CoPilot Service
Real-time drilling optimization service
CoPilot service

Spotlight the downhole drilling environment

Baker Hughes CoPilot™ real-time drilling optimization service raises the bar to deliver enhanced wellsite efficiency, reliability and borehole quality. This industry-leading service—based on comprehensive prewell planning, a versatile new data acquisition and diagnostic tool, and thorough post-well analysis—reveals insight into downhole conditions with a level of accuracy and detail never provided by a prior tool or service.

At the wellsite, the CoPilot service helps drillers optimize their drilling performance in real time via a multiple-sensor downhole tool, a customizable display reflecting the downhole conditions, and experienced personnel engaged in proactive processes and intervention techniques to improve the drilling process. The CoPilot service offers many benefits:

- Immediate feedback for informed, real-time decision making
- Proactive, safe drilling optimization
- Early detection and resolution of drilling problems
- Comprehensive data capture for detailed post-well analysis and identification of “lessons learned” in bottomhole assembly design, bit selection and best drilling practices.

The hardware

The CoPilot downhole tool represents the industry’s most advanced and versatile downhole drilling dynamics data-acquisition and processing system. The tool can simultaneously sample up to 14 sensor measurements at 1,000 Hz:

- Weight-on-bit (WOB)
- Torque
- BHA bending moment
- Annulus equivalent circulating density (ECD) and bore pressure
- Accelerations (four directions)
- Magnetometer signals
- Temperature

Execute

At the wellsite, we help execute the drilling plan following the operator’s actual drilling parameters, involving day-to-day drill plan management, data transmission and diagnostics, and recommendations and decision making.

CoPilot personnel actively review and interpret downhole information to efficiently control the drilling parameters, handle procedural changes, and proceed without loss of time and equipment. In addition to rig-based CoPilot personnel, the service can be supported in real time by application engineers located in one of our worldwide BEACON™ expert advisory centers.

Strong finish

At the conclusion of drilling operations, the CoPilot service includes further analysis of the captured data. Depending on the application, time and depth-based memory logs, coupled with surface-acquired log data, may be organized—along with any other data of client interest—to construct a full-featured, end-of-well report.

A synopsis of the drilling operation, key lessons learned, recommendations, and a collection of the daily detailed reports is created. Case studies may be developed to tell the complete story of the drilling operation.
**Drilling optimization**
The CoPilot service provides an optimized start-to-finish drilling service for enhanced rigsite efficiency and superior BHA reliability.

**Advanced prewell planning**
- Collaborate on thorough, prewell drilling plans
- Establish surface monitoring arrangements
- Optimize BHA design through advanced modeling

**Flawless rigsite execution**
- Deliver real-time information for quick, accurate decisions
- Enhance rate-of-penetration and optimize drilling efficiency
- Optimize overall drilling process reliability and minimize drillstring failure
- Improve wellbore quality

**Detailed post-well analysis**
- Deliver comprehensive end-of-well reports and rich data sets for detailed analysis
- Facilitate rapid development of best practices

**Accelerated learning**
Our CoPilot drilling optimization service is a key means for improving learning and the development of best practices throughout the drilling process.

**Drilling phase**
The CoPilot service provides drillers and drilling engineers unique insight into downhole conditions—improving their working knowledge of the drilling environment and the various forces impacting drilling efficiency and performance. Based on this knowledge, drillers can now proactively manage operating parameters to minimize nonproductive time, eliminate unplanned downhole trips and extend equipment life.

**Post-well analysis**
At the conclusion of drilling operations, the detailed data sets and wellsite reports (additional measurement-while-drilling/logging-while-drilling log data) can be used to construct a full-featured, end-of-well report. This includes a synopsis of the drilling operation, lessons learned, identification of best practices and recommendations for future wells.

**Ongoing research**
In addition to client use, the detailed CoPilot data is evaluated by Baker Hughes design and reliability engineers to further enhance overall reliability and performance. Analysis of high-frequency data sets acquired under diverse drilling conditions is leading to the development of new diagnostic algorithms, the design of improved MWD tools, the validation of drilling dynamics models, and the development of improved and more efficient drilling practices.

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**Real-time bending moment information**—A key CoPilot measurement, especially when drilling 3D-directional wells, is the bending moment. This measurement represents the bending stresses in the BHA caused by the wellbore curvature and gravity. The near-bit bending moment transmitted by the CoPilot tool provides better directional control and facilitates the early detection of unintentional high local doglegs introduced at formation interfaces. This permits the driller to take appropriate action (e.g., changing the steering force, initiating reaming trips) in a timely manner. As a result, hole quality is improved and BHA fatigue and component wear is reduced to avoid costly replacement and NPT.
Handling drilling challenges with the CoPilot service

The CoPilot service impacts drilling efficiency, downhole reliability and borehole quality at numerous points during the drilling process.

