INCREASING DRILLING EFFICIENCY WITH TELEMETRY

Paul Cooper, PhD, Halliburton, USA, shows how high-speed telemetry can help increase drilling efficiency.

Because new wells are becoming more complex, large amounts of measurement/logging-while-drilling (M/LWD) and formation evaluation data are necessary to enable exploration and production (E&P) operators to make timely decisions and achieve greater production at the lowest cost per barrel of oil equivalent (BOE). Drilling dynamics data are needed to help optimise the rate of penetration (ROP) and reduce well time. Pressure and wellbore stability data are necessary to deliver the well safely and help minimise operational risks and avoid issues, such as lost circulation, poor hole cleaning, and stuck bottomhole assemblies (BHAs). Additionally, rock and fluid properties data are needed to help understand the reservoir and accurately place the wellbore within the reservoir to maximise production. To realise the full benefit of these real time measurements, the capabilities of telemetry systems need to increase in parallel. As such, Halliburton introduces the JetPulse™ high-speed telemetry service, which delivers consistent, high data rate transmission of real time drilling and formation evaluation measurements, enabling operators to make quicker decisions at any point in the well plan to help achieve accurate well placement, improved well control, and increased drilling efficiency.

Engineered for high performance

The new system was engineered for high performance, incorporating the latest technological developments, including an integrated downhole generator, which provides power to the BHA and allows operators to drill long sections in a single bit run. The generator has been run with lost-circulation material (LCM) concentrations greater than 100 lbm/bbl and is the most LCM-tolerant high-speed telemetry system in the industry. Additionally, the system can be configured in a battery-only mode, which helps remove any LCM limitations from the telemetry system.

Durability and reliability are also key considerations for achieving longer runs, particularly because high-speed telemetry systems are typically used in offshore and deepwater environments where the cost of nonproductive time (NPT) is extremely high. Multiple valve concepts were evaluated before a valve design and material was selected that is sufficiently durable to deliver the number of cycles necessary. Design choices were made to help maximise the overall reliability of the system, such as minimising the amount of electronics and reducing the number of internal connectors.

Effective downhole data management

In addition to the physical mud pulser, software engineering efforts focused on ensuring consistent downhole data delivery during long runs, and that the data are optimised to enable operators to make the right decisions at the right time. The conditions for signal transmission vary significantly during the course of a drilling run, and the signal from downhole is attenuated as it travels up the drillstring. The choice of signal modulation is important to help ensure consistent data delivery during the entire run. The JetPulse service uses differential pulse position modulation (DPPM), creating pressure-drop pulses in the bore of the drillstring and encoding the data in the time intervals between these pulses. This DPPM encoding is less affected by changes in depth than phase-shift keying (PSK) encoding schemes and has provided consistent data rates during long runs in a broad range of drilling conditions. When it is necessary to adjust to the effects of varying mud properties and drilling noise, it is possible to downlink to the BHA tools using Geo-Span® downlink service during a run, which helps ensure reliable signal detection at surface and consistent data delivery.

The JetPack 3D™ data management service provides additional features to help optimise the data delivered while drilling the well. Just as high-tech companies stream large amounts of movie and television show data and use compression to optimise the available bandwidth to deliver high-quality videos to customer homes, the JetPack 3D service uses compression to increase the effective amount of useful data delivered to surface at the wellsite. Various compression techniques are available to tailor specific data types. Imaging tools measure a formation property azimuthally around the borehole (e.g. density, resistivity) and use a difference-encoding algorithm to transmit high-quality azimuthal images in a relatively small number of physical bits. Interpretive compression is used to transmit a mathematical representation of a set of data rather than the raw data, reducing the bandwidth consumed without impacting the decision making based on these data. For example, downhole standoff data from a caliper tool can be used to generate an ellipse representing the borehole, and the ellipse parameters can be sent to the surface to provide an understanding of the downhole stress directions. Axial compression can be used to compress any general curve data by accumulating several measurements of the same type, compressing them, and sending the data as a single block. The correct choice of compression techniques for the tools in the BHA can provide greater than a fourfold increase in the amount of useful data received at surface.

