



# Weatherford®

## MWD and Surveying Services

Offering **More** MWD options, with more reliability,  
for more optimized directional-drilling operations  
in any well environment

From routine to extreme, we deliver.

### Drilling Services

- Directional & performance drilling
- LWD
- MWD
  - Directional survey & gamma ray
  - Drilling performance
  - Magnetic ranging
  - Mud-pulse & EM telemetry
- Rotary-steerable systems



Drilling



Evaluation



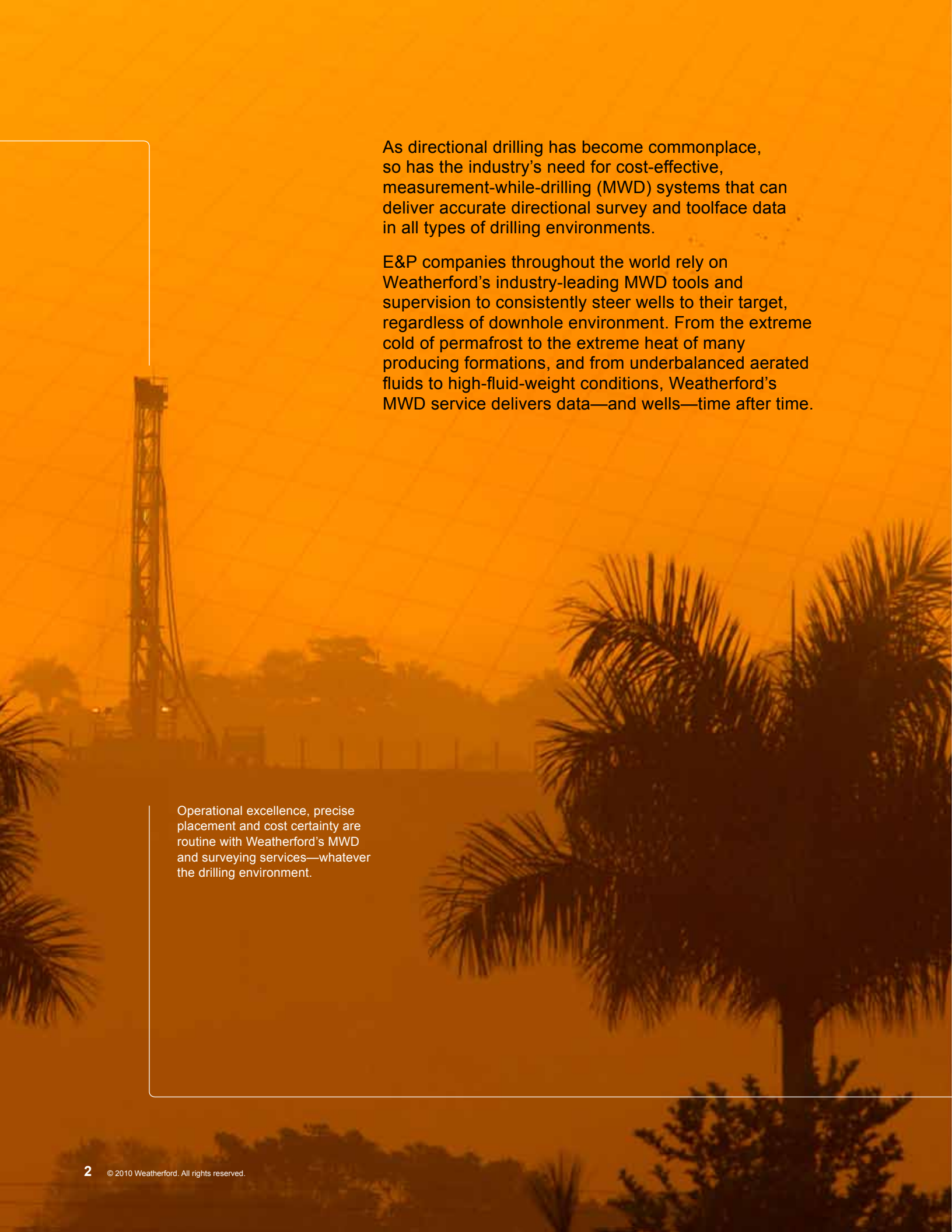
Completion



Production



Intervention



As directional drilling has become commonplace, so has the industry's need for cost-effective, measurement-while-drilling (MWD) systems that can deliver accurate directional survey and toolface data in all types of drilling environments.

