adjusting the predrill model for accurate estimation of pore pressure, fracture gradient, and overburden. Interpretations and recommendations are communicated to key decision makers both at the wellsite and in the office. Interpretation experts based at the Geopressure Technical Center provide additional support to the wellsite and customer teams as required, through in-depth analysis of the daily reports submitted by the wellsite analysts.

Event analysis
The PreVue service captures particular events during the drilling phase. All observations are recorded, including the type and time of the event and the recommendations made. The result is a cogent and immediate review of pore pressure issues.

Special emphasis is placed on examining the following events:

Flowback events
Abnormal flowback is recognized through connection fingerprinting and provides valuable insight into the relationship between the mud density and formation pressures.

Drilling events
Variations in ROP are used to estimate formation competency at the bit. Drilling breaks can signal the beginning of a pore pressure ramp.

Gas events
All gas events and their contexts are recorded. Accurate monitoring of lag time and identification of connection gas origins and propagation mechanisms can help detect the onset of abnormal pressure.

Mud events and torque and drag
Accurate control of mud weight can have a positive effect on the outcome of a well influenced by pore pressure. A record of pickup, slack-off, and free-rotating weights is a valuable indicator of hole cleaning effectiveness and also helps to analyze the origin of cavings.

Caving events
Observations at the shale shakers provide a digital record of the quantity, size, shape, and mechanism of the origins of cavings. The information is included in a caving report.

To find out more, visit the PreVue service web page.

Drilling Geomechanics Service

EXPERT SERVICES TO REDUCE DRILLING RISK, COST, AND UNCERTAINTY

Our drilling geomechanics services help reduce risks, costs, and uncertainty in complex drilling environments worldwide. Wellbore stability and pore pressure analysis is conducted while drilling using a variety of wellsite monitoring and data measurements—such as sonic, resistivity, density, pressure, and seismic—in real time to ensure better anticipation of potential risks.

Applications
- Extended-reach and challenging well trajectories
- Deepwater and HPHT reservoirs
- Drilling in and around salt structures
- Drilling in depleted zones and faulted or fractured reservoirs

Benefits
- Improve well placement and design
- Identify and reduce exposure to drilling hazards
- Monitor and update pore pressure predictions ahead of the bit
- Update wellbore stability forecasts while drilling
- Reduce NPT and well costs
- Increase well integrity and cementing success
- Enhance operational decision making

Features
- Predrill screening for well design and drilling engineering
- Predrill pore pressure prediction
- Safer mud-weight window planning
- Operational monitoring and interpretation of pore pressure and wellbore stability
- Geomechanics roadmap for well trajectory using DrillMAP* drilling engineering and operations plan, updated during drilling
- 24-hour forecast of geomechanics risks for current drilling operations using DrillCAST* drilling operations look-ahead
- Multidisciplinary expertise for wellsite and office support
- End-of-well review including an updated DrillMAP plan and geomechanics roadmap identifying all risks and events encountered

1D or 3D mechanical earth model can be used to create a planned drilling program.
Drilling Geomechanics Service

EXPERT SERVICES TO REDUCE DRILLING RISK, COST, AND UNCERTAINTY

Reduce NPT and risk while optimizing drilling performance

Geomechanical problems are associated with an estimated 40% of drilling-related NPT in challenging environments. Rapid changes in pore pressure and fracture gradient along a well track can lead to lost circulation, washouts, stuck pipe, loss of tools and equipment, additional casing strings, and unplanned sidetracks.

The move to more hostile environments and complex geometries has often resulted in narrower mud-weight windows. For efficient well engineering in these conditions, it is critical to know the precise wellbore stability boundaries. Offset well data does not give the accuracy that is now required to optimize casing points and adjust mud weights. Using MWD provides more accurate input to predict fracture gradient and pore pressure ahead of the bit.

At the wellsite or at the office, Schlumberger pore pressure analysts and geomechanics engineers provide continuous monitoring and interpretation of well data, communicating any changes to the safe mud-weight window while drilling. This enables operational decisions to be made with the most accurate information available, reducing exposure to drilling risk and mitigating the impact of geomechanical problems for optimal drilling performance.

Mitigate risk with operational monitoring and interpretation

Schlumberger has the industry’s largest pool of pore pressure and wellbore stability experts. For every drilling geomechanics operation, we provide experienced engineers to meet specific needs—at the wellsite, in the customer office, or through our worldwide network of PetroTechnical Engineering Centers (PTECs).

This dedicated team combines advanced processes, workflows, and technologies to offer continuous support and minimize the risk of costly wellbore hazards during drilling.

Based on available field and offset-well information, our geomechanics experts collaborate with the customer’s drilling and well-design team to build a predrill mechanical earth model. This provides a safe mud-weight window, including the wellbore stability, pore pressure, and fracture gradients, with uncertainty determination for optimal well planning.

The information is consolidated to generate a wellbore stability and pore pressure roadmap.

During drilling operations, pore pressure and geomechanics experts analyze all available drilling, log, mud, seismic, and geological data to visualize current downhole conditions. In close collaboration with the customer team, our experts validate the safe mud-weight window and deliver actionable recommendations to avoid potential hazards using the DrillCAST drilling operations look-ahead.

To find out more, visit the Geomechanics web page.

Case Study

Real-Time Drilling Geomechanics Reduces NPT

Wellbore stability prediction reduces risk in Gulf of Mexico well

Challenge

Reduce NPT caused by wellbore stability issues in a Gulf of Mexico field.

Solution

Implemented real-time drilling geomechanics services to monitor, update, and recalibrate the predrill pore pressure model; used daily updates to modify the drilling program as needed.

