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A New Era for Unconventional Value – The Well Production System

November 2018

It is time to change the existing approach to Unconventional development (UC) in order to achieve well cost and 'cycle time' reductions per well of over 25% and reduce operating cash required by up to 40%.

The industry has consistently advanced UC development, adopting multi-stage fracking, pad drilling and end to end supply chain management as needed. To sustain improvements, it is time for new capabilities and for the next era of performance improvement to close the UC performance gap relative to other sectors.

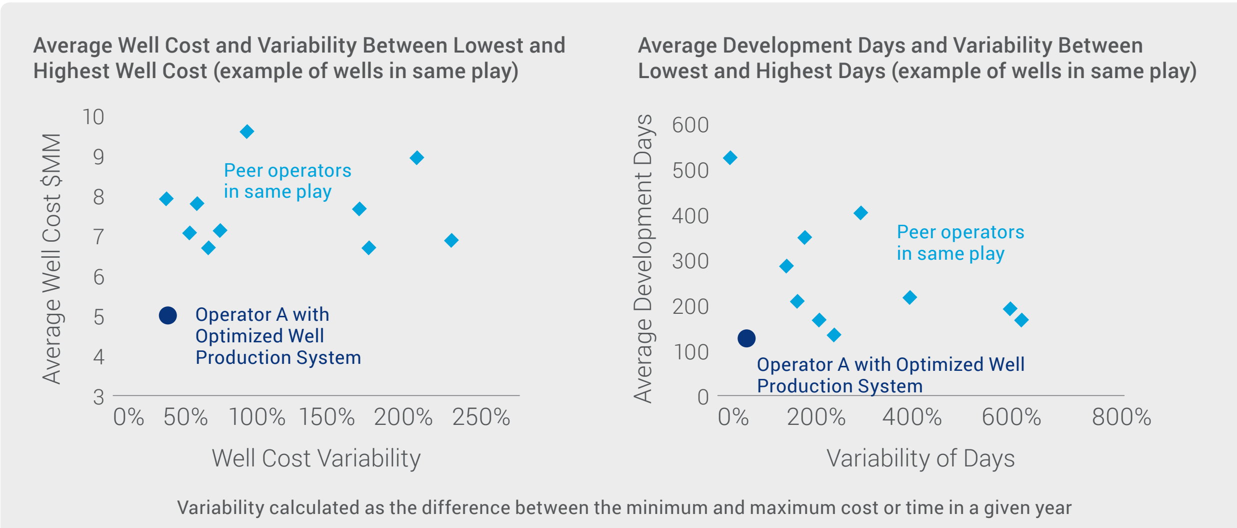
UC development in the Lower 48 has faced and addressed many challenges. In subsurface, the industry overcame barriers to the adoption of horizontal drilling and hydraulic fracturing, delivered developments in multi-stage fracturing allowing longer laterals and advances in subsurface technology continue to improve IP and EUR. On the surface, multi-well pad drilling simplified operations with the aim of reduced costs, and supply chain integration efforts optimized availability of scarce capacity from rigs or frac' sand to offtake constraints.

However, the resurfacing of some these challenges as focus turns to Permian development[1] (Reuters October 02, 2018: Too much oil? Texas boom outpaces supply, transport networks) highlights the absence of a systematic and dynamic solution, and structural change in the industry's approach to the 'end to end' well production system.

Such an approach, based on the well-established field of operations science, is field proven, firmly established, and incorporated into the Project Production Management (PPM) as applied to well production systems. First utilized in onshore field development in Bakersfield in 2000 and referenced[2] (Economist May 28, 2015: 'Offshore Fog') as an example of leading industry practice, PPM establishes the framework for control, system optimization, and continuous feedback required to ensure the well production system is continuously optimized.

An additional benefit is the agility and ability to rapidly respond to factors, both positive and detrimental, outside of the owner's control. This is a minimum stakes expectation in other producing industries and should be for UC development.

Figure 1: Differentiated Well Cost and Variability and Development Time and Variability Performance Under PPM



Development days defined as time between drill start and first production. Source: Wood Mackenzie North American Well Analysis Tool (NAWAT)

In the case of Operator A, as seen in Figure 1, adoption of PPM has enabled sustained differentiated cost and development time, or cycle time, performance from their peers, on 'like for like' wells while simultaneously delivering the most consistent, or lowest variability, in cost and development time. In addition as shown in Figure 8, since 2013, the approach has enabled sustained drilling and completion cost reduction of ~47% vs peer average of 8% and cycle time reductions of ~37% vs peer average reduction of ~7% in cycle time.

