Core Mud Logging  Drilling  Surface Formation Evaluation  Rig Operations Surveillance

Geoservices  Services Catalog

Version 1
# Core Mud Logging Services

<table>
<thead>
<tr>
<th>Drilling and Formation Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>GN4 Acquisition System</td>
</tr>
<tr>
<td>Sensors</td>
</tr>
<tr>
<td>Drilling Surveillance Options</td>
</tr>
<tr>
<td>Advanced Drilling Pack</td>
</tr>
<tr>
<td>Gas Portfolio</td>
</tr>
<tr>
<td>Mud Logging Units</td>
</tr>
</tbody>
</table>

### InterACT Visualization

### Geological Operations Services

# Drilling Services

<table>
<thead>
<tr>
<th>Wellbore Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLEAR Cuttings Loading and Wellbore Stability Surveillance</td>
</tr>
<tr>
<td>FLAG Fluid Loss and Gain Detection Service</td>
</tr>
<tr>
<td>PreVue Pore Pressure Analysis Service</td>
</tr>
<tr>
<td>Drilling Geomechanics Services</td>
</tr>
</tbody>
</table>

### Drilling Performance

| Thema Drilling Operations Support and Analysis Service |
| Drilling Analyst                                      |

# Surface Formation Evaluation Services

| FLAIR Fluid Logging and Analysis in Real Time |
| Isotope Logging Service                         |

# Rig Operations Surveillance

| SENSU Rig Operations Surveillance and Instrumentation System |
About Geoservices

People
Ever since its foundation, 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 many different nationalities and a healthy gender balance.

The structured career development program includes fixed-step training and relevant competence certifications.

Health, Safety, and the 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 in the communities in which it works.

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

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

Key laboratories and activities include the following:

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, for example, 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 with the drilling fluid.

Advanced Cuttings Characterization Laboratory
Evaluation of advanced analytical techniques such as x-ray diffraction, x-ray fluorescence, diffuse reflectance infra-red spectroscopy to characterize cuttings while drilling.

This is primarily used to characterize mineralogy, total organic carbon content (to predict zones of interest in unconventional reservoirs), and elemental composition.
Products and Services

Geoservices, a Schlumberger company, 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.

**Core mud logging services**
Geoservices is the recognized industry leader in mud logging services, and 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, optimizes the drilling process, and maintains a safe operating environment.

**Drilling services**
Through our new, comprehensive offering of drilling-related products and services, we now have direct alignment with the full range of our customer drilling functions and requirements to deliver reduced risk and improved performance across all drilling environments.

**Drilling performance services**
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 services**
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 non-productive time (NPT) and invisible lost time (ILT), and increase drilling efficiency, with minimal reservoir interference and maximum returns.

**Surface formation evaluation services**
Fluid logging and analysis services at the surface provide the first insight into reservoir fluid composition. Advanced real-time quantitative mineralogical and petrophysical analyses of cuttings and isotope logging help identify lithology for formation evaluation, geosteering, and well placement.

**Rig operations surveillance**
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 unmanned 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.
Geoservices: A History of Innovation

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.
Core Mud Logging Services

Drilling and Formation Monitoring
GN4 Acquisition System
Sensors
Drilling Surveillance Options
Advanced Drilling Pack
Gas Portfolio
Mud Logging Units
InterACT Visualization
Geological Operations Services
Core Mud Logging Services
Drilling and formation monitoring.

The core mud logging service, also known as SLS (surface logging service), is the combination of an acquisition system and a geological laboratory to produce the well stratigraphy and monitor all events during the well construction phase for wells site safety. The mud logging service is then leveraged with enhanced processes to produce high-end services such as accurate gas ratio, string issues detection, and process performance assessment with a secured real-time transmission that enables data to be accessed from any location.

The main mud logging activities include the following:

**Drilling monitoring**
Wellsite surveillance performed by monitoring drilling parameters, mud properties, and toxic gases:
- Surface drilling data—mechanical, hydraulic, and engineering parameters
- Downhole drilling data—parameters imported from other sources, such as downhole pressure, gamma ray, etc.

**Formation monitoring**
Geological and hydrocarbon evaluation:
- Geological data—obtained by physical examination of drilled cuttings
- Hydrocarbon data—obtained by the analysis of mud hydrocarbon content
GN4 Acquisition System

The GN4 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 (e.g., torque, standpipe pressure, cement unit pressure, and weight on hook) is vital to efficient and safe drilling operations. The GN4 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.

