Deepwater exploration drilling costs are prohibitively high, and operators look for new technologies to minimize uncertainty about reservoir characteristics and well deliverability. Reducing operational risk and increasing the information gathered from an exploration well are critical in deepwater frontier environments. Decreasing the individual well costs as well as the number of wells before proceeding to the subsequent phases of field development also rank high on the operator’s list of priorities.

Today, with wells more complex than ever, operators are putting a premium on real-time pressure and temperature readings. The objective of the well test is to analyze reservoir response during sequential flowing and buildup periods and determine reservoir characteristics such as skin factor, permeability, productivity index, and initial reservoir pressure.

Historically, reservoir information has been obtained using memory gauges without the benefit of real-time bottomhole data, requiring the extrapolation of surface data to estimate downhole conditions. This lack of real-time data encouraged engineers to design conservative estimates for the flowing and shut-in periods.

Planned well test durations often didn’t suffice to meet the minimum data requirements for interpretation. The planned duration was either too long or too short, incurring excessive rig costs or leaving out valuable data. Also, without the benefit of real-time downhole data, the operator would be unaware of problems that occurred during the operation, which could not be remedied after the drillstem test (DST) string was pulled out of hole.

Previous methods of acquiring bottomhole data during the test involved running an electric line connected either directly to a downhole gauge or to a probe capable of communicating with gauges installed in the string. The main limitation of electric line intervention is the risk associated with deployment during flowing periods. The electric line may be blown upward in the flow or stuck in the well if sand or fines are produced, making operators hesitant to deploy intervention tools beyond shut-in periods.

For deepwater environments where the price of failure is high, operators require reservoir testing solutions that deliver real-time information to optimize decision-making and reduce risks and rig costs. A wirelessly enabled downhole reservoir testing system was developed to transmit real-time bidirectional information throughout the test. Maersk Oil recently deployed the wireless system to manage uncertainty and transmit important bottomhole measurements in a challenging deepwater exploration well test in Angola, achieving significant value from optimizing the test and reducing total rig time.

Wireless-enabled testing

The Quartet downhole reservoir testing system enabled by Muzic wireless telemetry enables customers to isolate, control, measure, and sample a reservoir in a single run while providing bidirectional downhole tool communication and real-time readout of tool status and downhole pressure data. This advanced downhole reservoir testing system offers several advantages over conventional configurations, including the ability to function at a lower operating pressure, use less nitrogen, eliminate drill collars and slip joints, and use fewer seals and connections.

The modular telemetry system interfaces with the testing system and allows modifying the test sequence in line with the reservoir response and validating downhole pressure data during the test. Operators can now know exactly when sufficient information has been gathered for analysis, so test durations are optimized in line with objectives.

The platform provides reservoir testing in one package integrating four key tools, including Signature quartz gauges that deliver accurate downhole pressure and temperature measurements for the entire test duration. Enabled with wireless telemetry, the gauges pro-
vide bidirectional communication and verification of real-time pressure and temperature data. Each gauge can be independently interrogated for pressure or temperature data in either real-time or historical mode.

Other technologies in the system include the CERTIS single-trip isolation system that combines the elements of a retrievable isolation system with those of a permanent downhole packer; the intelligent remote dual valve for control; and SCAR inline independent reservoir fluid sampling, which collects representative samples. The system’s modular design gives operators flexibility in choosing which features to enable with wireless telemetry. All tools are equipped with conventional redundant backup control.

The exploration well is located southwest of the Chissonga discovery block in Angola’s Lower Congo and Kwanza deepwater basins, about 176 km (109 miles) off the coast of Luanda, Angola. Maersk Oil spudded the well in March 2013 and drilled into oil-bearing sandstones, with the primary target at a depth of approximately 5,000 m (16,000 ft) in water depth of 1,462 m (4,796 ft). The objectives of the well were to acquire data confirming the presence of hydrocarbons in the sand formations by testing the pressure and determining reservoir connectivity to the main wells of the Chissonga discovery block.

The operator launched the reservoir test after verifying the presence of hydrocarbons using MWD, LWD, and electric line logs. In an environment where rig costs can exceed US $1 million per day, the key challenge was to design a well test program that would optimize operational efficiency without compromising the objectives.

Remote decision-making
Schlumberger Testing Services proposed a single-trip solution using the reservoir test string enabled by wireless telemetry with the quartz gauges to monitor and manage the well test operation in real time. The decision to use wireless readout was delayed until completion of the logging program to confirm that the technology was suitable for the well.

The integrated system facilitated bidirectional communication between the surface and downhole gauges with real-time data streamed into the InterACT global connectivity, collaboration, and information service. This allowed engineers in Luanda and Copenhagen to make decisions, manage wellbore events, and refine the test sequence in real time.

The downhole gauges enabled by the wireless telemetry transmitted data successfully throughout the test duration. The operator was able to verify the underbalance prior to perforating, establish...
initial reservoir pressure after perforation, verify the status of the downhole tools used during the test, optimize the clean-up period by monitoring sandface pressure, reduce duration of buildup, and confirm that samples were being taken in ideal conditions. The RT Certain real-time test collaboration service with reservoir experts provided data interpretation.

Other aspects of the suite brought benefits to the well test. Using the single-trip isolation system, the operator avoided running two additional trips in the hole. Deploying the intelligent remote dual valve enabled the operator to efficiently shut in downhole and displace fluids into the wellbore as required, and the inline independent reservoir fluid sampling system captured representative reservoir fluid samples.

The wireless downhole testing system saved 28 hours of rig time and generated data to estimate key reservoir properties. A comparison of memory data from the gauges retrieved at surface against the real-time data used for interpretation during the test validated the decisions made during the operation.

Twenty-three jobs have been conducted globally using the wirelessly enabled reservoir testing system with a 100% success rate. As the industry increasingly ventures into challenging deepwater frontiers, wireless-enabled solutions that integrate all aspects of reservoir testing into one package with single-trip conveyance are giving operators greater certainty that their reservoir test objectives are being met efficiently and cost-effectively.

With the new testing system, the operator monitored reservoir parameters and made decisions in real time, shortening the well test by 28 hours and saving costly rig time. The operator obtained necessary downhole data to characterize the reservoir and meet test objectives.