E&P companies throughout the world rely on Weatherford's industry-leading MWD tools and supervision to consistently steer wells to their target, regardless of downhole environment. From the extreme cold of permafrost to the extreme heat of many producing formations, and from underbalanced aerated fluids to high-fluid-weight conditions, Weatherford's MWD service delivers data—and wells—time after time.

Operational excellence, precise placement and cost certainty are routine with Weatherford's MWD and surveying services—whatever the drilling environment.



## **More** reasons to choose Weatherford's MWD services

### **More economy**

**Cost certainty** because pricing, performance, reliability and retrievability make approved financial expenditure (AFE) cost—the final cost

**Less nonproductive time** because of the extreme reliability and vibration tolerance of Weatherford's MWD tools

**Less lost-in-hole cost risk** with retrievable configurations

**Rig-time saving** with electromagnetic (EM) telemetry, which can transmit data to the surface continually, independent of rig operations and fluid properties

### **More efficiency**

**Operational simplicity** under a wide range of flow rates

**Simple, rapid** rigsite installation

**On-the-fly operation** and inclination redundancy with the IncSonde inclination sonde sensor

### **More capability**

**Precise positioning between more wellbores** through active magnetic-ranging technologies

**High-dogleg and short-radius capabilities**

**High lost-circulation-material (LCM) tolerance** as a result of our hostile-environment pulser design

**No drilling-fluid restriction** when using EM transmission

**Greater EM depth capability** with extended-range option

**High mud-pulse telemetry rates**

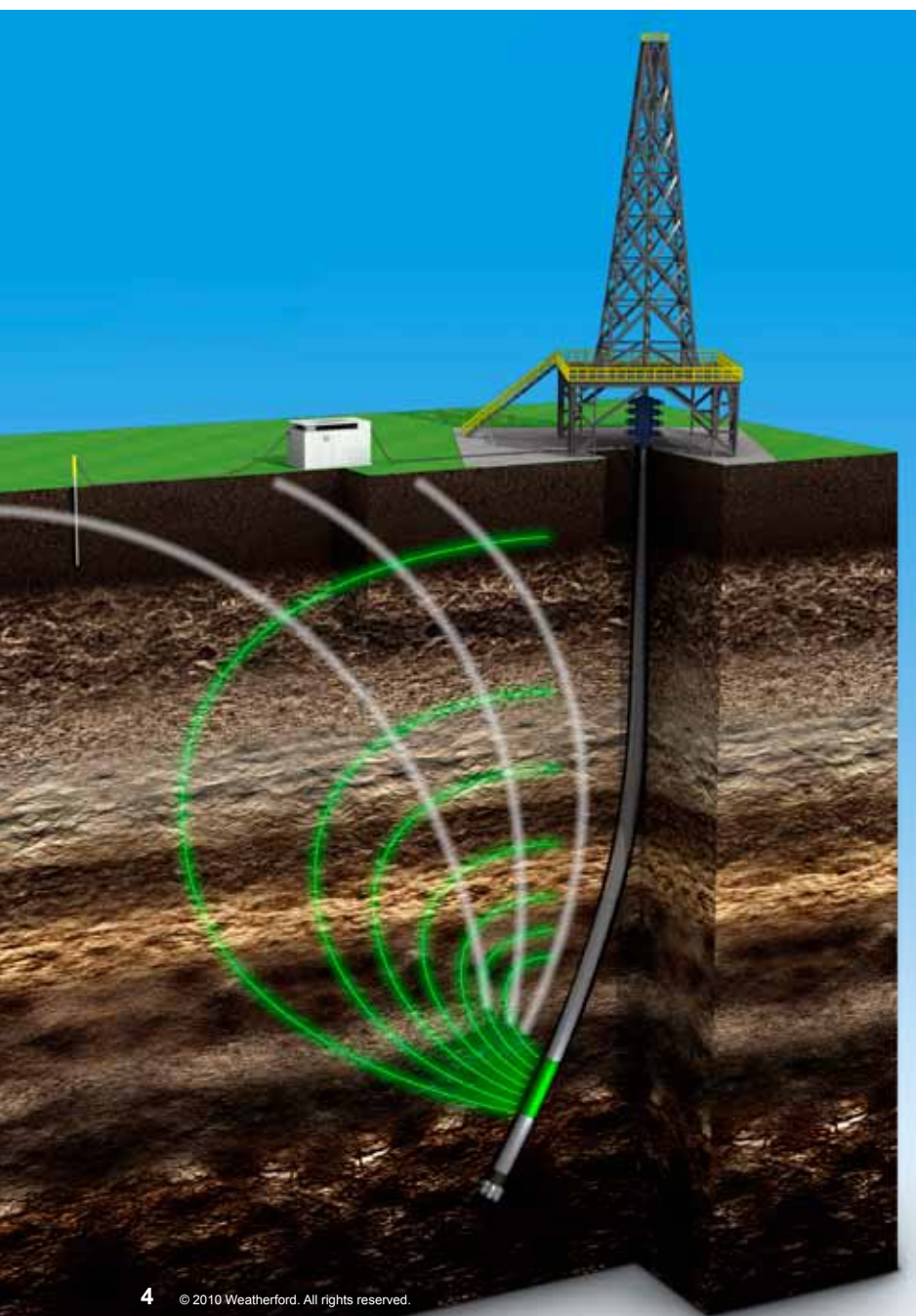
**Survey management services** through Tech 21\*