The following key capabilities are provided by the GN4 acquisition system:

- Well architecture creation and 3D cross-section view
- Trajectory computation and follow up
- Bottomhole assembly (BHA) reporting
- Mud reporting
- Prekick sheets
- Hydraulics reporting
- Alarm management (including parameter values, and process and hardware failure)

Benefits
- Enhanced safety through quality assurance monitoring and alarms
- Reduced rig-up time with simplified sensor connection
- Reduced NPT—all our services feature plug-and-play capabilities and are integrated 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

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

The information hub.

Featuring a modern, intuitive interface, the GN4 acquisition system is fast and easy to set up. Due to its flexible design, the system can be customized for the specific and unique challenges that each well presents. When required, additional services or sensors simply need to be plugged in to the GN4 platform—these can then easily be removed from the system when no longer required. This plug-and-play design lets you swiftly adjust the GN4 acquisition to meet your needs, reducing NPT and saving costs.

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- Alarm management (including parameter values, and process and hardware failure)
Sensors

The GN4 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 and connected to the system network by a reduced number of cables. Each field box is capable of connecting up to 12 sensors allowing quick and non-invasive rigsite installations.

Example of sensor layout on a land rig.
Using our domain expertise in well monitoring, the Geoservices mud logging service can be tailored to specific drilling challenges. Through early abnormal event detection and quick intervention, we can help minimize your recovery costs.

The Geoservices drilling surveillance options can be easily integrated to the core GN4 acquisition system.
Drilling Surveillance Options

**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), a function of wellbore geometry, fluid, and downhole string characteristics.

**Benefits**
- Optimizes wiper trips and pill frequency
- Detects abnormal wellbore conditions
- Optimizes reaming programs and reduces ILT
Drilling Surveillance Options

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

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

**Pressure Integrity Test**
This Pressure Integrity Test (PIT) application closely monitors all pressure tests, including formation integrity, leak-off, and BOP tests.

**Benefits**
- Determines fracture pressure and 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, LCM, and cement plug in real time.

**Benefits**
- Enables on site premodeling of cement jobs in planning phases
- Minimizes the risk of incorrect positioning of pumped pills and plugs
Drilling Surveillance Options

**TECH REPORT**

**OFFSHORE**

**DEEP WATER**

**Depth**

15,970 ft

**Background**

When a pump shut-off event occurs, a volume of drilling fluid flows back to the active mud pit system driven by several hydraulics factors. During a drilling program, analysts had to compare different flowbacks in real time to quickly determine if an unwanted wellbore event had occurred.

The advanced flowback feature of the latest data acquisition system provided the following:

- Fingerprinting mud return baseline
- Automatic flowback screen pop-up
- Real-time visualization of mud volume return
- Synchronized and superimposed events
- Internal and external alarm management

**Technology**

- Advanced flowback feature of the GN4 data acquisition system

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**GN4 Flowback Feature Enables Fast Detection of Abnormal Mud Volume Return**

Decision-ready information detects unwanted wellbore event and reduces NPT

Using the GN4 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 shutoff (10-bbl increase), and confirmation was received after five minutes (20-bbl increase).

slb.com/drilling
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 the efficiency of the drilling or lithological drillability variation. Generally, mechanical specific energy (MSE) increases when drillability decreases, and when the efficiency of the drilling process decreases. 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
- Provides enhanced 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
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.

**At-Bit Data Tracking**

At-Bit Data Tracking uses a unique synchronization process where lagged data measured at surface is projected 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

**Key Performance Indicators**

Using the automatic detection of rig activity, the duration of each operation (e.g., slip-to-slip time) is logged and made available for time analysis, enabling the tracking and monitoring of key performance indicators.

**Benefits**

- Enables ILT to be quantified to detect efficiency-improvement opportunities
- Provides metrics for post-well evaluations, enabling process-optimization analysis 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 encountered simultaneously on a rig equipped with two-derrick systems.

**Benefits**

- Enables simultaneous and flexible monitoring of all operations encountered 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

The real-time vibrations monitoring service of the GN4 acquisition system highlighted the severe torsional vibrations that caused the broken and fractured core.

For the second core, the data from the vibrations monitoring service was used to adjust drilling parameters, reducing vibrations and resulting in a clean and unbroken core.
Advanced Drilling Pack

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 native 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

A tandem pill was pumped, resulting in a specific response in the standpipe pressure. Using the highly accurate Coriolis mud weight sensor, the tandem pill was observed on the surface one lag time later. The pill was also automatically projected when it was at the bit. Both sets of data were then superimposed and synchronized, allowing actual versus theoretical lag time to be compared. A lag-time calculation error of 3 minutes was detected, which if left unnoticed could have resulted in inaccurate well stratigraphy.

slb.com/geoservices
Gas Portfolio

Pioneering the standardization of gas sampling.

