

# How High-Speed Telemetry Affects the Drilling Process

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Regardless of whether you look at consumer or industrial applications, whenever a technical breakthrough in available communication bandwidth is achieved, the affected environment and feasible applications change significantly. One recent example was the introduction of the digital subscriber line (DSL) to replace modems for Internet access.

With high-speed telemetry systems becoming economically viable in an increasing number of drilling applications, our industry is in a situation similar to that seen at the introduction of DSL. Following the parallel of Internet access via DSL vs. modem, the relevant questions are: How has high-speed telemetry changed the drilling process, and what further changes will we see in the near future?

This article first intends to explain why oilfield service companies continually strive for higher telemetry data rates. It then identifies and exemplifies fields of application for both available technologies—high-speed mud-pulse telemetry and wired drillstring telemetry—with two case histories. The conclusion provides an outlook on possible future opportunities and technological developments.

## Rationale for Higher Telemetry Data Rates

Every breakthrough in drilling technology creates an increasing demand on telemetry speed, requiring new telemetry technologies to meet that demand. Consequently, the meaning of high-speed telemetry has changed and will continue to change over time.

The most recent major change in drilling technologies has been the rise of increasingly sophisticated measurement-while-drilling (MWD) and logging-while-drilling (LWD) services, e.g., drilling dynamics, formation-pressure testing, high-resolution resistivity and electrical images, and magnetic-resonance measurements.

MWD and LWD services reduce the necessity for wireline runs and increase the log quality at the same time because the formation is logged immediately after penetration. In contrast to wireline logging, MWD/LWD tools “see” the freshly cut formation rather than logging it after days of exposure to drilling mud, which results in formation deterioration. They also make downhole drilling-dynamics measurements available in real time, something that has previously been impossible.

In the past, one of the major challenges with MWD/LWD services was the ability to transmit all the data gathered downhole. The majority of measurements were written to memory onboard the downhole tool, and only a fraction of the collected data was transmitted in real time to surface.

The data then was retrieved from memory after pulling the drillstring out of hole.

The availability of all the acquired information in real time through high-speed telemetry unleashes the full potential of MWD/LWD services, enabling real-time optimization of the drilling process. Optimization goals include the following

1. *Operational safety* potentially affects project cost, especially in the case of a severe incident. Therefore, high operational safety reduces the risk of incurring such costs.

2. *Rig day rate* is a major cost factor, especially in offshore operations, and drives operators’ desire for maximum gross rate of penetration (ROP). Even in today’s struggling economy, rig rates remain a major contributor to the overall cost of a well. As the economy recovers and the demand for oil and gas increases again, rig rates likely will rebound as well.

3. *Wellbore placement* to get the maximum recovery out of a field is an operator priority, especially as reservoirs mature.

4. *Wellbore integrity* is critical for a successful well completion. Prevention is less costly than remedying complex problems associated with a collapsed wellbore.

Maximizing the return on investment of a well means that the combination of all four abstract goals needs to be maximized. Technological constraints of the particular well have to be considered also, which further increases the complexity of the problem. Therefore, successful maximization can only be done through more automation of the drilling process than occurs today.

With the rise of extensive portfolios of sophisticated MWD and LWD services, telemetry bandwidth has been considered the limiting technical factor in the evolution toward automation.

The following discussion includes high-speed telemetry applications in real-world cases, illustrating the progression of this technology to optimize the above-described factors and to achieve predictable, repeatable drilling performance.

## Technologies Available for High-Speed Telemetry

The relative importance of optimization goals, specifying the requirements for real-time data, differs from well to well because of the variety and complexity of drilling applications. For every well, the requirements and constraints on real-time data and thus, the telemetry system, must be analyzed carefully by the operator and service provider.

Both telemetry technologies (mud-pulse and wired-pipe) have been under investigation for decades. Current mud-pulse telemetry systems date from work by Arps and Arps

# Deepwater: Horizontal Openhole Gravel-Pack Completions

## First Successful Horizontal Openhole Gravel Pack in Deepwater Stybarrow Field

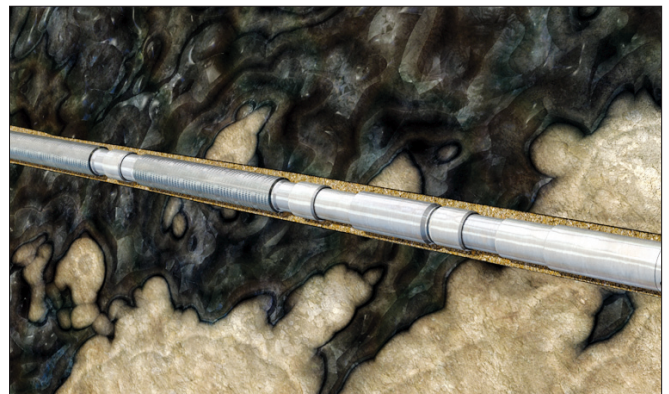
The Stybarrow Field consists of slope turbidite sandstones of the Macedon Formation in the Exmouth Sub-Basin offshore Western Australia. It is one of two fields in Australia's deepest water development, in more than 800 m of water, and was developed entirely by subsea wells connected to an FPSO.

