Rigging up for extreme reach

To best leverage today's directional drilling technology, the right drilling rig is required.

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A common feature of frontier exploration areas is a fragile environment with marine wildlife, unique soil conditions and high operating costs requiring special attention. Extended-reach drilling (ERD) technology and experienced people have minimized the operational impact on the environment while still allowing development of oil and gas reserves in these sensitive areas.

In addition to environmental risk mitigation, other technology drivers are the high cost of alternative offshore platforms, field recovery factors and facilities optimization. Since high-departure wells are more complex and react differently to earth stresses than do vertical or low-angle wells, drilling these trajectory types cost-effectively requires extraordinary accuracy, control and reliability.

Many technical challenges have been overcome, and the industry has drilled targeted reserves more than 6½ miles (10.4 km) from the rig's surface location.

Well trajectories being planned today have such departures and complexity that feasibility risk is a critical part of the evaluation prior to investing in the project. This risk in large part is determined by the rig design and capacity to drill these extreme-reach well designs.

To best leverage today's directional drilling technology and create new markets for well targets previously beyond the limit of existing techniques, the right drilling rig is therefore required. Drilling rig, directional drilling and completion technologies to date have focused mainly on overcoming drag forces preventing pipe from sliding, rotating friction forces increasing torque required to rotate pipe, and structural capacity for handling extended well tubulars. Other bases of design for extreme-reach rigs in operation today include efficient and automated tubular handling, offline stand building, increased power, and hydraulic and derrick requirements to reach total depth. To extend the technical limits of current drilling technology further, there remain significant constraints to overcome, including improved pressure management, ultradeep casing runs and efficient data communication.

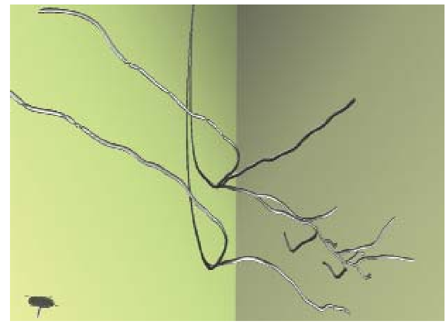
Early experience

There are numerous examples of how ERD technology has advanced. Prudhoe Bay's multiwell development drilling programs from pad-based surface locations required directionally drilled well trajectories to reach bottomhole targets distal to the small surface area. Improved bottomhole assembly technology at the time and increased rig hydraulic capacities enabled ERD where the horizontal well displacement is at least twice that of vertical depth. Besides increasing well productivity, the technique served mainly as an environmental system to limit location impact and avoid surface "obstacles."

Progressively smaller pad size and improvement of directional drilling allowed for recovery of oil and gas resources from a greater area with smaller and fewer pads. Early Prudhoe Bay pads were based on 65-acre spacing (20 wells per pad). Innovation since then reduced well spacing further to less than 10 acres with wellheads as little as 10 ft (3 m) apart. Because of the area reduction, new rig developments were required. Re-injection of cuttings rather than storage in pits on location and new cantilever designs were implemented to fit the rig between more tightly spaced wellheads. Early Arctic rigs required 18,000 sq ft (1,672 sq m) for rigging up, while third-generation designs reduced this further to 7,000 sq ft (650 sq m).

Xijiang 24-3 ERD wells

Ten years ago in China, production from the Xijiang 24-3 offshore field in



Actual multilateral, fishbone well trajectories targeting shallow reservoirs from a single mother bore. (Image courtesy of Schlumberger)

A Parker Drilling crew member shown while drilling the first Sakhalin-1 extended-reach well. Data on current activities and drilling progress is transmitted to the driller on the floor, rig offices and the drilling contractor's headquarters. Drilling engineers on-site and remotely can analyze drilling performance in real time. In addition to drilling performance, equipment packages such as the top drive and diesel engines transmit real-time performance information to remote locations. Maintenance issues can be evaluated and recommendations made by technicians working off-site. (Photo courtesy of Parker Drilling Company)

the South China Sea originally indicated booked reserves understated the actual amount of oil in place. Revised seismic interpretation provided several promising undrilled locations but with bottomhole locations requiring departures beyond the range of proven development drilling at the time. To date, 13 ERD wells have been drilled from the 24-3 Platform. This is a 24-slot platform with every well bay drilled with several multilaterals. The first extended-reach well drilled from the platform in 1997 was a world record at the time, with a measured depth of 30,300 ft (9,238 m) and horizontal displacement of 26,446 ft (8,063 m). Initial wells were considerably more difficult as they were drilled prior to the introduction of commercial rotary steerable technology. To manage annular hydraulic pressure profiles, a tapered string of HT-55 and 5-in. S-135 was used, carefully balancing torque limitations on conventional drill pipe with the equivalent circulating density impact of larger, high-torque tubulars. Today 8½-in. sections are under-reamed to 9-in. to better enable running casing to bottom as the tectonically stressed field depletes and hole stability changes.

