Innovating
WHILE DRILLING

Expandables, deepwater MPD moving into mainstream as drilling automation, automated MPD come into focus

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Have multilateral completions finally come of age? Proven to maximize reservoir production, horizontal multilateral completions have witnessed growth in numbers and in complexity. However, while these completions have become more prevalent over the past decade, hurdles remain to widespread adoption, such as it being viewed as high-risk and involving multidisciplinary teams with varying decision perspectives. Also, as the market has matured, less complex junctions are being favored for economic reasons.

In terms of the number of completions, Cole Benson, senior multilateral technical professional for Halliburton’s Sperry Drilling business line, shares his company’s growth experience with multilaterals.

“We started with multilateral completions around 1993. Between 1993 and 2000 we completed more than 250 junctions split pretty evenly between the lower-technology completions, TAML levels 2 and 3, and higher levels, TAML levels 4 and 5. We saw a higher preference for onshore work, with 75% of jobs being conducted onshore,” he said.

“During the era 2001 to 2011, we’ve definitely stretched our limits. We placed the world’s deepest level 5 junction in December 2010 in Norway at more than 6,900 meters deep just at the junction. We’ve performed more than 720 junctions in the last 10 years; the bulk of these have been levels 4 and 5. We increased offshore use of multilateral technology to 35% of all installations,” Mr Benson said.

In the Technology for Advancement of Multilaterals (TAML) ranking, level 2 is described as the main bore being cased and cemented and lateral is left open either barefoot or with slotted liner hung off in open hole. Level 3 is described as the main bore being cased and cemented and the lateral cased but not cemented, with the liner being mechanically anchored to the main bore casing. Level 4 refers to the main bore and lateral being cased and cemented at the junction. Level 5 includes pressure integrity installed at the junction.

Systems have evolved; continuous improvement has led to design changes to overcome problems experienced years ago. “More installs have led to a learning curve resulting in better designs to improve operational issues and higher success rate with lower risk levels,” Mr Benson said. “In heavy-oil applications, disconnected or thin pays were earlier applications. We are now moving into applications to support shale plays with selective fracturing, gravel packs and frac packs.”

Joe Sheehan, multilateral systems product line manager for Baker Hughes, sees significant hurdles facing widespread adoption of multilateral technology. “It typically takes a multidisciplinary team to effectively plan a multilateral system,” Mr Sheehan said. “The different disciplines may have different key performance indicators that drive their decisions. Many times these technologies are only considered when economic margins are tight. Ideally, multilateral technology would be used as a tool when

Figure 1: The rotating, self-aligning multilateral RAM system was developed by Baker Hughes as a solution for extended-reach drilling. It allows rotation of liners to depth and maintains completion flexibility. The RAM completion junction is created through the use of two primary components — 1) a hanger and 2) a sealbore diverter.
planning field developments to optimize production and return on investment. These completions are still viewed by many as risky, but the reality is that reliability of these systems over the years has increased significantly.”

According to Barton Sponchia, multilaterals product line manager for Schlumberger, the industry pushed hard for even more advanced multilaterals, but as the market has matured, customers sought less complex junctions due to cost concerns.

“It was oil and gas companies that drove a reduction in complexity to bring multilateral technology closer to mainstream,” Mr Sponchia said.

Focus and drivers within the multilateral segment have also shifted as a result of technology advancements in horizontal drilling components (bits, motors, formation evaluation) and workstring tubulars, including topside mechanization. “Drilling farther, faster in real time has effectively tightened the multilateral market boundaries during the last decade,” Ron Barker, global general manager of re-entry services for Weatherford, said. “The days of ‘every well’ being touted as a multilateral candidate have been replaced with selection processes that typically force rank by risk first, cost second. Simpler multilateral designs continue to gain traction as the client can better measure and control ‘at-risk dollars.’ ”

■ LOOKING AHEAD

“The next step will be more opportunities to combine intelligent wells with multilateral technology,” Doug Durst, global multilateral solutions manager for Halliburton’s Sperry business line, said. “This has been done on a limited basis up to now. More common usage of multilateral and intelligent wells will be the next natural step. Also, we will see more systems to accommodate larger through bores in support of stimulation completion programs, high frac rates and high frac volumes.”