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

The Geoservices portfolio covers mud logging challenges according to well complexity, enabling efficient and rapid on site extraction and analysis of hydrocarbon, as well high vertical resolution.

**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 offers industry-leading fast gas analyzers (such as GFF and Reserval* qualitative gas measurement of C₁–C₅) combined with solid quality-control processes to ensure data quality at all times.

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**Gas sampling under constant conditions**

The GZG Constant Volume Gas Extractor enables mud to be sampled very close to the well head. This minimizes the degassing effect on the light components (C₁–C₂) of the gas into the atmosphere. The positioning of gas traps in the shaker enables the degassing effect to significantly impact the gas ratios between components when using standard methods of sampling.

The GZG 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, offering the same gas sample extraction efficiency and enhanced comparability of the data measured. The gas measurement results can be easily standardized versus the drilling parameters, providing a powerful interpretation tool when comparing different sections of the wellbore or comparing with a reference well.

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Following gas data on the Reserval service.
Gas Portfolio

Pioneering the standardization of gas sampling.

In deepwater operations, the low mud temperature out (due to the riser-cooling effect) does not allow efficient gas extraction. Such conditions affect gas measurements and can mislead interpretations. The constant volume heated degasser from Geoservices allows better extraction in the traditional mud 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.

The constant volume heated degasser allows better extraction in cold mud (right) when compared to a standard degasser (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 impacted 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 expertise prevents gas data being contaminated, effectively removing contamination effects and providing clean gas results that are unaffected by synthetic chemical components and bit metamorphism effects.

Effect of contaminants on standard fast-response chromatographs.

The standard chromatographic analysis shows the effect of the contaminants on the gas readings.

A chromatogram showing that the contamination has been removed from the data.
Gas Portfolio

Pioneering the standardization of gas sampling.

Recycling indication options

Gas In

Gas Out

Gas Out corrected for recycled gas at bit

- Safety indicator for ‘gas-cut mud’ effect
- Control of the rig degassing system efficiency
- Indication of drilling fluid capability to retain hydrocarbons from drilling processes
The Geoservices mud logging units provide purpose-built, climate-controlled environments, onshore or offshore. 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, while the Combined Services Unit can accommodate up to six people full-time. Both have room for temporary visitors.

**Benefits**
- The mud 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, heliportable rigs, tropical forests, and deserts
- Cabins are pressurized, enabling operations in hazardous environments
- Pressurization and shutdown control system 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

**Applications**
- Purpose-built, climate-controlled environment, onshore or offshore
- Built to the highest standards and certified for hazardous oilfield operations
## Standard Mud 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>
<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 / shutdown systems</td>
<td>DNV 2.7.2</td>
<td>DNV 2.7.2</td>
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<tr>
<td>Dimensions LWH</td>
<td>7.30 x 2.59 x 2.75 m</td>
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### Weight

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<thead>
<tr>
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<th>ST3 Standard (worldwide use)</th>
<th>ST3 Xcold (for use within Europe only)</th>
<th>ST3 Norsok (complies with standards for Norway)</th>
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<td>Maximum gross weight</td>
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<td>Payload</td>
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<td>2.5 t</td>
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<tr>
<td>Tare weight</td>
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### Power Supply

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Input</td>
<td>3-phase 380 V, 480 V, 600 V, 690 V, 50 or 60 Hz</td>
<td>3-phase 380 V, 415 V, 440 V, 480 V, 600 V, 690 V, 50 or 60 Hz</td>
<td>3-phase 380 V, 415 V, 440 V, 480 V, 600 V, 690 V, 50 or 60 Hz</td>
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<tr>
<td>Output</td>
<td>220 to 224 V</td>
<td>220 to 240 V &amp; 110 V</td>
<td>220 to 240 V</td>
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### Power Consumption

<table>
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<tr>
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<tr>
<td>Standard</td>
<td>18 kVA</td>
<td>18 kVA (3-phase power required)</td>
<td>18 kVA</td>
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<tr>
<td>Optional</td>
<td>36 kVA (with enhanced gas analyzer)</td>
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<tr>
<td>Water supply</td>
<td>600 kPa [87 psi]</td>
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### Working Temperature

<table>
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<td>Standard</td>
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<td>Optional</td>
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### Certification Level