### Lateral Reservoir Quality, Sand/Shale Heterogeneities

Lateral reservoir quality variations, difficult sand/shale heterogeneities, and limited in-country technical experience and infrastructure were only some of the obstacles to completing four, near-horizontal production wells in this field. Others included gravel packing across much longer non-reservoir sections, gravel packing out of a milled casing window, narrow pressure margin between circulating pressures and formation fracture pressure, large wellbore washouts, and gravel packing at wellbore inclinations of up to 94°.

### Gravel-Pack Design With Ceramic Proppant

To solve these problems, Baker Hughes helped develop an optimized reservoir drilling fluid and gravel carrier fluid design. We also created a gravel pack pumping design that used a 16/20 US Mesh ceramic proppant. This combined with our EXCLUDER2000™ medium-weave premium screen to produce the optimal sandface completion. Baker Hughes engineers sized the screens to retain formation sand. This would ensure sand retention in case of incomplete gravel packs. Slurry and conformance tests with various screen types and a range of sand facies, along with various proppant sizes and types, concluded that inclusion of proppant drastically reduced pressure buildup across the screens as well as the mass of sand particles produced through the screens. The Baker Oil Tools

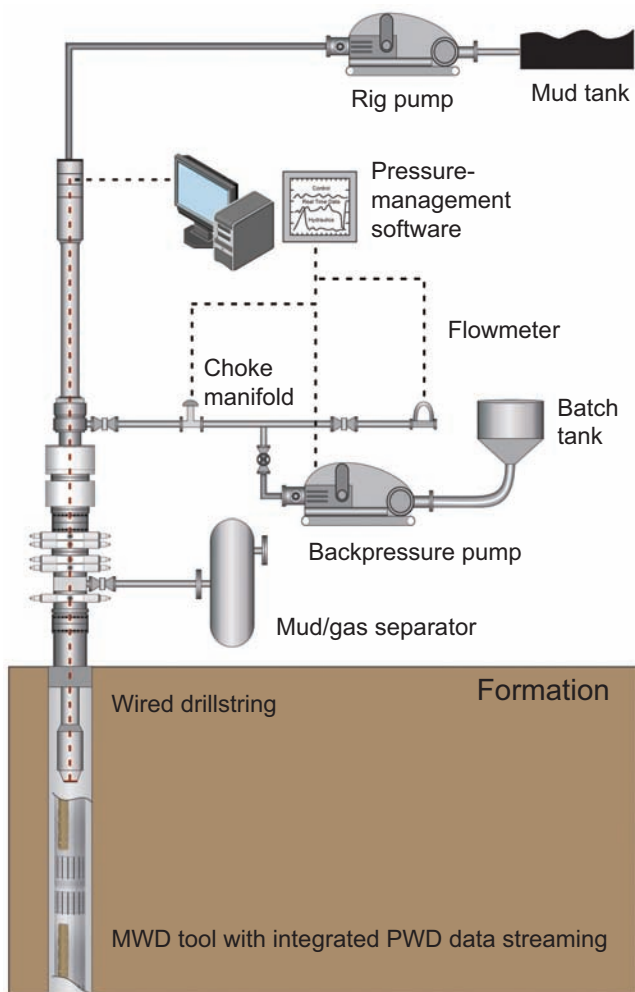


*EXCLUDER2000™ screens like those used in the Stybarrow wells have compiled an outstanding performance record in the world's most extreme conditions.*

gravel-pack design also contained contingencies specific to this design in case of poor installation outcomes. Another success factor in the project was continuity of key Baker Hughes personnel and essential equipment from concept through execution.

### Near-Record Australian Production Rates

Gravel-pack efficiency factors between 108% and 118% were achieved despite several unforeseen geological and technical challenges. All four Stybarrow production wells achieved maximum sand-free rates per FPSO design capacity. Maximum production rates from all four wells have exceeded 80,000 BOPD, with one well producing at near-record Australian rates of 32,000 BOPD seven months after first oil.



**Fig. 1—Closed-loop pressure-control system consisting of the pressure-management system fed with measurements from the flowmeter and from downhole pressure measurements by means of a wired drillstring.**

published in 1964. Patents on wired drillstring telemetry date to the 1930s (Karcher 1933).