Result

Provided predictions that reduced NPT, enabled revised casing set point decisions, and eliminated a casing string.

Real-time drilling geomechanics workflows and modeling predicted and mitigated wellbore stability issues during drilling operations.

A history of wellbore instability

The operator of a Gulf of Mexico field had a history of NPT related to wellbore stability problems. The most recent well had experienced losses, influx, stuck pipe, and cementing challenges.

As the team prepared for the next well, it focused on completing operations within the AFE and dealing with an expected pore pressure increase.

Capitalizing on real-time data

The operator decided to utilize Schlumberger real-time drilling geomechanics services to make more-informed decisions during drilling operations.

Schlumberger experts used offset well information to build a temperature-dependent predrill pore pressure model. Engineers in PetroTechnical Engineering Centers (PTEC) continued real-time monitoring of drilling operations to update and recalibrate the pressure model using all available data, including:

- gas information
- leakoff tests
- formation integrity tests
- logging while drilling resistivity and gamma ray data.

To find out more, visit the Geomechanics web page.
CASE STUDY: Wellbore stability prediction reduces risk in Gulf of Mexico well

The PTEC team provided drilling risk forecasts and recommendations to the offshore and onshore drilling team through daily updates, or as needed. High levels of communication and seamless teamwork established a proactive approach that was key for successful drilling.

Enabling predictive decision making
The real-time geomechanics workflow and modeling predicted and mitigated wellbore stability issues during drilling operations. This process calculated a pore-pressure ramp that was shallower and of greater magnitude than was anticipated from offshore well information.

This resulted in an informed decision to set the 117/8-in casing early. The 95/8-in casing was then pushed 1,700 ft deeper than planned because further real-time modeling indicated no stability issues would be encountered. The operator therefore had the flexibility to save a liner string or finish the well in a 71/2-in hole.

As the 81/2-in hole was drilled below the 95/8-in casing, real-time geomechanics modeling predicted a severe tightening of the mud weight window, requiring an unplanned 71/2-in casing string. Although the well was landed using a 61/2-in × 71/2-in bit, a slimhole section was avoided because the 95/8-in casing had been pushed much deeper than expected.

High-quality real-time data and timely predictions enabled each hole section to be completed ahead of schedule with no losses, stuck pipe instances, or influx—reducing the risk of NPT. Additionally, the improved drilling process helped eliminate remedial cementing work.

Contact your local Schlumberger representative to learn more.

www.slb.com/DrillGeo

Recommended for effective decision making.

Applications
- Exploration
- HP/HT
- Deep water
- Extended-reach drilling

Benefits
- Enhanced communication
- Methodical stream of up-to-the-minute data by receiving, analyzing and distributing information primed by the right people, with the right expertise
- Better integration of information
- Correlation and integration of information using the latest in information technology

Features
- Enhanced data quality
- Advanced hardware
- High-quality measurement
- Data frequency up to 50 Hz
- Information available earlier
- Intelligent processes
- Enhanced visual interpretation
- Faster information delivery

Wellbore stability prediction reduces risk in Gulf of Mexico well.
Our customers receive wellsite support in the form of a comprehensively equipped Geoservices surface logging unit (with mud logger and data engineer in situ) and a dedicated Geoservices engineer based in the customer’s office.

**Thema service analyst profile**
- Experienced in well operations
- High-level communication skills
- Supported by a team of experts
- Coordinates rig activity and objectives

The Thema analyst has real-time access to time and depth data from the Geoservices surface logging unit. Using this data, the engineer integrates, enriches, and combines surface and downhole information from the Thema service’s vast database, acquisition, and processing facility. This helps our customers reach the best possible decision in a timely and cost-effective way. The analyst conveys the analysis and recommendations back to the rig to complete the workflow loop.

**Metier and technical support**
Our analyst works closely with the local drilling performance domain champion, who supports our personnel in optimizing operations. Technical support is also available to our Thema service analyst from the worldwide Geoservices Quality and Operations Support team.

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**Thema service deliverables**
Deliverables and reports within the Thema service come from both the rig and the customer office with specific focuses.

**Rigsite deliverables**
- Semiautomated daily activity report (DAR)
- Master log
- Flowback log.

In addition, the Thema service analyst produces the following reports:
- Daily Thema service report (with optional KPIs and fluid displacement monitoring)
- Bit-run report focusing on well balance, hole cleaning status, and drilling efficiency
- Event report with real-time and postrun analysis
- Final well report review and synthesis.

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**Drilling Efficiency and Optimization**

**Drilling efficiency (DE) panel**
The DE panel takes real-time drilling analysis further and contributes to the assessment of the wear and behavior of the drill bit. Add-on applications can be aligned with the DE panel to provide a comprehensive drilling efficiency and optimization service—including vibration mitigation, MSE management, bit-wear interpretation, avoidance of low ROP, prevention of tools lost in hole, and monitoring of downhole conditions—entirely from the surface. Results are equivalent to those provided from downhole.

DE panel capabilities include
- Assessing the BHA’s efficiency response to drilling parameter adjustments
- Monitoring and analysis of MSE through parameter correlation and various easily accessible crossplots
- Analysis of combined surface and downhole measurements (when available), which is particularly valuable in complex well conditions, in extended-reach drilling, and while performing coring operations.

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**Hole Cleaning**

**Hole condition monitoring (HCM) panel**
Integration of data collected from the hole cleaning applications provides real-time information about the status of the well, addressing challenges that affect highly deviated wells and horizontal wells, such as stuck pipe, borehole integrity, and possible packoff.