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<tr>
<td>Certification Level</td>
<td>Zone 1 (standard model for worldwide use)</td>
<td>Zone 1 (Xcold model for use within Europe)</td>
<td>Zone 1 (NORSOK, complies with standards for Norway)</td>
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## Combined Services Unit Mud Logging Unit Specifications (Ratings A, B, C)

<table>
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<th></th>
<th>Model A</th>
<th>Model B</th>
<th>Model C</th>
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<tr>
<td>Certification Level</td>
<td>Zone 1 certification</td>
<td>Zone 2 certification</td>
<td>CE-Zone 2 certification</td>
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</table>
InterACT Visualization Service

Connectivity, collaboration, and information service for monitoring drilling parameters in real time.

The InterACT* Visualization service provides globally accessible and fully integrated drilling-parameter visualization. It incorporates an integrated and 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, together with real-time comments.

The InterACT service 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, an intranet, or a 3G network.

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

Benefits
- Make informed and timely drilling decisions
- Reduce risk and costs
- Monitor 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

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

Real-time data display of drilling, geological, and gas data, including real-time comments.
InterACT Visualization Service
Connectivity, collaboration, and information service for monitoring drilling parameters in real time.

Customizable displays and reliable data transfer
The InterACT Visualization 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 the option of online chats 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 InterACT Visualization service 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.

InterACT Visualization for tablets and mobile devices
Viewing logs via predefined viewing windows is as simple as clicking a link. The fully customizable viewer enables you to achieve the following:
- 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 of data values

From reservoir characterization to production, the InterACT global connectivity, collaboration, and information service delivers accurate and secure well and reservoir data directly to your web-enabled device—at any time, anywhere.

InterACT logs can also be viewed on tablets and mobile devices via predefined viewing windows.

The operations control room.
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 on site (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/quality assurance
- Wireline logging

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

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

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

- Supervising every stage of the drilling process
- Ensuring correct health and safety procedures are followed
- Identifying critical strata from rock-cutting, sidewall core, and conventional core samples data
- Compiling drilling reports and logs, including a final well report

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

**Wellbore Quality**
- CLEAR Cuttings Loading and Wellbore Stability Surveillance
- 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
The CLEAR* cuttings loading and wellbore stability surveillance service, delivered by Geoservices analysts, monitors hole cleaning effectiveness and wellbore instability. The weight of cuttings reaching the surface is continuously measured and analyzed. By comparing measured and theoretical volumes, the service provides early detection of inadequate hole cleaning and of excess returns caused by wellbore instability (caving) or damage.

**Benefits**
- Lower NPT and maximize ROP by monitoring and optimizing hole cleaning
- Improve safety with early detection of wellbore instability (caving) and formation damage through excess returns
- Avoid stuck pipe incidents caused by packoff
- Minimize off-bottom circulation time
- Facilitate casing running and landing

**Features**
- Four strain gauges per shaker to measure cuttings recovery
- Digital measurements for improved accuracy
- Data availability soon after cuttings return to surface
- Wellsite and remote monitoring
- Customizable displays including comparison of measured and theoretical volume

**Applications**
- Extended-reach drilling and highly deviated wells
- Difficult hole cleaning conditions
- Unstable wellbores
- Shale oil and gas drilling
- Equivalent circulating density (ECD) management
Comprehensive and customizable displays
Through the acquisition system, cuttings flow information is integrated with drilling parameters, cuttings geology, drilling fluid properties, and MWD/LWD data, providing a comprehensive picture in real time. Results can be viewed via customizable displays on monitors at the wellsite or in remote offices for analysis by well construction engineers. Various parameters and practices can be modified as required. Comparing the recovery ratio before and after a treatment allows accurate assessment of the effectiveness of the remedial measures selected.

Multiple sensors and digital signals
A cuttings flowmeter (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, cuttings accumulate on it and 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 equipment does not obstruct access to the shale shakers. It complies with the EU’s Atmospheres Explosives (ATEX) directive for use in explosive environments and is IECEx and European Conformance (CE) rated.

Mud-effect correction
Because the coating of mud on cuttings can vary considerably, a correction factor called the equivalent dry cuttings ratio (EDCR) is applied to account for this variation. The wet cuttings weight is converted into an equivalent volume of dry cuttings, which can be compared with the theoretical volume of formation drilled at any time.