\*Tech 21 is a wholly owned Weatherford company.



## More MWD options

Weatherford's broad portfolio of manned and unmanned MWD systems accommodates today's expansive range of simple, low-risk to complex, high-risk drilling scenarios.



- **Standalone tools—drift measurement tool (DMT), azimuth measurement system (AMS) and standalone azimuth measurement system (SAM)**—reduce survey time and expense while enabling operators to continually monitor the wellbore remotely.
- **HEL™** hostile-environment-logging **MWD** system is the industry's most robust hostile-environment positive mud-pulse telemetry system, with 356°F (180°C) temperature and 30,000-psi (207-MPa) pressure ratings.
- **HyperPulse™** positive mud-pulse telemetry systems provide directional surveying, formation gamma ray and temperature measurements in all routine drilling environments and in heavy-mud and high-loss-circulation-material (LCM) conditions.
- **EMpulse™** electromagnetic telemetry systems perform in mud-pulse environments and in borehole environments where mud-pulse systems cannot perform. When fully integrated into our industry-leading Weatherford® LWD (logging-while-drilling) and Revolution® rotary-steerable systems, the *EMpulse* MWD system helps pinpoint well placement in complex wellbores.
- **TwinWells™** active-magnetic ranging systems ensure accurate placement of steam-assisted gravity-drainage (SAGD) well pairs in heavy-oil environments.

*EMpulse* MWD bidirectional communication enables the operator to maintain control over data that the system is sending at any point in time, including while tripping in hole.





## More reliability

Weatherford provides MWD services for thousands of wells throughout the world, at an average rate of approximately 3,000 per year, with excellent mean-time-between-failure (MTBF) rates and an enviable ability to handle downhole vibration, high-LCM additives, high flow rates and high doglegs.

Basing our MWD systems on the HEL™ hostile-environment-logging platform, which is also the foundation for the record-setting Weatherford® LWD system, makes them the most robust and reliable in the industry.

We track the results of our operations in a comprehensive performance database. The database contains an extensive body of MWD knowledge and experience in all conditions—including hard-rock and underbalanced—which we use to optimize well placement and drilling performance. Our performance database also enables us to price our services fairly and competitively. Our intent is to share with our clients the savings associated with our performance.

The primary component of our HyperPulse™ MWD system is a robust hostile-environment pulser that has the same design as our record-setting *Weatherford* LWD pulser.

## More global competency

To meet the demands of an inherently global industry, Weatherford has built a network of more than 1,000 drilling specialists, including one of the industry's largest contingents of MWD engineers. To arm our specialists with the expertise needed to optimize your directional-drilling operations, we provide them with highly specialized classroom training. Their training continues in the field, where they are mentored by their more experienced peers to continuously enhance their skills.

### On call, around the world and around the clock

Weatherford's MWD engineers are on call 24 hours a day, 7 days a week, anywhere our clients operate. They are aided by our WellHub Web portals and real-time centers, and our extensive jobs database.

Leveraging our global network of WellHub real-time operating centers and advanced information management software enables Weatherford to deliver effective information management solutions. We provide around-the-clock, remote monitoring of a wide range of parameters pertinent to drilling optimization, including MWD data, that permits key stakeholders to view critical data and make rapid decisions remotely. To ensure data integrity, our information management software comes with built-in security features, including advanced encryption technology and firewalls that restrict information access to authorized personnel only.



## More wellbore accuracy

Weatherford's survey management services improve the accuracy of MWD surveys by evaluating and removing the effects of magnetic sources outside of the MWD tool.