Implemented in over 300 diverse projects, including onshore field development applications, since the late 1990's, PPM has a proven track record of delivering 20-30% or greater improvements in time and cost vs. the current approach.

Continued reporting of conventional metrics and benchmarks has failed to drive and sustain structural change or satisfy investors in UC. According to a recent New York Times article "The next financial crisis is underground" (September 1, 2018), investors, analysts and commentators are increasingly questioning the cash performance of UC operators.

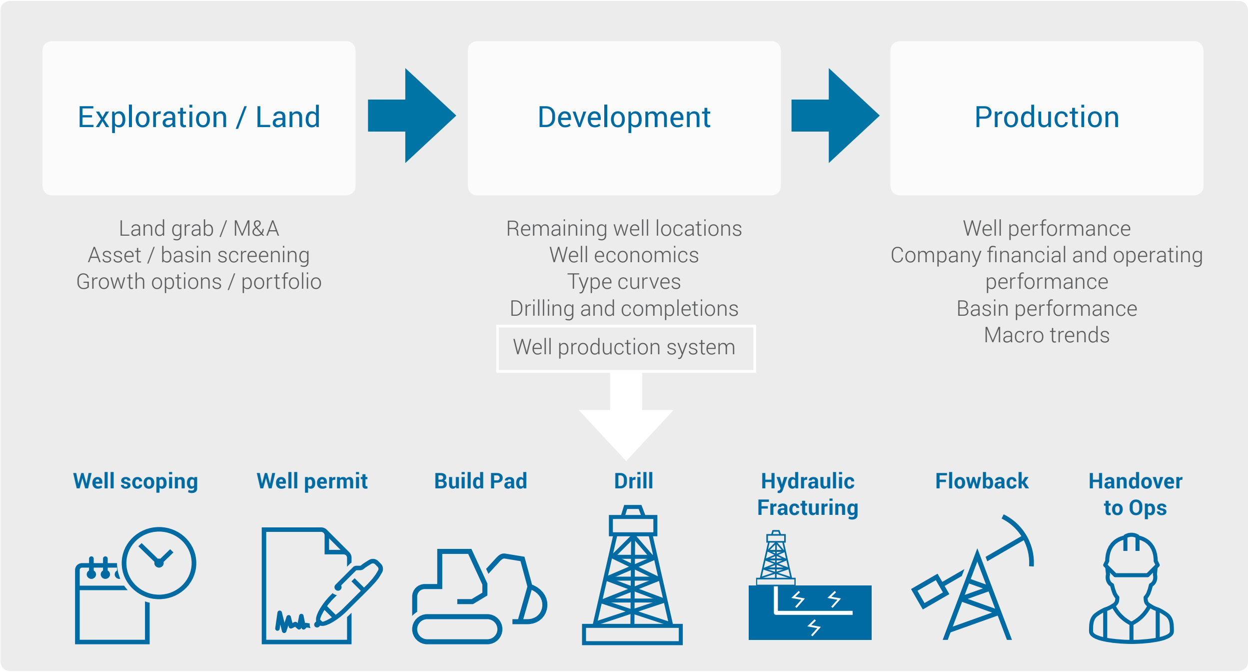
We are aware of no other near-term opportunity which can offer this level of performance improvement in the cost and capital efficiency of UC developments and, for most UC producers, the impact is of material benefit to the companies involved.

Unlocking this available value for companies and their investors, and implementing the systematic approach required to capture the unlocked value must become a top priority and an investor expectation as the UC matures.

The ‘Technical Gap’ – Inventory and Variability Drive UC Value Leakage

A Production System approach has proven successful in many other sectors such as manufacturing, automotive and fast moving consumer goods. However, despite recent performance improvement, the engineering and construction industry still lags 5 to 10 fold behind the improvements achieved in industries (reference The Economist article, “Efficiency eludes the Construction industry” August 17, 2017). This engineering and construction performance gap directly impacts the capital investment in the oil and gas industry and the capital efficiency of UC developments.