HCM panel capabilities include
- Lithology information for correlation of torque increase and excessive drag with the formation
- Torque and drag modeling
- Real-time drilling parameters correlated with information from the torque and drag model
- Real-time acquisition of torque and drag data through activity filtering
- Real-time rheology parameters display
- Display and correlation of dogleg severity and LWD data
- Monitoring and follow-up of backreaming and wiper trips.

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**Real-Time Applications**
- High-frequency data
- Vibration monitoring and alarms
- Imported third-party time data
- Cuttings flowmeter (additional equipment)
- Pickup and stack-off models

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**Surface Logging**
Drilling
Surface Formation Evaluation
Rig Operations Surveillance
Surface Logging
Drilling
Surface Formation Evaluation
Rig Operations Surveillance
## Thema

### DRILLING OPERATIONS SUPPORT AND ANALYSIS SERVICE

#### Well Balance Monitoring and Analysis

**Well surveillance panel**  
Primary well control is the foundation of all drilling operations. The Thema service well balance monitoring and analysis service applications are dedicated to the real-time monitoring and presentation of data pertaining to well equilibrium.

Well surveillance panel capabilities include:
- time-base log including display of hole gain and losses computations (from the optional FLAG service), and graphic pit trend follow-up (with alarms)
- follow-up of pumpoff gas magnitude and composition, with the ability to overlap and compare the causes of gas peaks
- active, real-time monitoring and recording of trip speed and trip tank volumes and variations.

To find out more, visit the Thema service web page.

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#### Drilling Analyst

**ENGINEERING INTEGRATION AND DRILLING OPTIMIZATION**

Geoservices drilling analysts provide an advantage in drilling performance services. Combined with the knowledge and expertise of Schlumberger, overall drilling performance is optimized, reducing time to TD through integrated engineering, execution, and evaluation work processes.

Our drilling analysts, who are specifically trained and have the relevant experience in drilling optimization and risk management, drive our drilling performance services. Their primary objective is to work with the customer's drilling team, Schlumberger experts, and third-party service providers to ensure a seamless execution of the well construction plan. The drilling analyst integrates the engineering and modeling outputs from well design, BHA and bit design, fluids system, geomechanics, and pore pressure to create an integrated well execution plan with the customer while also supporting the individual teams to execute the plan.

Drilling analysts are an integral part of the Schlumberger team, leading the integration of surface and downhole measurements with performance models that optimize the well construction process, reduce NPT, and mitigate risk. The drilling analysts are assigned to a project early during its planning stage to work with the customer drilling teams and other Schlumberger experts in our PTECs, helping to define key drilling performance indicators that are aligned with the project objectives and anticipated challenges. The geomechanics and pore pressure models can also be integrated into the execution plan, depending on the identified project challenges.

During the planning stage, the development of a multidisciplinary performance drilling plan (PDP) takes place as part of the well design deliverables. Based on the project and well objectives and anticipated challenges, the PDP includes risk assessments to prevent and mitigate different hazards, reduce unplanned flat time, and improve the drilling performance strategy.

Depending on availability of data and the timing of the project, a detailed offset well analysis can also be performed. The different historical drilling events and problematic zones are identified, and a detailed NPT analysis is performed in geological context.

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To find out more, visit the Thema service web page.
Drilling Analyst

ENGINEERING INTEGRATION AND DRILLING OPTIMIZATION

A graphical representation of the DrillMAP drilling engineering and operations plan includes a chart of the risk assessment, the performance strategy, and the different models to be monitored during the execution of the well.

The information presented in the DrillMAP plan provides a reliable roadmap that enables drillers to better manage operations and to respond more effectively to anomalies in drilling behavior. The drilling analysts then define tailored deliverables from the list of specific project and well requirements, which are prioritized and aligned with the drilling KPIs and integrated well execution plan.

During the execution phase, drilling analysts monitor and assess real-time surface and downhole data using proprietary software to track data trends and highlight any deviation from the models or precursors of upcoming drilling problems. They also interact with our various petrotechnical experts (petromechanics, fluids, bits, drilling, formation evaluation, etc.) to support any necessary model updates and to collaborate with the customer’s team.

The DrillMAP plan is continuously updated by the drilling analysts in the form of a DrillCAST drilling operations look-ahead. The DrillCAST look-ahead is a daily report that contains essential information about the drilling process over the last 24 hours and provides a reliable forecast of drilling hazards, as well as agreed recommendations to deal with them for the following 24 hours. This allows drillers to adjust the drilling process in order to mitigate drilling risks, prevent unscheduled events, and optimize drilling performance.

For trip monitoring, the DrillCAST look-ahead includes a detailed description of the hole condition observed while drilling or during previous trips and an updated forecast of hazards in the next bit trip, casing, or logging run.

Analysts located at the rig or off site
Drilling analysts can be located at the rig site or in a real-time monitoring center. The day-to-day activity of the drilling analysts varies depending on where they are located.

At the customer’s real-time monitoring center, analysts participate in rig calls and discussions with the customer’s drilling team. They can also participate in well planning meetings if there is no monitoring required.

At the rig site, in addition to rig calls, they participate in internal preoperation meetings to help highlight the main hazards identified for each specific operation.

In both cases, and in coordination with other petrotechnical experts, analysts provide recommendations when the precursor of an NPT event is observed and participate in analysis of the different drilling events until the determination of the root cause.

At the end of the well, the drilling analyst delivers a final well report and presents an updated DrillMAP plan that details the actual results versus the initial models and includes the lessons learned, which can be applied to future operations.

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In both cases, and in coordination with other petrotechnical experts, analysts provide recommendations when the precursor of an NPT event is observed and participate in analysis of the different drilling events until the determination of the root cause.

At the end of the well, the drilling analyst delivers a final well report and presents an updated DrillMAP plan that details the actual results versus the initial models and includes the lessons learned, which can be applied to future operations.