"Yastreb" – Arctic, seismic and extreme reach land rig

Russia's second major offshore oil and gas project commenced in Northeast Sakhalin Island targeting the northern flank of the **Chayvo** offshore oil and gas field with wells drilled from an onshore location. The Sakhalin-1 license area includes three fields discovered by Rosneft-Sakhalinmorneftegaz 28 years ago. Drilling continues today on Chayvo with well displacements of 5 miles to 6 miles (8 km to 10 km) and vertical depths of only 8,530 ft (2,600 m).

The basis of design for this purpose-built drilling rig combined innovative structural design and automation to drill offshore targets from a land location, underneath whale migratory routes and in an area of high seismic activity. These extended-reach well trajectories rival worldwide limits of this technology. Interestingly, the most experience with this class of wells is held by a few select drilling contractors with operator-owned rigs. The performance in China is especially exemplary since early wells were drilled prior to implementation of rotary steerable technology. New projects at the planning stage will enter the top 50, and recent experience is accelerating the pace of development.

The primary extended-reach design components of the "Yastreb" are:

- Automated pipe barn;
- Cuttings reinjection;
- Lightweight mast racking capacity;
- Top drive torque to 94,000 ft-lb (28,651 m);
- Four 7,500-psi mud pumps for hydraulics;
- Matched power with six generators;
- 9,000 bbl mud storage; and
- Pipe handling out of critical path.

Rig engineering and design

Based on lessons learned and industry best practices, high-impact operational requirements to drill extreme reach wells start with extensive planning. Because of long lead times for key equipment, rig availability, design and modifications, planning can span from less than one year to several years in advance of drilling operations. Personnel training, commitment of resources and competency of operations teams are other key requirements to successfully execute extreme reach well programs.

Exploration frontiers have unique geographical and geological features which impact future rig design or existing rig deployment in those areas. The recommended approach to deploying the right rig technology includes balancing new features that bring benefits to the user with industry standards, equipment standardization and engineering process. Another consideration is compatibility of rig design beyond the current work scope. A modular design platform optimizes rig utilization over a longer period of time while allowing specific modifications as required.

New rig designs to extend well departures and depths produce more power, handle more fluid capacity and occupy a smaller footprint than the previous generations of drilling units. Large well bores and associated casing programs require the appropriate set-back and hookload capacity to handle, store and run tubulars. As directional work is performed in large hole sections to take advantage of faster penetration rates and lower temperatures, the rig's capacity for handling high volume and large-size cuttings removal and hole cleaning plays a significant role in maintaining high penetration rates and avoiding trouble time due to hole conditions.

Engineered rig power supply, distribution and control enables simultaneous operation of large mud pumps, top drive and drawworks reliably for long drilling sections. Higher flow and mud circulation also impact directional and measurement-while-drilling tools, which transmit real-time information via the fluid column and have flow limitations due to electronics chassis design. Reliable pulsation dampening and clean drilling fluids impact real-time measurements critical for monitoring annular pressures, deducing circulating densities and managing pressure while drilling through formations with varying pore pressure regimes. As rotary steerable directional drilling expands, reliable mud pump systems facilitate downlinking to communicate revised trajectory plans to bottomhole microprocessors. Because of the significantly higher penetration rates with fully rotational directional systems, reliable downlinking is critical to avoid sidetracking, missed targets or downtime spent re-programming the tools.

Drilling with bi-center bits, underreamers and hole openers to optimize casing programs also requires higher capacity hydraulics and torque delivery from the rig. Operating three mud pumps simultaneously to achieve high flow rates while efficiently removing cuttings requires optimized rig power.

Conclusion

Especially in a period of new rig construction, the design and specification of extreme-reach drilling rigs will become increasingly important as frontier regions with environmentally sensitive surface conditions become more active exploration and development basins. Successful delivery of these new designs can also open new drilling markets by targeting prospects previously considered undrillable with the existing, available rig fleet. E&P