**Database quality-control (QC) audits.** Even the best survey technology requires careful control and handling of the information in the survey database. Tech 21, a Weatherford company, performs database QC audits to verify the integrity of survey data and identify missing or incorrect information in the survey headers, and uses in-house-developed, innovative mathematical techniques to identify wells with inconsistent survey data.

**In-field referencing (IFR) surveys.** Weatherford conducts IFR surveys on land and at sea to evaluate the magnetic influence of local geology and measure how the direction of the earth's magnetic field varies through the oil or gas field. Applying IFR corrections can improve the accuracy of existing MWD data and all future MWD surveys by up to 30 percent. The Tech 21 marine IFR survey system is the only one in the world that can make direct vector measurements of the earth's magnetic field at sea.

**Multistation analysis (MSA).** MSA combines data from multiple survey shots to calculate any residual magnetic interference from the bottomhole assembly (BHA). This calculation can be applied as a QC process to ensure that survey data are not being corrupted by magnetic interference. Or, it can be applied as a correction to downhole data to improve the quality of survey results.



Weatherford integrates multiple data streams with expert interpretation to maximize drilling efficiency at WellHub centers such as this one in Canada.



# More MWD options to meet the demands of every drilling environment

## Platform



Manned



Unmanned

## Power/telemetry/memory



Lithium battery



Mud-pulse telemetry



EM telemetry



Memory

## Operating conditions



High temperature  
(302°F/150°C)



Ultrahigh temperature  
(356°F/180°C)



High LCM tolerance  
(80 ppb)



High pressure  
(30,000 psi/207 MPa)



Compressible fluid



Air

## Measured parameters



Direction and inclination



Gamma ray



Temperature



Azimuthal gamma ray



At bit



Annular pressure



Inclination only



Tool face

## Platform

	Platform	
<b>Drift Measurement Tool (DMT)</b>		
<b>Azimuth Measurement System (AMS)</b>		
<b>Standalone Azimuth Measurement (SAM)</b>		
<b>HyperPulse™ MWD</b>		
<b>EMPulse™ MWD</b>		
<b>HEL™ hostile-environment-logging MWD</b>		



Weatherford offers an array of MWD systems to meet the demands of today's expanded range of drilling conditions. Our portfolio includes mud-pulse telemetry systems ideally suited for routine and high-pressure/high-temperature (HP/HT) environments, and an *EMpulse* telemetry system that is a key enabler of air, mist and multiphase underbalanced directional-drilling operations.

Power/Telemetry/Memory	Conditions	Measured Parameters	Applications
			<ul style="list-style-type: none"> <li>• Inclination-only monitoring for vertical wells</li> </ul>
			<ul style="list-style-type: none"> <li>• Inclination and azimuth monitoring for vertical wells</li> </ul>
			<ul style="list-style-type: none"> <li>• Inclination and azimuth monitoring on the fly, and toolface measurement for simple unmanned directional-drilling applications</li> </ul>
			<ul style="list-style-type: none"> <li>• Applications where EM-signal reception is poor because of depth or formation type</li> <li>• Where higher telemetry rates are needed</li> </ul>
			<ul style="list-style-type: none"> <li>• All compressible-drilling-fluid applications</li> <li>• High lost-circulation-risk/LCM applications</li> </ul>
			<ul style="list-style-type: none"> <li>• High temperature (356°F/180°C) and pressure (30,000 psi/207 MPa)</li> <li>• The <i>HEL</i> MWD is also the front end of Weatherford's <i>LWD</i></li> <li>• High-speed telemetry</li> </ul>

## More Real Results

The results and value added by Weatherford's MWD services are real, measurable and accessible through a comprehensive database that serves as both a reference and a learning tool for current and future directional-drilling specialists.

### Slashing survey time on challenging horizontal well

**Canada.** An operator called upon Weatherford to help reduce survey time and increase on-bottom time in a challenging horizontal well in northeastern British Columbia. In an area where other EM MWD systems had failed to perform, Weatherford's *EMpulse*™ MWD system performed flawlessly, transmitting data for the entire 15,256-ft (4,650-m) measured depth (MD) of the well. Using the *EMpulse* system enabled the operator to save 4.4 minutes per survey, or 15-1/2 hours of operating time, over the course of the well. Flawless execution resulted in zero nonproductive time (NPT).