The CLEAR service measures or computes and records the following data:
- Cumulative wet weight of cuttings falling from the shakers
- Cumulative dry weight of cuttings
- Measured dry cuttings volume
- Theoretical dry cuttings volume
- Measured cuttings flow rate (dry cuttings flow)
- Theoretical cuttings flow rate (nominal cuttings flow) based on ROP
- Volume excess or deficit
- Percentage of cuttings recovery
CLEAR
Cuttings loading and wellbore stability surveillance.

<table>
<thead>
<tr>
<th>Cuttings Flow Meter Specifications</th>
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<tbody>
<tr>
<td>Length 1.854 m (6.083 ft)</td>
</tr>
<tr>
<td>Width 0.501 m (1.644 ft)</td>
</tr>
<tr>
<td>Height Minimum: 1.043 m (3.422 ft)</td>
</tr>
<tr>
<td>Maximum: 1.103 m (3.619 ft)</td>
</tr>
<tr>
<td>Minimum free space required under shaker 0.111 m (0.364 ft)</td>
</tr>
<tr>
<td>Weight 145 kg (320 lb)</td>
</tr>
<tr>
<td>Strain gauges 4</td>
</tr>
<tr>
<td>Paddle volume 28 liters (7.4 gal)</td>
</tr>
<tr>
<td>Sensor nominal sensitivity 2 mV/V (+1%)</td>
</tr>
<tr>
<td>Sensor nominal load 100 kg (220 lb)</td>
</tr>
<tr>
<td>Air supply 6 bar minimum</td>
</tr>
</tbody>
</table>

The CLEAR service—putting science and measurements behind hole cleaning
CLEAR Service Identifies and Mitigates Wellbore Instability

Hole monitoring eliminates threat to operator’s schedule and budget

**CHALLENGE**
Wellbore instability was suspected during extended-reach drilling (ERD) operations, raising safety concerns and posing a threat to the operator’s schedule and budget.

**SOLUTION**
The CLEAR® cuttings loading and wellbore stability surveillance service was used by the operator to monitor cuttings removal from the hole and to analyze the efficiency of the pill program.

**RESULTS**
The CLEAR service engineer identified evidence of caving and concluded that a 900-psi pressure increase was causing instability at a certain point in the wellbore. Adjustment of the pills program, drilling parameters, and mud properties was applied with success, verified by subsequent CLEAR service monitoring. Learning from this situation was also applied to the drilling of further wells, resulting in time and cost savings for the operator.

The operator, Foxtrot International, was drilling the first horizontal ERD well of its development campaign in Ivory Coast. The MAHI-A1 well was to be drilled in the Mahi structure in the north/northeast of the country.

ERD has proven to be an efficient solution in restricted reservoir production, reducing wellsite footprint and minimizing environmental effects, while dramatically improving reservoir drainage at reduced cost. However, this method of drilling horizontal wells requires advanced technology that can describe downhole conditions accurately to identify the factors that cause harmful vibrations, bottomhole assembly (BHA) damage, poor performance, and inadequate hole cleaning.

**First ERD well of drilling campaign poses hole cleaning challenge**
A 12 1/4-in section of the well was to be drilled to 5,797 m measured depth (MDRT), in a long slant section of 3,795 m. The section TD was intended to be the top of the Albian reservoir. The main objectives were to:

- drill the long slant section with optimized parameters (to minimize the number of bit runs and avoid overloading the annulus with cuttings)
- maintain wellbore stability
- successfully run and cement the 9 5/8-in casing string to section TD.

Due to the nature of the horizontal well, cuttings buildup posed a significant challenge to efficient drilling performance. To ensure the success of operational objectives, hole cleaning during drilling of Well MAHI-A1 would have to be carefully monitored.

In order to optimize the drilling of this well, the operator used tandem pills (required for hole cleaning). Tandem pills consist of two pills: a low viscosity pill to stir up the cuttings from the bottom of the hole, followed by a weighted pill which then sweeps the cuttings out to surface.

CLEAR service equipment in operation, collecting cuttings from the shale shaker.
CASE STUDY: Hole monitoring eliminates threat to operator’s schedule and budget

Successful hole monitoring prevents wellbore instability and provides pill analysis

While drilling the 12¼-in section of the well, tandem pills were pumped on 200 to 300-m intervals. The CLEAR service engineer identified that mechanical cavings were present in the returned pill—there had been no signs of caving during drilling. Using the CLEAR service technology, the engineer analyzed the mud logging surface data, detecting cavings at the point where the pill emerged from the drillstring into the open hole and concluded that they were creating an area of instability in the wellbore.

It was decided that, if it was necessary to pump a pill, the flow rate should be reduced once the pill was close to the bit to reduce the impact of the change in mud properties.