A graphical representation of the DrillMAP drilling engineering and operations plan includes a chart of the risk assessment, the performance strategy, and the different models to be monitored during the execution of the well.

The information presented in the DrillMAP plan provides a reliable roadmap that enables drillers to better manage operations and to respond more effectively to anomalies in drilling behavior. The drilling analysts then define tailored deliverables from the list of specific project and well requirements, which are prioritized and aligned with the drilling KPIs and integrated well execution plan.

During the execution phase, drilling analysts monitor and assess real-time surface and downhole data using proprietary software to track data trends and highlight any deviation from the models or precursors of upcoming drilling problems. They also interact with our various petrotechnical experts (petromechanics, fluids, bits, drilling, formation evaluation, etc.) to support any necessary model updates and to collaborate with the customer’s team.

The DrillMAP plan is continuously updated by the drilling analysts in the form of a DrillCAST drilling operations look-ahead. The DrillCAST look-ahead is a daily report that contains essential information about the drilling process over the last 24 hours and provides a reliable forecast of drilling hazards, as well as agreed recommendations to deal with them for the following 24 hours. This allows drillers to adjust the drilling process in order to mitigate drilling risks, prevent unscheduled events, and optimize drilling performance.

For trip monitoring, the DrillCAST look-ahead includes a detailed description of the hole condition observed while drilling or during previous trips and an updated forecast of hazards in the next bit trip, casing, or logging run.

Analysts located at the rig or off site
Drilling analysts can be located at the rig site or in a real-time monitoring center. The day-to-day activity of the drilling analysts varies depending on where they are located.

At the customer’s real-time monitoring center, analysts participate in rig calls and discussions with the customer’s drilling team. They can also participate in well planning meetings if there is no monitoring required.

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FLAIR
REAL-TIME FLUID LOGGING AND ANALYSIS SERVICE

The FLAIR service provides C₁–C₆ reservoir fluid composition and monitors other fluid characterization markers (e.g., light aromatics), enabling early assessment of potential pay zone and acquisition of formation evaluation information ahead of downhole sampling and well testing.

The FLAIR service applies a proprietary process from extraction to data processing, enabling quantification of hydrocarbons for reservoir fluid characterization and interpretation.

**Features**
- Fluid surface logging while drilling
- PVT-comparable quantitative hydrocarbon characterization
- Proprietary calibration of extractor efficiency and correction from recycling and contamination

**Applications**
- Interwell and intrawell fluid facies mapping
- Support for geosteering and well placement
- Formation evaluation data assurance in challenging environments

**Benefits**
- Provides early insight into reservoir structure and fluid distribution
- Allows for de-risking and optimization of formation testing, sampling, and downhole fluid analysis
- Enables evaluation of hydrocarbons in unconventional reservoirs

**Data acquisition**
The FLAIR service’s fluid extractors continuously sample mud from the flowline returning from the well and in the pump suction line. Extraction occurs at controlled constant thermodynamic conditions and is calibrated for each mud system. The extracted hydrocarbons are transported to a specifically designed detector, which provides a full chromatographic analysis up to C₁₀, including differentiation of several C₆ isomers.

**Data processing**
The constant and repeatable extraction conditions, including calibration against the mud system in use, enable the recycling effect to be quantified.

**Data interpretation**
Using the Techlog* wellbore software platform, our experts generate a fluid facies log and compositional analysis of various facies, which can be integrated with other formation evaluation data (e.g., from triaxial resistivity induction and the MDT* modular formation dynamics tester) to allow for enhanced reservoir characterization.

Graphics indicating that the fluid of the sidetrack hole had the same composition as the fluid in the pilot hole confirmed by PVT analysis of downhole fluid samples taken from the pilot well.

<table>
<thead>
<tr>
<th>Cₙ</th>
<th>FLAIR Service Pilot Hole, mol%</th>
<th>PVT Pilot Hole, mol%</th>
<th>FLAIR Service Sidetrack Hole, mol%</th>
</tr>
</thead>
<tbody>
<tr>
<td>C₁</td>
<td>89.2</td>
<td>89.2</td>
<td>89.5</td>
</tr>
<tr>
<td>C₂</td>
<td>6.1</td>
<td>5.9</td>
<td>6.0</td>
</tr>
<tr>
<td>C₃</td>
<td>2.4</td>
<td>2.1</td>
<td>2.5</td>
</tr>
<tr>
<td>n-C₄</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>i-C₄</td>
<td>0.9</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>C₅</td>
<td>0.5</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>n-C₅</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
</tr>
</tbody>
</table>

CₙF = Quantitative fluid composition provided by the FLAIR service. This composition is comparable to reservoir fluid.

PVT-equivalent quantitative composition of hydrocarbons in place.

To find out more, visit the FLAIR service web page.
Integration of FLAIR Service Enables Cost-Effective Reservoir Characterization

Continuous fluid typing while drilling enables optimized downhole sampling and maximizes information acquired in complex HPHT exploratory well.

**CHALLENGE**

Offshore, multilayered HPHT reservoir required optimized sampling program to reduce risk and increase sampling recovery.

**SOLUTION**

Acquire reservoir fluid properties from surface logging while drilling using FLAIR® fluid logging and analysis in real time.

**RESULTS**

- Identified subtle compositional variations in fluids across several reservoir layers while drilling
- Optimized sampling and downhole fluid analysis program
- Maximized value of acquired information
- Improved planning for future wells

Hostile downhole conditions required optimized sampling program

While drilling an HPHT (16,400 psi, 327 degF) exploration well offshore Malaysia, a major operator in Southeast Asia wanted to optimize its downhole fluid sampling and analysis program. A continuous fluid facies log along the entire drilling interval, covering all sands of interest, would improve selection of both the sample depths and the estimates of the likely fluid type. Minimizing risk and cost was a priority in this challenging environment, while maximizing the amount of information acquired while drilling was paramount for the project.