Figure 2: The Application of PPM to the Well Production System is the next frontier for UC

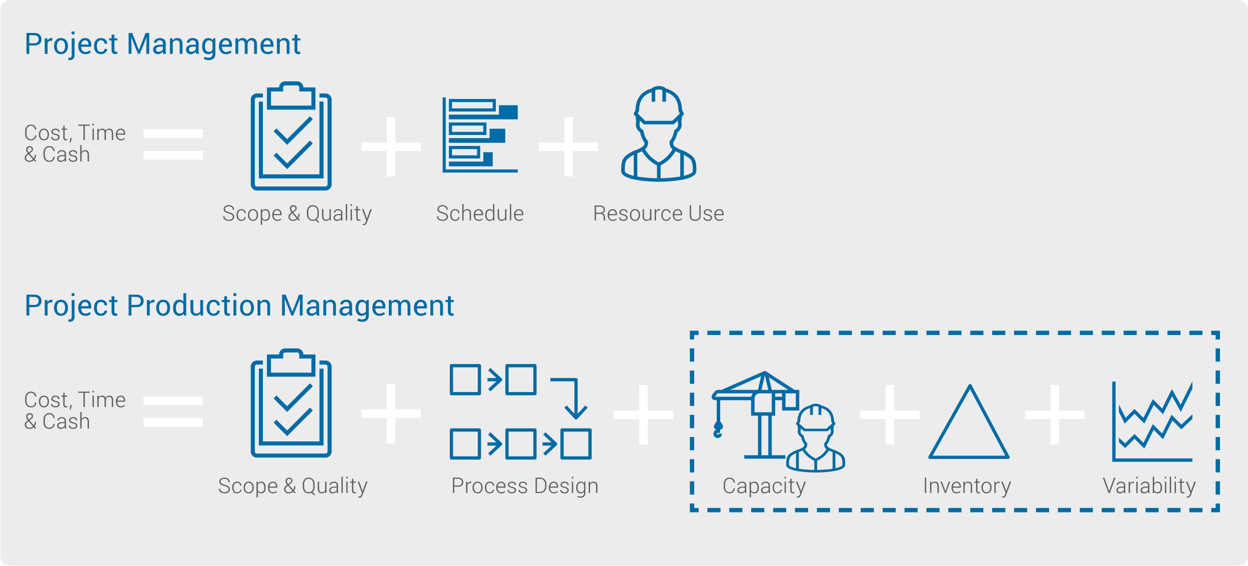


The prevailing approach to the complex planning and execution challenges of UC field development still relies on conventional project management practices such as the use of Gantt charts to plan and schedule activities, work-breakdown structures to plan the allocation of resources to activities, and the assumed trade-offs between cost, time and scope and/or quality based on underlying principles that are largely unchanged since the 1950’s.

The performance gap relative to other sectors reflects an underlying technical gap in the prevailing approach to UC field development. The key parameters in the Technical Gap are Inventory, or Work-In-Process (WIP), and Variability.

Figure 3 illustrates these parameters, understood through Operations Science, modified for use in well production systems by our partner Strategic Project Solutions, and first applied in the year 2000 for unconventional field development near Bakersfield, CA.

Figure 3: Conventional Project Management compared with Project Production Management. Source: SPS

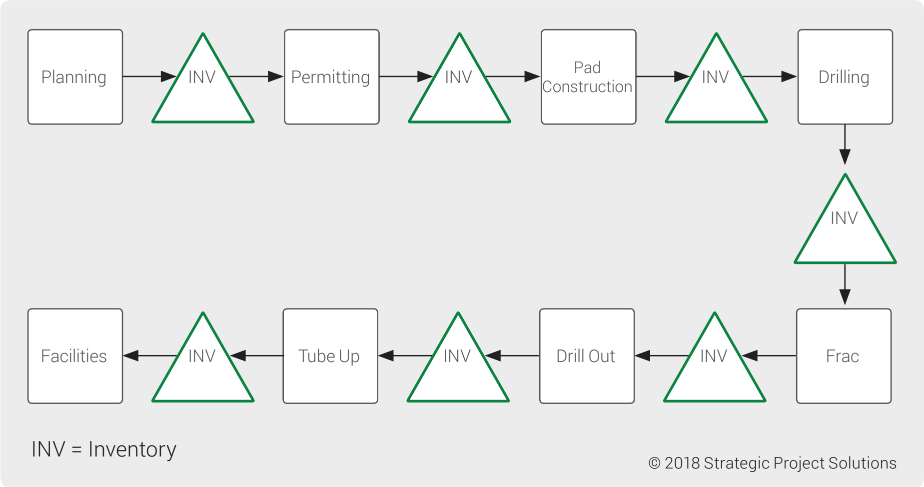


As seen above, Inventory, or Work-In-Process (WIP), and Variability, are absent in the prevailing approach to UC field developments, or if present, adopted without the consistent, integrated and systematized scientific framework and understanding necessary to unlock and capture the associated value.