This learning was also successfully applied in the drilling of further wells. It is estimated that, without this intervention, around 15 to 20 pills would have been pumped in each subsequent well without additional benefit. The actions prompted by the CLEAR service analysis saved the operator valuable time and cost in the drilling of its wells.
FLAG
Fluid loss and gain detection service.

The FLAG* fluid loss and gain detection service, delivered by Geoservices analysts, detects influx or loss in the well significantly faster than sensors monitoring the mud pits.

Benefits
- Improved well safety
- Reduced NPT
- Lower environmental risk
- Optimized drilling procedures

Features
- Reliable differential flow-out 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, making a 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

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

Winner of the Offshore Technology Conference (OTC) 2014 Spotlight on New Technology Award
FLAG
Fluid loss and gain detection service.

**Accurate differential flow out 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.

The algorithm is accurate under a number of operating conditions such as drilling, tripping, circulating, and cementing. The system automatically compensates for mud compressibility and disturbances that could mask the true flow, such as pipe movement or heave on a floating rig. Transitional flow regimes, like those created by starting or stopping of the pumps, can also be accommodated.

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-based 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.

**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.

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

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 slimhole 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.

![FLAG service detecting an influx substantially earlier than was possible using a conventional flow paddle method.](image)
PreVue

Pore pressure analysis service.

The PreVue* pore pressure analysis 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 while drilling), drilling (ROP and torque), gas (C₁–C₅), and other mud 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, together with potential loss of life and property. The PreVue service can play a decisive role in minimizing these risks and improving drilling performance.

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

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

![Resistivity used as porosity dependent curve to estimate pore pressure.](image)
PreVue
Pore pressure analysis service.

**Predrill planning**
Before drilling starts, pore pressure experts in the Geopressure Technical Center analyze offset data such as results from leakoff tests (LOT), 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 service provide a 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 client 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.

![Pore pressure and fracture gradient log versus depth.](image)
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.

**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 well site and office support
- End-of-well review including an updated DrillMAP plan, including a geomechanics roadmap identifying all risks and events encountered

**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

*Using formation evaluation logs and seismic, core, and drilling data, our geomechanics experts build a 1D or 3D mechanical earth model 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 safe and 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 measurements while drilling 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 client 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 client’s drilling and well-design team to build a predrill mechanical earth model (MEM). 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 road map.

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 client 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 assist during well planning and design, our geomechanics experts provide a DrillMAP plan that provides actionable wellbore-stability and pore-pressure information. During operations, our pore pressure and geomechanics experts use DrillCAST drilling operations look-ahead to continuously monitor data while drilling, providing recommendations to avoid potential hazards ahead of the bit.
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.

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**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.

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The real-time drilling geomechanics workflows and modeling predicted and mitigated wellbore stability issues during drilling operations.
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 offset well information.

This resulted in an informed decision to set the 11¾-in casing early. The 9½-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 7¾-in hole.

As the 9½-in hole was drilled below the 9½-in casing, real-time geomechanics modeling predicted a severe tightening of the mud weight window, requiring an unplanned 7¾-in casing string. Although the well was landed using a 6½-in × 7½-in bit, a slimhole section was avoided because the 9½-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
The Thema* service offers a unique workflow; connecting information from rig-site resources and data with our experts and knowledge. The service supports, analyzes, and maximizes performance of all elements in a drilling project, both at the rig and in the client office.

**Benefits**
- Enhanced communication
- Geoservices analysts offer a 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
- Our analysts and Thema system tools correlate and integrate 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

**Applications**
- Exploration
- HPHT
- Deep water
- Extended-reach drilling

Through data replication, all data produced at the rig site, together with contextual information such as well architecture, mud details, and string data, among others, is sent to our customer’s offices.

A dedicated Thema analyst (based at the customer’s office) then integrates all downhole and surface data, delivering detailed reports directly to the customer as well as finalizing objectives and making recommendations for effective decision making.

The Thema analyst communicates these conclusions, models, best practice recommendations, and detailed analyses both to the customer and the rig-based team—ensuring that information reaches the right people, at the right time.

*Based in the customer’s office, the Thema analyst makes recommendations for effective decision making.*
Our customers receive wellsite support in the form of a comprehensively equipped Geoservices mud logging unit (with mud logger and data engineer in situ), and a dedicated Geoservices engineer based in the customer’s office.

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

The Thema analyst has real-time access to time and depth data from the Geoservices mud logging unit. Using this data, the engineer will integrate, enrich, and combine 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 engineer 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 analyst from the worldwide Geoservices Quality and Operations Support team.