Cost-effective fluid typing while drilling

The FLAIR service was used to continuously analyze hydrocarbons extracted from drilling mud returning to the surface, providing a quantitative C₁–C₅ composition of the downhole reservoir fluid, and qualitative measurement in the C₆–C₈ range. Integration of the FLAIR service within an innovative workflow— including downhole fluid analysis (DFA) and pressure-volume-temperature (PVT) data—was implemented to provide a cost-effective solution for formation evaluation analysis.

Early identification of compositional variability improved downhole evaluation

FLAIR analysis identified subtle compositional variations with depth while drilling. Fluid families with a characteristic signature were identified and a detailed fluid distribution was then used to select depths for fluid sampling and DFA. The downhole data, in turn, was used to calibrate the fluid signatures. Subsequent PVT analyses of the samples further corroborated the results of the FLAIR analysis. The validated fluid signatures were then used to optimize evaluation programs, enabling both time and cost to be saved in future wells within the field.

**FLAIR data acquisition**

- DFA interpretation and single-phase representative fluid samples
- Detailed DFA lab sample analysis
- Established typical fluid signatures to correlate to future wells (from FLAIR, DFA, and PVT results)
- Update reservoir model with validated fluid properties

**FLAIR data QC and processing**

- FLAIR reservoir fluid composition in the C₁–C₅ range
- Recommended fluid sampling based on FLAIR analysis

<table>
<thead>
<tr>
<th>Sample</th>
<th>Fluid Type</th>
<th>C₁mol%</th>
<th>C₂mol%</th>
<th>C₃mol%</th>
<th>iC₄mol%</th>
<th>nC₄mol%</th>
<th>iC₅mol%</th>
<th>nC₅mol%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condensate</td>
<td>85.29</td>
<td>84.70</td>
<td>6.67</td>
<td>7.07</td>
<td>0.89</td>
<td>1.11</td>
<td>0.59</td>
<td>0.58</td>
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<tr>
<td>Condensate</td>
<td>85.16</td>
<td>84.48</td>
<td>6.71</td>
<td>7.07</td>
<td>0.89</td>
<td>1.11</td>
<td>0.59</td>
<td>0.58</td>
</tr>
<tr>
<td>Condensate</td>
<td>86.04</td>
<td>85.73</td>
<td>7.16</td>
<td>7.16</td>
<td>0.88</td>
<td>1.17</td>
<td>0.59</td>
<td>0.58</td>
</tr>
<tr>
<td>Condensate</td>
<td>86.04</td>
<td>85.73</td>
<td>7.16</td>
<td>7.16</td>
<td>0.88</td>
<td>1.17</td>
<td>0.59</td>
<td>0.58</td>
</tr>
</tbody>
</table>

The reservoir fluid analysis workflow, comprised of FLAIR analysis, DFA, and PVT data.
Isotope Logging

CONTINUOUS ISOTOPIC RATIO MEASUREMENTS IN REAL TIME

The Geoservices Isotope Logging service delivers real-time measurement logs of isotopic ratios, opening up early access to geochemical characterization of hydrocarbons in the formation in terms of source, generation, and processes.

Applications
- Complex fluids and fluid uncertainties
- Unconventional reservoirs
- Assistance with downhole fluid sampling programs, including selection of spot-sample analysis

Benefits
- Assessment of fluid migration mechanisms, such as sealing characteristics of caprocks and faults, connectivity, and compartmentalization
- Early identification of active and nonactive hydrocarbon systems
- Reduced uncertainty and risk associated with the collection, shipment, and analysis of samples

Features
- Continuous measurement for reliable identification of small-scale features
- Real-time data delivery for optimized decision making
- Field-proven, robust, and reliable logging technology with integrated quality assurance procedures

Laboratory technology ruggedized for rig environments
The Isotope Logging service is a key tool within the Geoservices formation evaluation portfolio. With consistent accuracy, more than 300 km has been logged in more than 100 wells drilled in a variety of basins and reservoir configurations—from unconventional reservoirs to deepwater wildcats.

Integrated interpretation and decision making
The availability of real-time isotopic ratio logs enables immediate and accurate interpretation of geological and geochemical systems, optimizing key decisions affecting the development of the reservoir. Our community of geochemists and reservoir engineers works closely with customer teams to assist in understanding their reservoir complexities.

An example of the utilization of various integrated datasets available from Schlumberger formation evaluation tools (isotope logging, FLAIR, GeoFlex, and LWD services) for a complete picture of the petroleum system. The GeoFlex service provides mineralogical and elemental composition and kerogen content of cuttings through integration of XRD, XRF, and diffuse reflectance infrared Fourier transform spectroscopy (DRIFTS).

Mineralogical and elemental composition and kerogen content of cuttings through integration of XRD, XRF, and DRIFTS.

To find out more, visit the Isotope Logging service web page.
CASE STUDY: At-surface real-time isotope logging assesses lateral heterogeneity in Marcellus Shale, USA

At-Surface Real-Time Isotope Logging Assesses Lateral Heterogeneity in Marcellus Shale

Thermal maturity calculation from isotope logging service provides insight into hydrocarbon fluid type in place

**CHALLENGE**
Evaluate rock and fluid heterogeneity to identify the optimal landing point

In a horizontal development well targeting the Marcellus Shale, the operator needed to acquire accurate formation data. Specifically, the operator wanted to assess lateral heterogeneity of the fluid and rock to gain initial information for determining hydrocarbon fluid type in place.