### Saving big in a hostile environment

**United States.** Newfield Exploration Company used Weatherford's *HEL*™ MWD system to fully exploit a deep, hot, south Texas reservoir with a cost-effective sidetrack. Temperatures in excess of 350°F (177°C) at depths below 15,000 ft (4,572 m) precluded using conventional MWD systems. The *HEL* MWD system presented a more viable, cost-effective alternative to single-shot surveys for obtaining data critical to accurately placing the well within the reservoir. Drilling the deeper sidetrack eliminated the need to drill a new well at an estimated cost of US\$1.2 million.

### Extending field life and optimizing drilling

**Oman.** Weatherford's *EMpulse* MWD/LWD system significantly enhanced drilling efficiency to help extend the operating life of the mature Nimr field. Severely depleted reservoirs require the use of drillpipe gas injection on underbalanced drilling (UBD) operations, thereby rendering the application of mud-pulse MWD/LWD telemetry for directional surveys and geosteering impractical. Petroleum Development Oman (PDO) leveraged Weatherford's *EMpulse* telemetry system to overcome those limitations. As a result, this highly significant operation proved the application of UBD for severely depleted reservoirs previously thought to be undrillable. The *EMpulse* system's capability to transmit MWD data to the surface independent of drilling operations also yielded time and associated cost savings, reducing total drilling duration for one 3,878-ft (1,182-m) lateral by eight hours.





### Locating and accessing a deep gas reservoir

**China.** An operator faced a challenge in locating and accessing the target reservoir in a deep gas well (more than 22,000 ft/7,200 m), in an area where most conventional mud-pulse signal transmissions cannot stand up to the pressure (16,740 psi/115 MPa). Weatherford's HyperPulse™ MWD system overcame the challenge to provide reliable detection and signal transmission throughout the operation, which enabled the operator to locate and access the reservoir. The system's robust design and reliability saved significant time and expense by ensuring continuous operation.

### Enabling an industry first for underbalanced offshore drilling

**Indonesia.** The need to gather real-time annular-pressure, directional and formation-evaluation data from a highly depleted offshore reservoir overlaid with very low-resistivity formations led to a breakthrough in electromagnetic-pulse telemetry. Using conventional overbalanced drilling methods in previous wells in the field offshore Java had caused costly and time-consuming drilling problems, the most significant of which were massive lost circulation and stuck pipe. To address these problems, the operator decided to drill this well underbalanced with a gas-and-liquid medium. The two-phase flow conditions precluded using conventional mud-pulse MWD telemetry. The very low resistivity of the formations overlying the reservoir also precluded use of standard EM MWD services.

Weatherford overcame the challenges with the first-ever deployment of the extended-range (ER) EM MWD system, which placed thousands of feet of antenna inside the drillpipe. Using ER EM MWD, the operator successfully drilled the well underbalanced; prevented costly drilling problems; reduced formation damage; confirmed the lack of fracture systems; and estimated bottomhole pressure and productivity index. Drilling efficiency was improved. Trouble time was dramatically reduced. Penetration rates improved 300 percent.

### Replacing vertical infill drilling with pad drilling in a low-cost, environmentally sensitive location

**Australia.** Proving the technical and economic feasibility of replacing vertical infill drilling with pad drilling would provide the operator with an opportunity to reduce infrastructure complexity and costs and lessen the environmental footprint in a low-cost desert environment. To prove feasibility and convert a five-spot to a nine-spot pattern using existing drilling locations, Weatherford used its EMPulse™ MWD system with gamma ray services to drill four J-shaped directional wells from a pattern-centered pad. After a quick learning curve, the final well was drilled in a time equivalent to the average vertical well in the region, and one day ahead of schedule.

For more Real Results from our MWD and surveying operations, please see [weatherford.com/realresults](http://weatherford.com/realresults).



MWD and Surveying Services

**From routine to extreme, we deliver.**

Weatherford provides worldwide service and support from more than 800 locations in more than 100 countries. To learn more about our MWD and surveying services, visit [weatherford.com/MWDServices](http://weatherford.com/MWDServices), or contact your nearest authorized Weatherford representative.



**Weatherford**<sup>®</sup>

[weatherford.com](http://weatherford.com)

© 2010 Weatherford. All rights reserved. **6713.00**

Weatherford products and services are subject to the Company's standard terms and conditions, available on request or at [weatherford.com](http://weatherford.com). For more information contact an authorized Weatherford representative. Unless noted otherwise, trademarks and service marks herein are the property of Weatherford. Specifications are subject to change without notice. Weatherford sells its products and services in accordance with the terms and conditions set forth in the applicable contract between Weatherford and the client.