CoPilot job overview

Job preparation
- Service delivery plan
- Downhole and surface system setup
- Communication plan
- Distribution list for daily report and logs
- Web-based data transmission (when applicable)
- Prejob presentations
- Drilling program education with emphasis on known or perceived drilling hazards

Job execution
- Active drilling parameter management and optimization
- Transmission of CoPilot data and diagnostics
- Interpretation of CoPilot and other wellsite data
- Advice/recommendations on drilling parameters and procedure changes
- Communication and documentation
  - Daily client reports
  - Experienced CoPilot personnel
  - Office-based BEACON support

Daily reporting and logs
- Key statistical summary
- Detailed CoPilot data and summary of actions taken

Job closure
- Data analysis and documentation
  - Time and depth-based logs of memory data integrated with surface measurements and other data of client interest
- Synopsis of drilling operation
- Lessons learned and recommendations
Day 3, 15.20 hours—2,463 ft
After drilling out the casing shoe, the CoPilot service’s downhole WOB data confirmed successful activation of the underreamer in the BHA.

Day 4, 04.21 hours—4,295 ft
CoPilot diagnostics flagged a severe whirl event (caused by a loss of weight to the bit when the underreamer hit a harder formation). Rotary speed was immediately reduced and drilling operations proceeded with caution at low RPM until the desired WOB could be safely re-established.

Day 6, 18.35 hours—4,956 ft
Casing shoe and float were drilled out efficiently with the CoPilot tool. The CoPilot service confirmed a low bending moment value—ensuring no high local dogleg was created while exiting the cement.

Day 7, 02.38 hours—5,623 ft
Operator encountered a drill break after hitting a hard stringer. Downhole torque confirmed good bit status. ROP picked up after breaking through a hard stringer into softer formation. The drilling parameters were optimized for maximum ROP. A minimal increase in bending moment confirmed good borehole quality with no high local dogleg.

Day 7, 14.51 hours—6,117 ft
At 50° hole inclination, a comparison of downhole WOB measurements with surface weight indicated a weight transfer problem. The problem was diagnosed as cuttings buildup. Drilling procedures were modified to ensure optimal hole cleaning and avoid packoff problems.

Day 8, 02.38 hours—6,976 ft
The driller increased WOB to maximize ROP. The CoPilot tool flagged an increase in torsional oscillations that developed into full stick/slip. Drilling parameters were adjusted to ensure safe drilling at optimum ROP.

Day 12, 10.23 hours—7,897 ft
Successfully optimized drilling parameters when drilling through a calcite-cemented nodule. Maintained optimal ROP without creating a local dogleg. Torque information confirmed that the bit started to “bite” a harder formation with a slight increase in bending moment.

Day 14, 20.25 hours—14,860 ft
Bending moment data indicated an azimuthal dogleg was being created by a calcite-cement nodule in the reservoir sand. AutoTrak™ steering forces, as well as drilling parameters, were immediately adjusted to mitigate and minimize fatigue.

Day 15, 12.32 hours—16,315 ft
CoPilot service detected increased lateral vibrations and whirl motion. Drilling parameters were constantly adjusted to minimize vibrations while achieving superior ROP.

Day 16, 01.21 hours—18,371 ft
TD reached pilot well. Downhole weight and torque data confirmed good bit cutting action. Decision was made to perform an openhole sidetrack with the current BHA.

Day 16, 22.45 hours—10,517 ft
Efficient execution of an openhole sidetrack. After drilling a short section with minimum weight, bending moment data confirmed that the new hole was drilled out of the low side of the pilot hole. Drilling parameters were gradually increased to achieve optimum ROP.

Day 17, 06.57 hours—12,860 ft
The directional driller adjusted AutoTrak steering forces based on the CoPilot service’s bending moment data to execute an azimuthal turn without exceeding the desired dogleg severity.

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**CoPilot service benefits**

**Improve drilling performance**
- Safe optimization of drilling parameters based on immediate feedback from the CoPilot downhole tool
- Optimize ROP
- Provide bit status information
- Improve directional control
- Execute openhole sidetracking faster
- Eliminate unnecessary reaming trips

**Enhance risk reduction**
- Early detection and resolution of drilling problems
- Resolve “whirl” situations, avoiding trips for failed equipment (or fishing after twist off)
- Initiate timely reaming to overcome weight transfer problems
- Improve hole cleaning
- Detect and provide for mitigation of formation induced local doglegs

**Accelerate learning**
- Views of the downhole conditions
- Make quick, informed decisions
- Integrate on-rig team members with data center support for collaborative review
- Comprehensive data set for detailed post-well analysis
- Document lessons learned and identify best practices
- Learn from data rather than from failure patterns
Optimize the drilling process

Real-time information about the downhole environment has never been more critical. Today’s complex drilling plans, operational schedules, and multiple target zones all require precise information to maximize drilling performance and wellsite efficiency.