The type of data necessary for optimal decision-making changes depends on the position of the well plan and the drilling activity at any given time. The JetPack 3D service enables the operator to configure different data sets based on expected needs along the well plan. During drilling, the operator can switch between these data sets to deliver the most relevant data at any given time.

Table 1. Measured depth and effective data rates of wells.

Location	Measured depth (ft)	Effective data rate (bits per second)
US Land	2100	35.3
Gulf of Mexico	9700	13.7
Central Asia	10 900	15.2
Brazil	11 300	10.9
US Land	12 000	12.4
Central Asia	12 700	26.0
Central Asia	19 300	14.6
Norway	20 000	10.3
Central Asia	20 100	24.0
Gulf of Mexico	22 900	9.4
Gulf of Mexico	27 900	5.6

Figure 1. *The JetPulse™ high-speed telemetry service provides consistent, high data-rate transmission of real time drilling and formation evaluation measurements to deliver the right data at the right time, helping ensure reliable and fast decision making.*

Delivering the right data, at the right time, for better decision making

The JetPulse service is currently being used at multiple locations globally; Table 1 shows performance data. It has delivered data rates greater than 20 bits per second at more than 20 000 ft measured depth. Additionally, it has demonstrated the necessary endurance to operate downhole for longer than 600 hours and delivered hole sections of more than 14 000 ft in a single run. Using the service, operators can consistently receive the necessary data to drill and place wells efficiently. For example, an operator in the Middle East was geosteering through thin reservoirs. The JetPulse service transmitted density images, multiple resistivity images, and geosignal data. Through subsurface insight, the operator was able to accurately

place the well in the target reservoir while maintaining high ROPs and reducing well time.

Case study: managing ECD with high-fidelity pressure data

An operator in Asia recently deployed the JetPulse service at a location where high formation pressure existed in the zone above the targeted reservoir section and a high overbalance existed in the production zone. To drill wells successfully in such an environment, decisions to adjust drilling parameters and equivalent mud weight (EMW) or equivalent circulating density (ECD) need to be made quickly to help avoid unwanted fracturing and/or becoming stuck. If the mud weight is too light, high-pressure water can flow out of the wellbore; if the mud weight is too heavy, undesired fractures in the formation can occur. The JetPulse service was able to provide high-fidelity, real time pressure-while-drilling (PWD) data updates for the drilling team without sacrificing the data density of measurements for formation evaluation data to assist the geologists with lithology analysis. The data flexibility provided by the service allowed the operator to use a transmission option focused on pressure data when necessary, delivering pressure updates with a 1 psi resolution every 5 seconds. Decisions to adjust the EMW could be made before the well was fractured or unwanted formation fluid flowed into the well. With the right data at the right time, the operator was able to anticipate potential problems and react quickly to the dynamic drilling environment before any NPT was incurred. The operator reached the gas production zone within budget and without fracturing the well or allowing unwanted formation fluid to enter.

Case study: lost-circulation cement solution

Wells drilled in the southern North Sea region in Norway frequently encounter severe lost-circulation events in both the overburden and the reservoir. Overburden drilling includes narrow drilling margins between the fracture gradient and pore pressure, and multiple severely depleted zones often exist in the reservoir. A cement-based lost-circulation solution was deemed necessary to carry sufficient mud weight for wellbore stability in the overburden without encountering excessive losses. The challenge during this process was providing a solution that could be pumped through a directional BHA without tripping out of the hole. The high-LCM tolerance of the JetPulse service allowed a lost-circulation solution based on FracCem™ cement to be pumped through the BHA. During 19 FracCem cement operations, more than 2800 bbls were pumped through the BHA with concentrations ranging from 120 - 220 lbm/bbl. No damage or plugging occurred during these operations, and in seven cases, the operator drilled directly to the section total depth after the cement operation, eliminating the need for a trip and reducing the overall well time.

Summary

The JetPulse high-speed telemetry service is able to provide higher physical and effective data rates in a broad range of complex operating environments in offshore, deepwater, and mature fields, allowing operators to make better real time decisions to overcome the challenges faced while drilling current wells. By delivering the right data at the right time to make the right decisions, new technology can help operators maximise production at the lowest cost per BOE while increasing drilling efficiency and maximising the value of their assets.