A Holistic Approach

Integrated workflows drive holistic trend to boost production, efficiency in shale plays.

More than a decade since the unconventional boom changed the paradigm for oil and gas development and unleashed a technological revolution that has had worldwide impact, the industry has come a long way in learning about the complex and unpredictable nature of shale formations. However, the learning process is an evolutionary one, as all sectors of the business continue to enhance their knowledge of unconventional plays and how to efficiently produce them in a challenging climate of depressed commodity prices.

From understanding the rock, to drilling and landing the well in the sweet spot to designing fractures that will enhance production, operators now know that a one-size-fits-all approach is not a viable option in developing these unique and heterogeneous reservoirs. That knowledge, bolstered by a host of sophisticated technologies, has enabled the industry to expand the potential of unconventional plays. On the surface, efforts have been focused on efficiency and cost reductions, decreasing cycle times, the footprint and the number of people on location, while increasing the number of stages completed each day. While every basin is different, lateral lengths, stage counts and sand volumes are growing. In general, stage spacing is decreasing, in some places to less than 150 ft. This further drives efficiency because crews are working for longer periods at a given location. In contrast, the subsurface is about improving productivity and recovery.

Along with efficiency gains, productivity is a key driver for achieving project economics in unconventional plays. Estimated ultimate recovery (EUR) rates have improved to 12% to 18%; however, they are still very low when compared to conventional well rates of 30% to 40%—or more with secondary recovery techniques. Even boosting unconventional recovery to 20+% for liquids-rich unconventional reservoirs would dramatically improve the economics of these wells. Better understanding of well spacing, fracture modeling, flowback and how interfaces in rock layers impact landing points and fracture design is key to reaching that next level of recovery in unconventional reservoirs.

There is no denying that $45/bbl to $50/bbl oil prices have changed the way the industry looks at unconventional reservoirs and contributed to an emerging holistic approach to developing these basins, a marked shift from the traditional practice where each phase of the well is carried out independently. Today, taking on an unconventional field involves a full cycle managed by sophisticated workflows encompassing multiple fields of expertise. It is the integration of technology, process and workflows at the subsurface and surface levels that will increase production and improve efficiency to impact the overall economics of the unconventionals in a low-price environment.
Successful producers are seeing improved results by adopting this new way of thinking about field development. An operator in the Eagle Ford Play used the Schlumberger GeoEngineered Performance geocentric approach (Figure 1), which integrates the disciplines of rocks and fluid, drilling, completion, and production systems, to improve productivity by as much as 80% over base wells in the play. The approach is rooted in the recognition that drilling impacts completion and completion impacts production—and it all starts with understanding the rock and fluid.

This same data is also critical for determining completion quality (CQ), a term used to describe how the rock properties impact the hydraulic fracture initiation and propagation both vertically and horizontally away from the wellbore. This knowledge ultimately determines what areas of the reservoir are going to produce, and serves as the basis for developing integrated workflows—drilling to fracture, fracturing to produce and producing to recover—to drive performance.

**Drill to fracture**

The drill-to-fracture process incorporates 3-D earth models that integrate seismic, core, and log data to determine the best landing points to drill the well in the sweet spot based on RQ and, even more important, CQ.

The industry has come to realize that the interfaces—some weak, some strong—present in every layer of rock impact fracture height growth. Weak interfaces, in fact, are a more significant issue than previously thought, and a lot of testing has been done to learn what happens to the geometry of hydraulic fractures when they intersect the rock interfaces. For example, the fracture may move vertically, then horizontally, and back to vertical, losing energy and reducing the fracture height growth needed in the area of contact (Figure 2).

Determining the optimum landing point of the well plays a central role in reducing the impact of weak interfaces. Using measurements along the lateral to steer within the landing point, a window that may be as small as 10 ft to 15 ft, helps ensure that a hydraulic fracturing completion will be successful. Tools that have had an impact in determining the optimal landing points from pilot well evaluation include litho scanners, magnetic resonance,
sonic scanners and image logs that identify the sweet spot from both RQ and CQ standpoints.

**Fracture to produce**

Once the well is drilled, the next step is to fracture to produce, which is optimizing the completion, including fracture design, completion system and efficient single-well or pad development. Fracture modeling software has continued to evolve, and now allows the service provider or operator to efficiently model different scenarios, including stage length, cluster spacing, proppant loading and fluid volumes, to determine the optimum completion for each well that is drilled. Multiple scenarios can be run to determine what design will provide the best return on investment.

Optimum well spacing is a key question for all unconventional operators who are focused on infill development. It is estimated that billions of dollars will be squandered on drilling too many wells based on fixed well spacing. Drilling the right number of wells at the right well spacing can significantly improve an operator’s ability to lower costs while achieving the same or even higher EURs.

Many operators are finding that when they drill infill, sometime referred to as “child” wells, they are seeing much lower productivity than the parent wells due to interference between the parent/child wells. Enhanced understanding about the role of geomechanics in this scenario, specifically how pressure depleting from the parent well negatively impacts the ability to effectively fracture the children wells, has proved beneficial. In many cases, the parent well can be re-stimulated to re-pressurize the reservoir, enabling the children wells on the same pad to be successfully fractured the next day.

A well drilled in the right spot, in the right interval should produce; however, achieving a well’s full potential is more complicated. To address that challenge, advances in fracture modeling software to better stimulate the reservoir and increase wellbore productivity are yielding results, along with techniques that ensure the entire interval is producing.