With the Baker Hughes CoPilot service, operators have access to a comprehensive, start-to-finish drilling optimization program—allowing them to plan and execute complex drilling programs with confidence.

Prior to deployment, our experts work closely with the operator to develop a thorough drilling plan. Then, at the wellsite, our CoPilot team monitors the well’s progress with real-time access to critical downhole information and adjusts drilling parameters "on the fly" to optimize drilling efficiency, enhance BHA reliability, and improve borehole quality.

Once the well is completed, drilling application engineers can review the full set of dynamics data to further refine drilling programs in that field or similar fields.

Plan for success

The integration of drilling planning with the CoPilot service provides an optimized course of action that increases the likelihood of success of the venture. The start-to-finish services cover job preparation, execution, and closure, with extensive communication and reporting features as a standard part of the entire process.

As part of this detailed planning process, Baker Hughes applies BHASys_Pro, an industry-leading modeling software application, to analyze the bending moment distribution in a BHA for the planned wellbore geometry and anticipated operating environment.

BHASys_Pro is the perfect complement to the CoPilot service, giving the drilling application engineer the ability to accurately predict the bending moment response as a function of dogleg severity, identify potential roadblocks, build operational parameters, and gauge tool quality and longevity throughout the drilling process.

Baker Hughes works closely with the client and operator to establish a thorough, reliable, service-delivery plan. This includes BHA design and modeling, as well as rigfloor display arrangements for surface monitoring.

A communications plan is agreed upon that outlines distribution and contacts for daily reports/logs, web-based data transmission (when applicable) and pre-job presentations to specific personnel.

The preparation phase includes a review of the drilling program and the known or perceived hazards of the venture.

All data is fed into a digital signal processor for advanced downhole processing and analysis. The CoPilot tool transmits the data to the surface every five seconds via mud pulse telemetry.

Communications include static data and diagnostics that indicate the occurrence and severity of drilling dynamics problems.

The processed data is stored in tool memory for later retrieval and post-well analysis. In addition, the tool can record intervals of raw data at high rates for detailed analysis.

We engineered the modular CoPilot sensor sub for flexible placement within our downhole BHA, based on the application’s requirements.
Monitor downhole data
At the surface, the rigfloor monitor displays the downhole data alongside surface-acquired data, permitting the driller to easily view downhole conditions—facilitating crucial, real-time decisions during the drilling process.

The CoPilot rigfloor display can be configured based on various requirements:

- Service type and level provided (e.g., AutoTrak RCLS, steerable motor)
- Available rigfloor space (can be integrated with other displays)
- Operator preferences (modifiable on-site)
- Integration with other communication services (e.g., web-based communications)

CoPilot data may be integrated into the Baker Hughes BEACON service to permit online sharing of information among various rigsite and office-based locations. This flexibility creates an accessible network and facilitates more informed and collaborative decision making in the drilling process.

The industry’s most advanced drilling data acquisition and processing tool
Our advanced downhole CoPilot tool, the backbone of our drilling optimization service, has sophisticated and dynamic features:

- Low-noise, high-speed, simultaneous data capture of 14 dynamic channels
- Continuous downhole processing
- High-frequency data storage

Applications
CoPilot services have been employed in numerous challenging operating environments worldwide—enabling operators to safely and efficiently drill some of the industry’s most complex well plans.

With the CoPilot service, Baker Hughes can address critical drilling issues and challenges:

- Maintaining drilling efficiency in challenging applications, such as interbedded formations or complex well formations
- Drilling high-end applications, such as deepwater and ERD, with increased confidence
- Establishing best practices for new fields more quickly and efficiently than previously possible
- Improving established drilling performance in existing fields to minimize NPT
- Introducing new downhole technology while minimizing the impact to the drilling process

CoPilot Key Data and Diagnostics

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<thead>
<tr>
<th>Static Measurements</th>
<th>Dynamic Diagnostics</th>
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<tbody>
<tr>
<td>Axial</td>
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<tr>
<td>WOB</td>
<td>Bit bounce</td>
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<tr>
<td>Axial acceleration</td>
<td>Axial vibration severity</td>
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<tr>
<td>Lateral</td>
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<tr>
<td>Bending moment</td>
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<td>Bending rate</td>
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<td>Lateral acceleration</td>
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<td>Torsional</td>
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<tr>
<td>Downhole string rotation rate</td>
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<tr>
<td>Tangential acceleration</td>
<td>Stick/slip</td>
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<tr>
<td>Motor RPM (if applicable)</td>
<td>Tangential vibration severity</td>
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<tr>
<td>Hydraulics</td>
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<td>Annulus pressure (ECD)</td>
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The CoPilot service has proven critical in helping operators drill challenging well profiles and extended-reach multilateral wells. (Courtesy of Hydro, Norway)
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