**SOLUTION**
Determine hydrocarbon fluid in place with thermal maturity log

Schlumberger proposed using isotope logging service to continuously measure isotopic ratios of δ¹³C–CH₄ from surface while drilling to produce a continuous thermal maturity log. A continuous thermal maturity log is the first step toward determining hydrocarbon fluid type in place, and providing this data would enable improved while-drilling reservoir management decisions. The isotope logging service, which poses no additional operational risk, would also help in identifying vertical and lateral discontinuities, including gradients and small-scale features. Acquiring this information is particularly challenging in unconventional reservoirs but would provide the initial information needed to determine hydrocarbon fluid type in place, improve geostatistical analysis, and increase the accuracy of target allocation.

**RESULTS**
- Confirmed homogeneity of the fluid maturity and the formation.
- Provided continuous measurement of the surface with isotope logging service and obtain thermal maturity proxy at lateral.

**CASE STUDY**
Lateral Heterogeneity in Marcellus Shale

- Provides insight into hydrocarbon fluid type in place
- Determines hydrocarbon fluid in place with thermal maturity log
- Confirmed official VRE maturity map with real-time formation property information
- Evaluated rock and fluid heterogeneity to identify the optimal landing point

Thermal maturity calculation from isotope logging service was provided to help in identifying vertical and lateral discontinuities, including gradients and small-scale features. Acquiring this information is particularly challenging in unconventional reservoirs but would provide the initial information needed to determine hydrocarbon fluid type in place, improve geostatistical analysis, and increase the accuracy of target allocation.

**Example**

- **Challenges**
  - Assessing lateral heterogeneity
  - Evaluating rock and fluid heterogeneity

- **Solutions**
  - Using isotope logging service
  - Continuous measurement of isotopic ratios

- **Results**
  - Confirmed homogeneity of fluid maturity and formation
  - Continuous thermal maturity log

- **Case Study**
  - Marcellus Shale
  - Thermal maturity proxy

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*Image: Comparison of δ¹³C–CH₄ with VRE map.*
GeoFlex

QUANTITATIVE CUTTINGS ANALYSIS AND IMAGING SERVICE

The modular GeoFlex service determines the mineralogical and geochemical composition of drilled cuttings as well as their TOC content in near-real time, supporting operational decisions and minimizing risk.

Combining high-resolution digital microscopy, accurate mineralogical quantification, precise elemental composition, and TOC assessment, the GeoFlex service enables cost-effective, near-real-time formation evaluation in all drilling environments.

This at-surface modular service is especially advantageous in operations traditionally considered cost- or risk-prohibitive for conventional formation evaluation techniques.

Accurately determine lithology and mineralogy

The GeoFlex service makes it possible to conduct accurate and repeatable mineralogical evaluation from cuttings at the rig site and outside of the critical drilling path. Using high-resolution digital microscopy (HRDM) and XRD, the GeoFlex service enhances appraisal of rock texture, shape, and color and quantifies mineralogy with laboratory-quality accuracy.

Together, these technologies classify and quantify a wide range of minerals. As a result, describing cuttings is made easier, faster, and virtually error free for the wellsite geologist. The addition of synthetic total and spectral gamma ray also ensures perfect depth matching to acquired information from other data streams, such as LWD or wireline logs.

Define geochemical fingerprint to assess production potential

Geochemical fingerprinting is performed using XRF, which quantifies up to 50 inorganic elements to part-per-million levels. Evaluation of elemental data to this degree enables highly accurate well-to-well correlation and identification of preserved organic matter, which both offer insight into production potential in unconventional reservoirs.

Features

- Portable, modular devices and services for wellsite mobilization
- Integrated real-time transmission and visualization for wellsite and remote data monitoring and interpretation
- Automatic mineral recognition and quantification technology for fast and reliable wellsite analysis
- Synthetic total and spectral gamma ray for accurate depth matching and well-to-well correlation

Benefits

- Conducts formation evaluation at surface, adding zero operational risk
- Charactizes lithology independently of wellbore geometry, temperature, and pressure
- Acquires reliable and repeatable data for near-real-time evaluation
- Integrates with LWD, wireline, and other available data sources to provide a comprehensive log
- Minimizes NPT through early remediation of the well path when necessary

Applications

- While-drilling formation evaluation and reservoir characterization in conventional reservoirs
- Assessment of reservoir quality and optimization of completion quality in unconventional reservoirs
- Onshore and offshore exploration and development

Real-time data transmission for seamless collaboration.

To find out more, visit the GeoFlex service web page.

Quantify TOC to identify organic-rich formations

To optimize well placement in unconventional reservoirs, fast-field TOC quantification precisely identifies organic-rich formations in 7 minutes. This technique uses a patented process to directly measure TOC in cuttings regardless of mineralogy and mud type.

Enhance multidisciplinary collaboration

Information from the GeoFlex service is transmitted in real time and can be integrated with other available data sources for seamless collaboration between the customer’s drilling, geology, and geophysics teams. Integrated logs further enhance understanding of reservoir characteristics and potential productivity, which, in turn, reduces the risks inherent to key decision-making processes.

Integration of GeoFlex with proprietary surface logging acquisition system allows automatic generation of log answer products integrating all GeoFlex data as well as improvement of data integrity by having all data stored into a secured database.
Carbonate reservoirs: Unlock potential productivity

In carbonate reservoirs, production potential is highly influenced by the mineral composition of the matrix. By clearly identifying and quantifying calcite, dolomite, and siderite, the GeoFlex service provides information critical to assessing porosity and permeability and, thus, production potential. Identification and quantification of clays and anhydrite, for example, provide significant insight into the porosity and permeability of carbonate reservoirs. Accurate quantification of pyrite can notably improve any subsequent petrophysical log interpretation.