**Produce to recover**

Once the well has been completed, the next phase of the process is produce to recover. In this phase of the life of the well, one needs to take into account the drill-out of mechanical plugs, the flowback and the optimum artificial lift method needed. Over the last couple of years, it has become evident that the drill-out process and the flowback need to be better managed. A hydraulic fracture just created can be seriously compromised if the flowback is too aggressive. Too low a flowback rate can leave excess fluid trapped in the hydraulic fractures. Oftentimes, there is a very narrow window for producing wells to ensure they aren’t damaged.

The final phase of the produce-to-recover process centers on appropriate artificial lift selection. Each well should be evaluated individually, and the right lift equipment installed, to maximize the production/EUR that gives the greatest return on investment.
As unconventional activity continues to ramp up in North America, international markets, including the Middle East, Colombia, Australia, Argentina, the U.K. and Mexico, remain important frontiers. The Ahnet Frasnian shale gas field in Algeria is now estimated to rank third globally in the amount of shale gas resources, with 707 Tcf of technically recoverable shale gas and 5.7 Bbbl of technically recoverable shale oil resources. International operators are generally receptive to the integrated workflow approach because they need to drill and produce wells with precision due to lack of infrastructure and low oil prices. In these markets, project economics are very challenging. Operators cannot afford to drill excess wells to develop their fields, so they need to get it right from when they first start their field development.

In the U.S., operators are increasingly embracing the methodology as they push for increased productivity and efficiency. Lonestar Resources

![Graph](image_url)

**Figure 3:** (Top graphic) Wells developed using the GeoEngineered Performance approach in one area of the Eagle Ford outperformed by 80% offset wells drilled, stimulated and completed using the traditional approach, including fixed, geometric well spacing. In a second field, engineered wells outperformed prior geometric completions by 78%. (Image courtesy of Schlumberger)
has successfully implemented the GeoEngineered Performance approach since 2016 to optimize reservoir contact and dramatically improve performance for multiple wells in the Eagle Ford. Oil production has increased by as much as 80% over offset wells drilled, stimulated and completed using the traditional approach, including fixed, geometric well spacing. This process has continued with Lonestar Resources, with another field seeing a 78% improvement versus offset wells (Figure 3).

**Case studies**

Lonestar Resources has used integrated workflows for all phases of the wells to analyze reservoir rock and fluid, determine the correct lateral landing point, optimize fracture design and engineer flowback. The use of advanced tools and technology has been instrumental in applying the workflows to improve production rates. To model the fractures and optimize the completion strategy, the operator has implemented the Kinetix shale stimulation-to-production software platform, which optimizes the completion strategy using a comprehensive set of simulators, models and workflows for hydraulic fracturing.

To maximize production from each interval, the Broadband Sequence fracturing service has been instrumental in facilitating sequential stimulation of perforation clusters to increase reservoir contact. Developed with a composite fluid comprised of degradable fibers and multimodal particles, the technique sequentially isolates perforations and fractures at the wellbore to ensure every cluster in each zone is fractured to deliver greater production and completion efficiency.

Lonestar Resources also has used the Schlumberger AvantGuard advanced flowback services to engineer a flowback design strategy that prevents damage to the well and the formation during the transition to production. The system uses a secure operating envelope based on multiple operational parameters defined from real-time pressure and production data, including solids-production monitoring. Changes in production rates are measured using a multiphase flowmeter, which accurately captures flow dynamics for all fluid and solid types. The service provides production monitoring over the lifetime of the well to ensure flowback is being managed within the operating envelope to protect hydraulic fractures and ensure operators are achieving maximum productivity.

An emerging trend in unconventional development centers on refracturing, which has significant potential for thousands of underperforming wells as technology continues to evolve. The key is to select the right well candidates that will deliver adequate incremental production. Good RQ and CQ, adequate reservoir pressure to produce the remaining reserves and sufficient recoverable reserves in place are important criteria to consider.

The advent of mechanical, expandable systems developed by Saltel Industries, a Schlumberger company, is helping to move the refracturing business forward, while the Broadband Sequence fracturing service, with its capability to divert composite fluids to higher stress regions for increased fracture stimulation and manage fracture geometry through far-field diversion, has already been an important game-changer.

In a collaborative undertaking with Schlumberger, Sundance Energy launched a successful multiwell refracturing campaign in the Eagle Ford that involved a rigorous candidate selection process and an engineered treatment design, including implementation of the fracturing service for near-wellbore diversion. The service effectively plugged perforation clusters and near-wellbore fractures, inducing temporary isolation, to stimulate more perforations and ultimately contact more of the reservoir.

Initial 30-day average incremental production was approximately 65 bbl/d of oil with more than 100% uplift in production compared to pre-refracturing rates. Estimated average EUR increased by 60,000 bbl, a 45% increase over the predicted base EUR.

**Moving forward**

The industry has unlocked many of the mysteries of unconventional plays through greater reservoir understanding and technological innovation. The shift to a holistic approach, including an integrated, geo-engineered performance workflow that encompasses both the surface and subsurface aspects of the reservoir, through all well phases, is having a dramatic impact on production and efficiency.

Going forward, technical integration and the application of the workflows will be critical in reaching the next level of improved field economics in these complex and heterogeneous fields as the industry continues its quest to conquer the learning curve—which is what makes the un-conventionals so exciting.