“I agree that there will be an increased drive to integrate multilateral technologies and intelligent completions both from a monitoring standpoint and a flow control standpoint — through an ability to isolate a watered-out zone or optimize production flow from different zones without intervention,” Mr Sheehan said. “In addition, as newer technologies, such as material sciences, or completion techniques are developed and adopted, they will continue to drive the innovation of multilateral systems.”

“The level 2 multilateral completion systems with multizone stimulation are still expanding and innovation is evolving, not only for stimulating more zones—but for more laterals with less trips, which reduces the time and completion cost,” Lance Rayne, multilateral product champion for Schlumberger, said. “We are also seeing an increase in the offshore market, with the development of complex and small pocket reservoirs. To continue the growth of multilaterals, flexibility and simplicity are the keys as operators still consider multilaterals as costly and risky, even with the high success rate that multilateral operations have today.”

■ BENEFITS OF MULTILATERAL WELL DESIGN

Horizontal multilateral completion allows the placement of the junction in the reservoir, reducing overburden drilling, casing and cementing costs. These cost savings are in addition to the service capital expenditure costs (structures, wellheads, pipelines) and operating expenses. There are three general areas where these types of completions make sense, according to Mr Benson: high-cost drilling markets (such as offshore or deep reservoirs), plays where increased reservoir exposure is required.
The completions component of a multilateral design allows operators more ability to independently control and monitor the flow from each lateral leg of a multilateral junction. This affords the benefit of increasing the life of the well and increasing productivity.

“It definitely helps reduce the drawdown that is experienced on a single lateral leg, and it extends productivity from more reservoir exposure,” Mr Benson said. “Some multilateral components are part of the actual well construction, and some are mixed with conventional completions, addressing the isolation, re-entry and control aspects of a multilateral system. Multilateral wells or junctions will typically accommodate upper conventional completions; various sand-face completions, such as conventional screens, frac and gravel packs and expandable screens; and intelligent completions.

“The key to multilateral technology is that it permits more reservoir to be exposed per wellbore, which was one of the main drivers for the original horizontal wells,” Mr Sponchia said. “By going to multilaterals, you’re essentially doubling that capability. There is a limited amount of length that you can push the horizontal. … You get the same reservoir drain that you can achieve with a very long horizontal well but with lower drilling risk.”

**Completing a Multilateral Well**

Multilateral wells have multiple completion options. As with any completion, design must address reservoir type, drive mechanism, fluid properties, well configuration and any other complications that might exist, such as sand influx and water and gas coning. Laterals are completed open-hole or with uncemented or cemented liners. Other designs employ mechanical assemblies to provide connection, pressure integrity and selective access to junctions.

In a multilateral well, some components complement the planned completion, whereas other completion components are defined as being what is put into the well after the junction has been completed. “A lot of these pieces are needed to meet special requirements of the well. A piece that would allow remote flow control of each lateral leg, such as inflow control valves (or choking devices), associated with an intelligent completion have to be properly matched to the multilateral junction components to ensure complete compatibility,” Halliburton’s Mr Durst said.

Completion in a well with multiple branches can take myriad forms. It can be barefoot. Or it can take the form of a customized multilateral junction with a standard completion. Or it might have a standard multilateral system with a customized completion. “We can use conventional completions or intelligent completions,” Mr Durst said. “We’re getting to the point where we can tie in sand-face completions as an integral part of installing a multilateral well.”

“At Schlumberger, we take the concept that we are completing wells, not building junctions,” Mr Sponchia said. “We don’t actually install the junction itself until we know that it’s a good well and we’re ready to complete it. The junction...
is more of a completion solution rather than a drilling solution. The most important thing for us is that we understand what is going to occur in the well after the junction is installed. Is open-hole gravel packing, through-tubing access or intelligent completions required? These kinds of questions drive the multilateral solution."

**CURRENT TECHNOLOGIES**

Service companies continue to invest in research and new product development to provide operators with reliable multilateral tools and systems.