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

**Rig-site deliverables:**
- Semi-automated daily activity report (DAR)
- Master log
- Flowback log

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

The Thema service provides added information to improve the decision-making process.
Applications

**Thema Drilling Efficiency (DE) Panel**
The DE Panel takes real-time drillstring 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, mechanical specific energy (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 downhole.

DE Panel capabilities:
- Assessing the bottomhole assembly’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, extended-reach drilling, and while performing coring operations

**Real-time add-on applications:**
- High-frequency data
- Vibration monitoring and alarms
- Imported third-party time data

**Applications**

**Thema 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:
- Lithology information for correlation of torque increase and excessive drag with formation
- Torque and drag (T&D) modeling
- Real-time drilling parameters correlated with information from the T&D model
- Real-time acquisition of T&D data through activity filtering
- Real-time rheology parameters display
- Display and correlation of dogleg severity and LWD data
- Monitoring and follow-up of back reaming and wiper trips

**Real-time add-on applications:**
- Cuttings flowmeter
- Pickup and slack-off models
Thema
Well Balance Monitoring and Analysis

Applications

Thema Well Surveillance Panel
Primary well control is the foundation of all drilling operations. The Thema 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:
- Time-based log including display of hole gain and losses computations (from the optional FLAG fluid loss and gain detection 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

Real-time add-on applications:
- Flowback monitoring
- Synchronized event display
- Fluid displacement monitoring
- Synchronized data at bit
- FLAG fluid loss and gain detection service
- Real-time display
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 Petrotechnical Engineering Centers (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/well objectives and anticipated challenges, the PDP will include 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.

Integration role of the drilling analyst during the engineering, execution, and evaluation phases of the well.
Drilling Analyst

Engineering integration and drilling optimization.

A graphical representation of the PDP (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/well requirements, which are prioritized and aligned with the key drilling performance indicators 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 (geomechanics, fluids, bits, drilling, formation evaluation, etc.) to support any necessary model updates and to collaborate with the operator’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.

**Analyst 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 operator’s real-time monitoring center, analysts participate in rig calls and discussions with the operator’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 pre-operation 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.
Surface Formation Evaluation Services

FLAIR Fluid Logging and Analysis in Real Time

Isotope Logging Service
FLAIR

Fluid logging and analysis in real time.

The FLAIR* fluid logging and analysis in real time 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.

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

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

Applications
- Inter- and intra-well fluid facies mapping
- Support for geosteering and well placement
- Formation evaluation data assurance in challenging environments

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**CnF Mole%**

<table>
<thead>
<tr>
<th></th>
<th>FLAIR pilot hole</th>
<th>PVT pilot hole</th>
<th>FLAIR sidetrack hole</th>
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<tr>
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<td>89.5</td>
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<tr>
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<td>0.3</td>
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</table>

CₙF = Quantitative fluid composition provided by the FLAIR fluid logging and analysis in real time service. This composition is comparable to reservoir fluid.

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Pilot hole: OBM  
Sidetrack hole: WBM

Used in both pilot and side track wells, FLAIR analysis indicated that the fluid of the sidetrack hole had the same composition as the fluid in the pilot hole. The FLAIR quantitative data was confirmed by PVT analysis of downhole fluid samples from the pilot well.
FLAIR

Fluid logging and analysis in real time.

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

**Data acquisition**
The Flex fluid extractors continuously sample mud from the flowline returning from the well (Flex OUT) and in the pump suction line (Flex IN). Extraction occurs at controlled constant thermodynamic conditions and is calibrated for each mud system. The extracted hydrocarbon is transported to a specifically designed detector, which provides a full chromatographic analysis up to C8, including differentiation of several Cn isomers.

**Data processing**
The constant and repeatable extraction conditions, including calibration against the mud system in use, enable the recycling effect to be quantified. Processing of the acquired data includes synchronization of ‘in’ and ‘out’ data, and filtering for potential equipment quality control issues and drilling artefacts. The formation fluid composition with respect to the C1–C6 components can therefore be quantitatively determined throughout the drilling of the well. Accurate measurement and robust data processing are foundations for enhanced interpretation.

**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. From daily quicklooks (including facies and star diagrams) to more in-depth analysis such as multwell studies, our expertise contributes to greatly enhanced reservoir understanding.

**Proven formation evaluation technology**
The FLAIR service has been successfully used worldwide in over 1,000 exploration, appraisal, and development wells in all geological settings and complex operation conditions (deep water and shallow offshore, onshore HPHT, and tight formations), and with different reservoir fluids.