The Impact of Inventory and Variability in the Well Production System

The concept of Inventory or Work-In-Process in the context of the Well Production System, as illustrated in Figure 4, simply adds focus on the partially finished work/raw materials in between the activities in Figure 1.

Figure 4: A Simplified Unconventional Well Production System



Simply stated, each operation in Figure 4 "supplies" its output to fulfill the "demand" of the input of the operation succeeding it. When supply and demand are misaligned, reflecting system variability and an absence of effective control on the execution of work, then inventory or work-in-process results between operations "waiting in the queue" for the succeeding operation to be ready to accept it, or the subsequent operation stalls waiting on supply from the prior operation, resulting in operational inefficiency. Optimal performance of the overall system is achieved by controlling to the ideal level of WIP within a production system supported by efficient workflow design, effective use of capacity and inventory to absorb beneficial variability and relentless removal of detrimental variability.

Systematic adoption of PPM enables owners to address variability, optimize system inventory or WIP and as a result reduce cost, cycle time and cash require to run the well production system.

Figure 5: Examples of Operating Variability and WIP levels in UC Development

Field A – Cycle Time/Operation Days – Variability

	Ave	Low	High
Planning	96	62	210
Permitting	19	0	81
Pad Construction	30	12	51
Drilling	47	10	164
Frac	44	26	117
Drill Out	9	3	27
Tube Up	8	3	23
Facilities	23	11	41

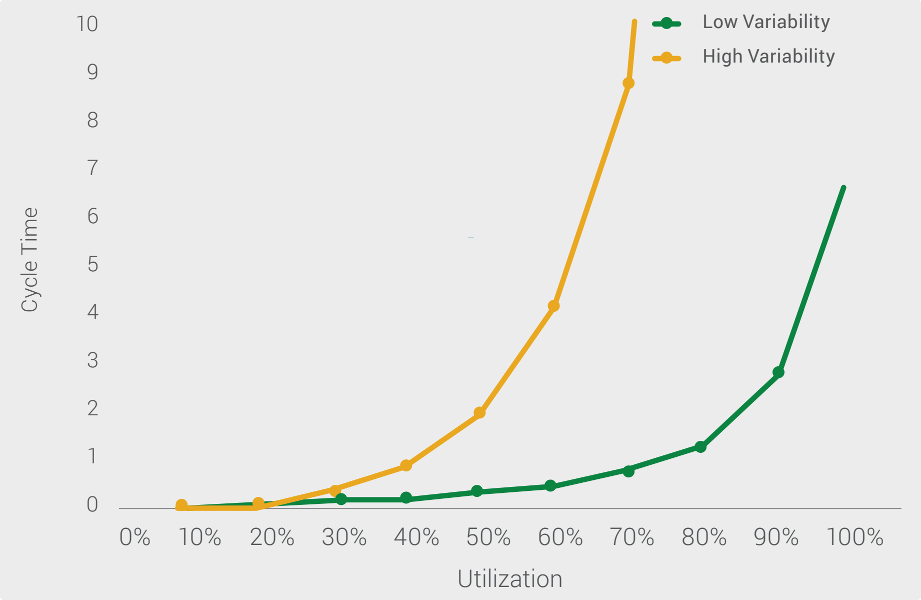
Field A – Cycle Time/WIP Days – Variability

	Ave	Low	High
Planning/Permitting*	21	18	35
Permitting*/Pad Construction	29	6	85
Pad Construction/ Drilling	77	5	201
Drilling/Frac	68	5	190
Frac/Drill Out	14	1	54
Drill Out/ Tube Up	12	1	45
Tube Up/ Facilities	-75	-177	-15
Facilities/Put on-line	71	13	196

Figure 5 takes the process flow illustrated above and shows an example of the levels of variability within a typical well production system using the prevailing approach to onshore field development. In the tables, variability is shown both in the operations (operating days) and between the operations (WIP days). The high levels of variability shown are a mixture of designed in variability (such as different pad size, number of wells, etc) and manifestation of the inefficiency and lack of control of the prevailing approach.