**HALLIBURTON**

A key differentiator in multilateral drilling and completion products for Halliburton is the Latch Coupling. It provides full drift ID access that is equal to or greater than the adjoining casing. “Within this coupling there is a unique profile that allows all of our tools to be landed and directed to a specific orientation repeatedly throughout the life of the well,” Mr. Durst explained. The coupling provides permanent depth and orientation reference for a precise window exit for either new wells utilizing a pre-milled window or in existing wells utilizing a proprietary window milling machine.

“This full-bore-ID casing coupling has a recessed keyed profile,” he continued. “This profile accepts a mating keyed assembly on the bottom of all of our tools and can only be locked in at one depth and orientation. This depth and orientation is unique and is recorded in the well file, and since it is a permanent part of the casing it can be accessed repeatedly for the life of the well.”

The company has a high-strength level 4 junction with sand control that has been installed with a 97% success rate. Associated with levels 2, 4 and 5 applications, this LatchRite system provides full-gauge access to the main bore and laterals; it also allows re-entry to both lateral and main bore. Employing multilateral washover operation, the system achieves hydraulic integrity using cement.

For subsea applications, the FlexRite system with an aluminum wrapped pre-milled window removes the chance of steel debris entering the lateral or main bore. A high mechanical strength level 5 junction enables long lateral screens to be installed and sand production to be

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**Multilaterals present extra debris-removal challenges**

“Operators report that debris left in the wellbore results in one third of all failed completions,” Ron Barker, global general manager re-entry services for Weatherford, said. “I think the industry is finally recognizing that just circulating the wellbore to remove debris is not enough. These days a big differentiator is the casing wall. We’re starting to run a lot deeper and heavier walled casing strings. In the case of horizontal wells, there is consistent contact of the casing wall and tubulars for long extended periods of time and there is a lot of additional debris being generated.”

In the past, wellbore cleaning meant circulating the well bottoms up before tripping out. But downhole technology has changed that. Today’s completion technology is about equipment engagement, dependent on seals and expansion of materials, and therefore, demands a clean environment.

Sources of debris vary from well to well, ranging from debris created during drilling or milling operations to fluid that has not been properly maintained.

Multilateral wells experience the same debris issues as other wells but present additional challenges. “Horizontal wells are extremely challenging to clean; it’s more difficult to remove debris from the toe or heel of the horizontal section. The debris lies on the low side, and typically pipe rotation is very limited or unobtainable,” Mr. Barker said. “Mechanical wellbore cleaning is typically required to physically remove drilling debris or settled solids that are created during the well construction process.”

By the very definition of a multilateral, there’s more than one wellbore, so one can’t depend on turbulent flow to get debris to surface. “Circulating environments may only bring half of the debris to the surface,” Mr. Barker said. “The rest of the material is either strung out in the wellbore or in the junction area.”

There is also the issue of debris going into another wellbore as one wellbore is being cleaned out. There are more places where debris can settle, for example, around tubulars of various outside and inside diameters.

In addition to selecting the right level of multilateral and the most effective completion, wellbore cleanout has become a critical element that has a direct impact on getting the most out of the well. Installing the junction is just the first half of the equation on these wells; installation of a successful fully functional completion is the second half. There is always the potential to create debris and increase risk.

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“Debris” continued on next page
Service companies have been tasked by operators to not only combat the challenges of debris management but to do so in the most time-efficient manner, reducing the number of trips. Weatherford believes its ClearMax service can help attack debris on three fronts – chemical, mechanical and hydraulic.

“Clients are recognizing that wellbore cleanout and debris removal has an impact on time, especially in offshore environments where spread rates are high,” Mr Barker said. “One thing complements the other. An installation can become damaged as the result of a simple debris issue; a standard cleanout sequence could have eliminated the damage.”

With the chemical portion of the cleanout service, HSE-compliant drilling fluid cleanup solutions, including filter-cake breakers, water-wetting surfactants and oil-based mud thinners and pipe-dope solvents are unleashed. The mechanical portion of the cleanout involves the use of a proprietary line of casing-cleaning, debris-extraction, circulation and wellbore integrity-validation management tools. The third portion of the service, hydraulic software, is used to ensure that chemical and mechanical elements are optimized for a specific operation. Hydraulic programs are modeled to be sure that the flow pattern is within the operational limits of the rig.