Within the last 6 years, telemetry has seen a technological step-change. For data rates up to 40 bps, high-speed mud-pulse telemetry is an option. If higher data rates are required, current wired-pipe telemetry is the only option.

One of the less appreciated facets of high-speed mud-pulse telemetry development is the tremendous advance achieved in the realm of surface acquisition and processing technology. This results in the ability to transmit data in extended-reach drilling (ERD) wells at speeds much higher than ever possible in the past. Over the last couple of years, mud-pulse telemetry systems' achievements in ERD wells include:

- 3.5 bps @ 34,570 ft (Baker Hughes aXcelerate)
- 3 bps @ 35,000 ft (Schlumberger Orion II)
- 3 bps @ 38,320 ft (Baker Hughes aXcelerate)
- 1.5 bps @ 40,320 ft (Schlumberger Orion II)

As wired-pipe systems use repeaters to boost signals transmitted to surface, depth does not limit the bandwidth.

### Examples of Applications Using High-Speed Telemetry

Telemetry system selection depends on the operational constraints associated with a particular well. The two cases presented below illustrate applications of both technologies: reservoir navigation in the Middle East using high-speed mud-pulse telemetry; and managed-pressure drilling (MPD) with wired-pipe telemetry in the Andaman Sea, offshore India.

**Reservoir Navigation in a Thin Lateral Reservoir (Onshore Middle East).** Horizontal wells in this particular field are navigated within tight tolerances through the complex carbonate reservoir to maximize reservoir contact and recovery. The operator wanted to place the wellbore optimally in the reservoir and, at the same time, maintain a high ROP to reduce operating cost. With high-speed mud-pulse telemetry at a data rate of 20 bps, the operator had high-resolution density and 60-sector electrical images available in real time to steer the 3,700-ft (1128-m) long horizontal section within the zone of interest, which had a true stratigraphic thickness as low as 3 ft (90 cm). Besides the successful well placement, the well was finished in 3 days less than it took to finish a previous offset well.\*

**Closed-Loop MPD (Andaman Sea).** In January 2007, Petronas drilled its Nagar-1 exploration well in the Andaman Sea in more than 1,312 ft (400 m) of water. From the investigation of seismic surveys, Petronas expected shallow gas-bearing sands between 853 and 1,312 ft (260 to 400 m) below the sea floor. Kick-detection speed, response time, automatic kick control, and accurate control of bottomhole pressure (BHP) while drilling during connections and during a kick were identified as mission-critical during the planning phase of the well (Frederiks et al. 2008).

Because no conventional drilling and telemetry system could provide these capabilities, a pressure-management system was connected with an MWD system by means of a wired drillstring to create an MPD system (Fig. 1). The pressure-management software was fed with annular flow data from a flowmeter for micro-kick detection, as well as with pressure-while-drilling (PWD) data that was streamed from the MWD tool to surface using wired drillstring telemetry.

It was the first time these technologies were combined and used as a closed-loop pressure-control system.

With this setup, a gas influx volume of down to 1 gpm (3.8 Lpm) could be detected. Kicks could be detected early, and the well could be shut in and controlled using PWD data that was fed into the MPD system.

Because there is no mud flow during well-control operations, a mud-pulse telemetry system could not provide the required data. Because of the lack of flow, the bottomhole assembly could not be powered exclusively by a turbine, but alternatively had to be powered by batteries during well-control operations and connections to acquire PWD data.

The BHP was kept within 15 psi of the desired pressure window while drilling and +/-45 psi during connections. The well was finished without any well-control events.

\* Baker Hughes Case History INT-08-23067. Inteq Enables Precise Reservoir Navigation With aXcelerate High-Speed Telemetry Service.

## Conclusion

The examples illustrate applications for both types of high-speed telemetry systems, high-speed mud-pulse telemetry and wired-pipe telemetry. On the one hand, wired-pipe telemetry has the advantages of low transmission latency and providing data even under flow-off conditions, making the service attractive, at present, for special applications such as MPD. The future potential of this system must surely be great.

On the other hand, the latest generation of high-speed mud-pulse telemetry delivers high-resolution, real-time MWD and LWD data for real-time drilling optimization and reservoir navigation—without requiring a new drillstring, changes to the topdrive, or the logistics of managing a system consisting of hundreds of components. The mud-pulse system runs with conventional drilling technology, making it less expensive and allowing universal use.

Telemetry, now capable of delivering a huge amount of real-time MWD/LWD data, is no longer the bottleneck in moving toward automated drilling. The next considerations are managing the high volume of real-time data and automating data interpretation and decision processes.

The pressure-management example given in Fig. 1 was unique because of its closed-loop approach of data acquisition and transmission, automated interpretation and decision process, and active system control. With the availability of high-resolution real-time data today, future applications will follow the concept of high-level system integration to maximize the economic success of drilling projects.

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