The impact of variability on cycle time and utilization in the well production system can be expressed mathematically as an application of Operations Science. Figure 6 is a graphical depiction of the impact of this equation.

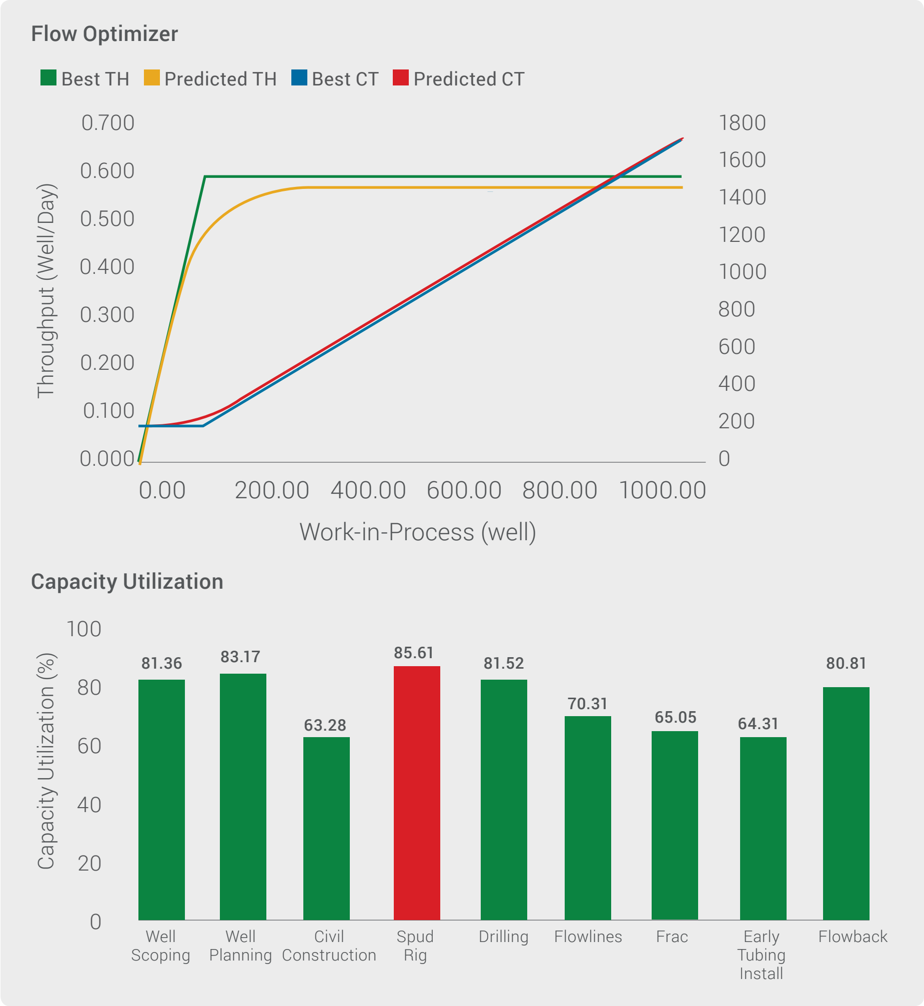
Figure 6: Impact of Variability and Capacity Utilization on Cycle Time for A Given Production System



As a whole, UC well production systems are high variability systems. As shown in Figure 6, attempts to drive up operational utilization with the aim of increasing throughput, and/or reducing cost or cycle time, unconsciously and directly increases the cycle time of that operation. In practice, a system 'under control' with lower utilization and even 'idle time' for individual operations, will be lower cost, offer quicker end-to-end cycle time and consume less cash than a system where owners attempt to run every operation at 100% utilization. This can seem counterintuitive to many in the industry who have been trained and often incentivized to pursue high utilization for their individual operation and, in turn can be challenging to accept that their prevailing belief of the 'right thing to do' has had the unconscious consequence of degrading overall well production system performance.

Through a science-based and rigorous system for real-time optimization of the well production system, PPM can overcome these barriers and enable rapid implementation of new capabilities as well as higher levels of performance.

Figure 7: Impact of Variability and Capacity Utilization on Cycle Time for A Given Production System



The output shown in Figure 7 shows a well production system operating under PPM. The top chart shows Work in Process. The operational approach bottleneck can be seen on the bottom chart, the SPUD rig shown in red. This approach to system modelling and optimization, combined with operational control, enables dynamic optimization for business objectives in real time.