As an example of a cleanout operation taking place from a single string, the engineer can scrape the casing, establish plug-back total depth, boost annular flow in the wellbore, extract ferrous metal with high capacity rare earth magnets, and brush and scrape the area where packers are going to be set in cased hole. All of this can be accomplished in a single run, according to Weatherford.

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eliminated. According to Mr Durst, the system has a 100% success rate in more than 137 junctions.

For re-entry applications, the ReflexRite system uses a level 2 junction window with specially engineered geometry and the junction is completed with a level 5 system with hydraulic pressure integrity at the junction.

To isolate the junction from stimulation fluids in both land and offshore applications, the company uses a temporary level 5 multilateral completion. The Junction Isolation system is installed with integrated completion, stimulation and service products, including frac completions. Multilateral drilling and completion processes are combined into one system capable of constructing the junction and providing the required pressure isolation for selective stimulation.

WEATHERFORD

With more than 10,000 successful casing exit installations around the globe, Weatherford has focused on its core competency milling technology for its multilateral systems. “Building off of our proven milling expertise has enabled us to offer a variety of multilaterals designed for varying requirements and yet continually satisfy the industry’s demands for simplicity and low-risk solutions,” Cliff Hogg, global product line manager of re-entry services for Weatherford, explained.

The company’s Selective Re-Entry System (SRS) has been developed for new and existing well applications requiring a level 2 junction. This system uses a large-bore orientation packer to provide a permanent depth and orientation data point for both whipstock and later re-entry operations. It also provides multiple junctions within the span of a joint or two of casing, therefore providing an opportunity for maximum reservoir exposure. The resulting laterals can be completed or left open hole.

For wells in which maximum mechanical integrity at the junction is required, the StarBurst level 4 multilateral system uses a hollow whipstock-anchor assembly that eliminates the need for whipstock retrieval. Once the lateral well has been completed, the lateral liner and hollow whipstock can then be perforated in order to regain main bore hydrocarbon production.

In the one-trip version of the StarBurst level 4 system, a milling/orientation system provides for orientation of the whipstock-anchor assembly, milling the window and drilling of the ratheole all in a single trip. This version has been installed in various North Sea wells.

The StarBurst systems do not provide re-entry access back into the main bore leg of the well, but Mr Hogg believes this is not as much of an issue as one might assume. “The reality is that in many wells, particularly in offshore environments or those involving existing mature wells, the costs and/or limited production uplift opportunities of a re-entry workover into the main bore simply don’t make such an operation economically justifiable. Additionally, the costs and benefits realized by leaving the whipstock in place typically offer a much greater risk/reward than would normally be realized from such a main bore re-entry intervention.”

For projects that do require potential main bore re-entry capability, there’s the MillThru level 4 multilateral system, which relies on standard casing exit equipment for creating a lateral window that is followed by conventional liner running, cementing and completion procedures. Main bore access is achieved through the use of a stiff mill assembly that mills out a window in the lateral casing, and in the process, create a mechanical re-entry option for the main bore.

The company is also developing completion systems for extended-reach, horizontal multilaterals. One key consideration in such a design is eliminating the need for lateral access in such horizontal configurations. “The challenge to horizontal and multilateral completions is access at a later time. It’s very difficult to get to the end of a 10,000-ft lateral section even with coiled tubing. So we’re having to devise systems that don’t need access,” according to Rich Jones, director of completion and stimulation technologies for Weatherford.

One such system is the ZoneSelect ball drop system that allows for stimulation of up to 25 intervals in the main bore and laterals without having to intervene in the well. Weatherford believes the system is evidence of how horizontal completions have exploded in the US over the past couple of years.
The company has shipped 5,800 suites of its open-hole ZoneSelect system and is averaging between 12 and 15 suites per well.

“That will give you an idea of how many wells we’ve completed this year. And that’s not including plug and perf systems with composite bridge plugs. We shipped 36,000 of those last year,” Mr Jones said. “It’s not been something we’ve run into in the completions business ever. We’ve never made 100 of one size and type of plug before, and now we’re making 400 to 600 at a time.”