High-resolution digital pictures from the GeoFlex service also aid in the recognition of microfossils and the subsequent characterization of biomarkers, resulting in a more comprehensive stratigraphy and dating of the reservoir.

Siliciclastic reservoirs: Complement mineralogy with geochemical fingerprinting

The GeoFlex service conducts geochemical fingerprinting, one of the most advanced formation evaluation techniques available for a sediment. By identifying feldspars, clays, and carbonates as well as the distinction between cement and matrix, geochemical fingerprinting helps predict producibility in siliciclastic and all other reservoirs.

This enhanced formation evaluation method improves wellsite lithology identification and easily pinpoints intrafield formation tops. Mineral recognition can be done in semiautomatic or automatic mode to simplify this task for field personnel. The limit of detection for each mineral is established in relation to the matrix and is programmed into software used at the wellsite that is proprietary to Schlumberger.

Further, geochemical fingerprinting from the GeoFlex service enables you to update petrophysical models and optimize logging and coring operations.

Igneous rock: Easily identify basement rock

The identification and characterization of igneous rock has become increasingly important to hydrocarbon exploration and production. While drilling, reaching the basement rock often means that the bottom of a potentially hydrocarbon-producing interval has been reached.

Additionally, the production of hydrocarbon resources trapped in igneous fractured formations has made significant progress in the past few years. In both cases, identifying the presence of igneous, volcanic and volcanoclastic rocks is of paramount importance.

The GeoFlex service identifies all rock types, making basement rock easy to detect.

Presalt reservoirs: Reveal complex formations

Presalt formations are among the most difficult environments to drill and evaluate. The presence of carbonate lithology with complex mineralogy—pyrite, k-feldspars, plagioclase, calcite, dolomite, clays—and the frequency of encountering altered volcanic rocks and hydrothermal depositions create challenges for rock and reservoir classification.

The cuttings-based GeoFlex service helps solve this challenge by clearly flagging biogenic silica and accurately identifying and quantifying volcanic, carbonate, and hydrothermal minerals. Using high-resolution digital microscopy, X-ray diffraction, and X-ray fluorescence, the GeoFlex service provides direct and comprehensive measurements of lithology, mineralogy, and elemental composition. Near-real-time data from this service is combined with other available data sources to create a comprehensive log that enables advanced modeling, including basin reconstruction and dynamic simulation.

The GeoFlex service optimizes geostopping by accurately detecting basement rock. The service uses high-resolution digital microscopy to identify the texture of igneous rock and to characterize flow structure and crystal sizes. Magnification of up to 200 times enables the mud logger to easily recognize altered and reworked volcanic rocks.

The GeoFlex service identifies all rock types, making basement rock easy to detect.
**CASE STUDY**

**Marcellus Shale Operator Receives At-Surface Formation Evaluation in Near-Real Time**

GeoFlex service cost-effectively provides completion optimization data.

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**CHALLENGE**
Assess rock and fluid heterogeneity in the complex lithology of the Marcellus Shale while drilling a lateral well.

**SOLUTION**
Use the GeoFlex* quantitative cuttings analysis and imaging service to conduct formation evaluation from cuttings at surface.

**RESULTS**
- Provided at-surface characterization of formation evaluation from cuttings at surface.
- Identified brittle zones and formation tops.
- Located zones with optimal production.
- Provided information critical to optimizing fracturing design.

**SOLUTION**
An operator drilling a lateral well in Pennsylvania needed to evaluate rock and fluid heterogeneity at surface and outside of the critical drilling path.

**RESULTS**
- Provided at-surface characterization of formation evaluation from cuttings at surface.
- Identified brittle zones and formation tops.
- Located zones with optimal production.
- Provided information critical to optimizing fracturing design.

**CASE STUDY:** GeoFlex service provides at-surface formation evaluation in near-real time

Through analysis of cuttings samples, the GeoFlex service identified lateral variations in mineralogy and TOC and revealed zones of superior production potential. Logs from the GeoFlex service confirmed that the lateral was landed in the target zone. Providing further proof that the well was landed in the Marcellus Shale, TOC concentration exceeded 10% and the concentration of redox proxies, such as molybdenum and uranium, increased.

Measurements of brittleness from the GeoFlex service identified brittle zones that the operator can use to optimize the fracturing strategy of this well. Additionally, the GeoFlex service identified intervals where the lateral was drilled out of zone. The changes in formation are indicated by spikes in calcite, as shown in the logs, and provide valuable information for optimizing completion design.

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**Ternary Diagram**
This ternary diagram from the GeoFlex service reveals the heterogeneity of the rock, and the color of the plot points indicates the brittleness of the cuttings sample. Together, this information can be used to improve completion design.

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*Mark of Schlumberger

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GeoFlex service provides at-surface formation evaluation in near-real time

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slb.com/GeoFlex

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SLACK: 2016 GEOSERVICES SERVICES CATALOG | 61
Rig Operations Surveillance

SENSU Rig Operations Surveillance and Instrumentation System

Featuring digital instrumentation and an advanced driller’s console, the SENSU® rig operations surveillance and instrumentation system provides the granular operations metrics and KPIs to deliver a step change in well construction efficiency. By reducing NPT and ILT, the SENSU system enables cost reduction of daily rig operations.