To note, in order to successfully implement a transformative process such as PPM there are considerations that must be addressed both within the organization and with suppliers and partners. Due the breadth of the PPM solution, a change management program, including a comprehensive communications plan outlining the reasons for and benefits of the change, is key to successful implementation. Other considerations, after or during implementation of the PPM solution, may be to address organizational structure and make an assessment of the capabilities of internal resources, as well as workflow processes, data management processes and training requirements. Optimal performance of the overall system is achieved by controlling to the ideal level of WIP within a production system supported by efficient workflow design, effective use of capacity and inventory to absorb beneficial variability and relentless removal of detrimental variability. Many of these can be addressed once the system is operational and the value capture is under way. This change management program must be clearly defined and communicated from upper management prior to the start of any implementation. The ultimate success of the integration and sustainability will depend on the successful execution of the program.

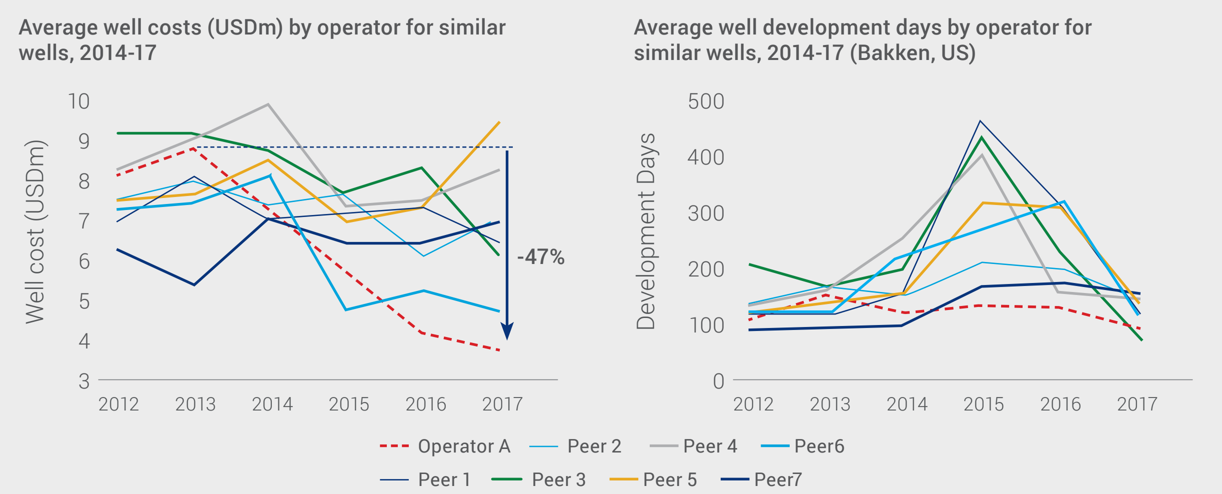
Conclusion – It is time for new capabilities and for the next era of performance improvement – the application of Project Production Management, an operations science-based approach to UC field development – the time to act is now.

The case is clear that there is significant additional value that can be derived out of the UC development process. Our analysis has highlighted the potential for cost reduction and release of cash through optimization of work in process. This is before one even starts to tackle the complexity created by multiple completion designs and revisions during planning and permitting.

As can be seen in Figure 8 in an example from the Bakken, the adoption of PPM drives disciplined, controlled and systematically relentless performance improvement. The ~47% cost reduction and controlled cycle time benefits relative to peers are visible across the rapidly changing business environment and activity levels through 2013-2017. In addition, the underlying control and resulting agility offered by the PPM framework facilitates both the 'ramp down' and 'ramp up' of activities in response to business cycle and exteral factors. This ability to deliver predictable and sustained cost and cycle time improvement during an unstable economic environment contrasts with the chaotic and unpredictable performance of peer companies.

The benefits of this agility and the ability to rapidly respond to factors, both positive and detrimental, outside of the owner's control is a minimum stakes expectation in other producing industries and should be for UC development.

Figure 8: Cost and Development Days Impact of Project Production Management (PPM)



This analysis uses wells in the same play and with similar physical characteristics including:
• Well vertical depth of 9-12k ft • Well lateral length of 8-11k ft

Source: NAWAT Tool, WoodMackenzie analysis. Note: There is not enough information available for 2018

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