“Our ZoneSelect system can be dropped into the lateral without having to be manipulated into the lateral via a junction. Our ability to operate these systems without having to intervene during the installation or the frac process is critical,” he continued.

BAKER HUGHES

Since the mid-1990s, Baker Hughes has installed more than 600 multilateral junctions level 3 and higher, with the HOOK Hanger system comprising about 80% of those runs. The system provides large internal-diameter drift access that can create level 3, 4 or 5 junctions and uses standard liner running and completion techniques, and provides positive re-entry access to all bores.

The main bore is completed as normal in a single well. The casing exit is created, and the lateral drilled to total depth. The lateral completion is run on the HOOK Hanger system using standard liner hanger running tools and procedures. A bent joint on the bottom of the liner allows for the lateral liner to enter the lateral bore. The hanger engages the lower end of the casing exit giving mechanical support and a known location in the wellbore. The process can be repeated for multiple laterals.

The company’s rotating, self-aligning multilateral RAM system was developed to allow liners to be rotated to depth and create a mechanically supported junction in long extended-reach applications or when it may be difficult to get liners to depth due to wellbore and formation conditions. To add completion flexibility, accessory tools can be landed in the RAM system to allow a level 3 or 5 completion, to stack multiple junctions and have positive re-entry access to all bores, and utilize intelligent completions to control and monitor production.

Similarly, during the RAM operational procedure, the main bore is completed as normal in a single well. The casing exit is created and the lateral drilled to total depth. Then the RAM sealbore diverter is installed and aligned to the casing exit window. The lateral completion is run on the RAM hanger and can be rotated to

Figure 6 (left): Effective in new and re-entry applications, Weatherford’s StarBurst level 4 multilateral system creates a level 4 cemented junction with full-liner access to the lateral bore. The system requires only one whipstock run and is compatible with conventional and intelligent completions. Figure 7 (right): Run in South America and the Middle East, Weatherford’s MillThru level 4 system relies on standard casing exit equipment for making a lateral window, enabling creation of a low-cost level 4 junction. A simple mill assembly is used to create access back into the main bore through a standard liner.
total depth. The RAM hanger self-orientates on a helical profile on top of the sealbore diverter, creating a mechanically supported junction.

Another Baker offering, the HydraSplit system, creates a low-risk level 5 hydraulically isolated junction suitable for intelligent completions. The main bore is completed as it would be in a single-well application. A combination casing exit system is run and creates the casing exit and the lateral is drilled to total depth.

The upper portion of the combination casing exit system is retrieved, leaving a sealbore diverter in place that is directly aligned and optimally positioned to the casing exit window. The lateral completion is then run in hole with the HydraSplit system, which has two legs facing downhole — one is attached to the lateral completion and the other seals in the sealbore diverter, creating the hydraulic isolation. Accessory equipment allows positive re-entry access and pressure isolation between all bores.

“The Hydrasplit and casing exit systems were integrated to save an entire trip as opposed to similar systems,” Mr Sheehan said. “This reduces lateral open-hole exposure time between when the lateral leg is drilled and the lateral completion is installed, reducing installation risks.”

**SCHLUMBERGER**

Most suited for unstable or caprock applications, the company’s RapidX level 5 multilateral junction offers formation stability at the casing exit and pressure isolation to 2,500 psi. The system includes a specially designed seal combined with a continually interlocking rail system and can be used for new or re-entry wells that have different pressure regimes requiring inflow control.

For new wells with similar pressure regimes, the RapidAccess level 2 junction gives selective access and multiple kickoff points for multilateral wellbores. The system is based on a self-orienting and locking casing nipple concept that has three components: an indexing casing coupling (ICC), construction selective landing tool and a construction re-entry deflection tool. RapidAccess has the ability to be stacked for multiple junctions and has an internal diameter (ID) that is equal to, or greater, than the casing with which it is deployed. The system provides permanent depth and orientation points are retained without compromising the casing ID.

The RapidConnect multilateral completion system is the only level 3 junction that provides complete sand exclusion at the junction. It permits reliable re-entry access and selective production to either lateral in both new and existing wells.

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