Applications

- Real-time monitoring of drilling parameters and pit volumes, on the rig and in the office
- Uniform system independent of rig vendors
- Benchmarking the performance of the rig and crew
- Automated reporting for rig maintenance and for tracking operation metrics and drilling KPIs

Benefits

- Optimize well construction performance using daily, automated KPI dashboard; detailed performance benchmarking; and gap analysis
- Obtain decision-ready information—precisely where and when it is needed
- Improve critical activities through constant, comprehensive access to rig and drilling information
- Modernize data acquisition systems on existing rigs cost effectively
- Achieve accurate, consistent, and timely reporting through automated IADC reports and daily drilling logs

Features

- Easy-to-install, reliable, and automated system
- Customizable and intuitive driller displays (numerical and graphical) with Live Setting console
- Fast, responsive, and proactive control of rig instrumentation and drilling processes
- Redundancy and mirroring to minimize lost data and NPT
- High-frequency data acquisition and processing
- Automatic rig-state detection
- Stop and start system with automatic loading of sensor calibration

Continuous decision-ready rig and drilling information for enhancing operational efficiency.
Lean deployment at the wellsite
With a reduced footprint and automatic reloading of sensor calibrations, the SENSU system has true start and stop functionality. Noninvasive rig installation and quick configuration enable the rig crew to power up the system and begin real-time monitoring immediately. Data from more than 200 sensors can be processed at 1 Hz—with the ability to acquire data up to 50 Hz—facilitating instantaneous event detection, while high-resolution processing enables in-depth trend analysis.

Customizable interface
With its intuitive and customizable interface, the SENSU system provides continuous decision-ready rig and drilling information. The driller can adjust parameters, set alarms, and reset counters in the Live Setting mode, while real-time data remains visible. Low- and high-level alarms can be assigned to each parameter, and alarm states are indicated by visible and audible cues.

Automatic rig-state detection
The embedded Schlumberger rig-state engine—unique to the SENSU system—automatically detects 17 individual rig activities and states, enabling real-time calculation of 18 event metrics, including:

- backreaming, on-slip, and off-bottom time
- maintenance measurements for critical rig component parts
- operations metrics, calculating various drilling and tripping KPIs in real time at the rig site.

Identify invisible lost time
The rig-state engine enables the SENSU system to identify ILT through real-time data analysis and statistical comparison of activities on a single rig or across a rig fleet, enabling the setup and achievement of desired efficiency targets.

Continuous real-time updates enable an entire rig fleet’s performance to be benchmarked and corrective actions taken, minimizing the time and cost of operations.

Enhanced data backup, security, and reporting
Full data redundancy is assured by a second core computer running in parallel to the primary system. Live sensor backups on critical measurements can also be installed, while real-time monitoring of acquired data quality and proactive detection of anomalies are provided by the embedded diagnostic tool.

Automated reporting
The SENSU system provides automated reporting applications, enabling the driller to spend more time focusing on operations and optimizing rig performance, and less time on everyday reporting tasks. Key reporting applications include automated daily logs and reports in IADC-approved format.

Automatic reporting
The SENSU system provides automated reporting applications, enabling the driller to spend more time focusing on operations and optimizing rig performance, and less time on everyday reporting tasks. Key reporting applications include automated daily logs and reports in IADC-approved format.

Real-time operational metrics and KPIs that empower the driller and wellsite team to deliver consistent, superior performance—whether in conventional or unconventional environments.

Identification of ILT through real-time data analysis and statistical comparison of activities on a single rig or across a rig fleet.

To find out more, visit the SENSU system web page.
CASE STUDY

SENSU System Logs over 3,000 Hours of Successful, Uninterrupted Run Time for Saxon Energy Services

Real-time critical rig information enables improved drilling performance, rig operations, and safety.

**CHALLENGE**
Increase operational efficiency and reduce NPT, while improving safety on the rig.

**SOLUTION**
Deploy SENSU* rig operations surveillance and instrumentation system to enable the following:

- Robust and comprehensive rig monitoring
- Greater, more focused rig operations surveillance with new rig-states
- Enhanced decision making by the driller and crew, based on reliable alarms and decision-ready information

**RESULTS**

- Improved real-time decision making by the driller, reducing rig time and costs
- Automated real-time monitoring of critical drilling parameters and KPIs
- Greater operational reliability and ease of use compared to traditional systems

“**The SENSU system offers a range of solutions in one place. It is not only an instrumentation system—it also provides the best reporting tool. The rig state engine automatically detects and displays 17 rig states, helping us to easily understand the operations.**”

Umar Naved
Wellsite Drilling Engineer
Saxon Energy Services

**Fast, accurate data streamlines monitoring**

Using the rig-state engine, the SENSU system’s software capabilities provide Saxon’s rig crew with unique, automatic rig-state detection, allowing them to carefully monitor drilling operations. With accurate depth measurement and calibration capabilities, confidence is increased while drilling wells.

Saxon Energy Services also benefits from the range of applications provided by the SENSU system, including the ability to export data, produce pipe tallies, and create automated daily logs and reports in IADC-approved format. The advanced reporting applications of the SENSU system have been tested extensively by the rig crews and acknowledged as effective time savers.

**New system enables opportunities for time and cost savings**

Saxon Energy Services rig personnel found the new SENSU system easy to install, operate, and configure. Between first deployment in mid-December 2013 and the end of March 2014, SENSU systems on both rigs logged over 3,000 hours without failure and successfully withstood more than six rig moves.

After initial installation on the rig, the SENSU system was set up at each new well location in less than 2½ hours due to its reduced footprint, quick-start feature, and automatic reloading of sensor calibrations.

"**The SENSU system is extremely easy to use and helps save the drilling crew precious time.**"

Khalfan Alabir
Rig Electrician
Saxon Energy Services

Customizable, real-time displays provide accurate, decision-ready information.

www.slb.com/SENSU

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