The FLAIR service: From data acquisition to data interpretation, a proprietary process delivering a PVT-equivalent quantitative composition of hydrocarbon in place.
Isotope Logging
Continuous isotopic ratios measurements in real time.

The 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.

Our quantitative continuous isotopic ratio measurement (left) provides a unique robust input for geochemical characterization of reservoirs (right and center).

Benefits
- Assessment of fluid migration mechanisms, such as sealing characteristics of cap rocks and faults, connectivity, and compartmentalization
- Early identification of active/non-active hydrocarbon system
- 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

Applications
- Complex fluids and fluid uncertainties
- Unconventional reservoirs
- Assistance with downhole fluid sampling programs, including selection of spot-sample analysis
Isotope Logging
Continuous isotopic ratio measurements in real time.

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

**Integrated interpretation and decision making**
Integrated with other formation evaluation data sources, the availability of isotopic ratio logs in real time 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 client 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, Advanced Cuttings Characterization, and Logging While Drilling services) for a complete picture of the petroleum system. Advanced Cuttings Characterization (ACC) is a suite of measurements providing mineralogical and elemental composition and kerogen content of cuttings through integration of x-ray diffraction (XRD), x-ray fluorescence (XRF), and Diffuse Reflectance Infrared Fourier Transform Spectroscopy (DRIFTS).
Rig Operations Surveillance

SENSU Rig Operations Surveillance and Instrumentation System
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 non-productive time (NPT) and invisible lost time (ILT), the SENSU system enables cost reduction of daily rig operations.

Benefits
- Optimize well construction performance using daily, automated KPI dashboard; detailed performance benchmarking; and gap analysis
- Obtain decision-ready information—precisely 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 unmanned 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/start system with automatic loading of sensor calibration

Applications
- Land rigs and fixed platforms with minimal, unreliable, or no drilling instrumentation
- 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
- Factory drilling rigs
SENSU

Rig operations surveillance and instrumentation system.

**Lean deployment at the well site**
With a reduced footprint and automatic reloading of sensor calibrations, the SENSU system has true start/stop functionality. Non-invasive rig installation and quick configuration enables 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—enabling 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/states, enabling real-time calculation of 18 event metrics, including:

- Back reaming, 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.

The SENSU system provides a unique platform with real-time operational metrics and KPIs, empowering the driller and wellsite team to deliver consistent, superior performance—whether in conventional or unconventional environments.
SENSU
Rig operations surveillance and instrumentation system.

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 is 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.

Extensive networking and connectivity
The SENSU system has the unique ability to connect to the majority of rig equipment, including all types of sensors, pit volume totalizers, and detectors for hazardous gas. The system also connects the rig with office-based personnel, enabling the sharing of wellsite information—such as real-time drilling data—via the InterACT Visualization* modular real-time data display.

Data can be viewed on a wide range of devices, including tablets, and mobiles (HTML5 and specific Apple iPhone and iPad applications are supported) using the WITSML industry standard.
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

Opportunities for improved efficiency and reduced risk on a mature rig
The rig instrumentation systems on two Saxon Energy Services rigs in Oman were in need of updating to improve rig operations and well construction. The existing system required considerable human intervention to set up, record measurements, and compute parameters. This consumed a significant amount of time, increased the likelihood of errors, and prevented the rig crew from improving the efficiency of daily operations.

**Integrated digital system provides efficient solution**
Schlumberger proposed the SENSU rig operations surveillance and instrumentation system, which helps improve drilling performance and safety by networking more than 200 digital electronic sensors—located at various positions on the rig—with data processing units and user-friendly displays to provide a complete, reliable, and real-time rig operation monitoring system. These capabilities, combined with Geoservices’ extensive experience in surface data acquisition, deliver improved data quality that enables enhanced decision making at all times.

The rig-state engine (which includes automatic detection of 17 rig activities) provides the granularity that enables real-time monitoring of KPIs. Through the automatic generation of reports and tracking of flat time via a real-time dashboard, Saxon Energy Services rig personnel are able to improve overall well construction. All well data is stored within an easily accessible database. Data can also be transmitted to remote offices via standard protocols such as WITS0 and WITSML, enabling real-time monitoring and performance benchmarking on the rig and over a rig fleet.

Customizable, real-time displays provide accurate, decision-ready information.
CASE STUDY: Real-time rig information enables improved drilling performance, rig operations, and safety in Oman.

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

Khalfan Alabir
Rig Electrician
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.