KEY CONTRIBUTION & INTEGRATION OF NOVEL DIGITAL TOOLS FOR OFFSETS ANALYSIS, MONITORING & OPTIMIZATION IN LATERAL WELLS

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Abstract

In upstream Oil & Gas industry a digital tool is any software, program or application that may support the delivery of a well. In well engineering there had been a lot of advancement into complementing these tools to get a digital twin of the correlations & target well. This case expanded the use of offset analysis & drilling engineering software for unconventional drilling pads. A software environment for holistic well construction modeling & simulation in job planning & execution, aiming to interact between several areas involved for risk mitigation & performance optimization. Plus accompany by cloud platform integrating real time software providing advanced analytics.

Within the well engineering software, the Data Management Solution (DMS) option was employed. All data of the project was centralized in one auditable environment, providing a single source of data. As opposed to working in a single solution, DMS enables worldwide collaboration between teams from different disciplines & allows for sharing data at all stages of the project. On this occasion, a multidisciplinary team collaborated from diverse locations around the world such as Argentina, Ecuador, Mexico & United States of America.

The case involved planning & executing production sections of extended-reach drilling (ERDs) pads in unconventional land Argentina, building meticulous offset digital twins for the analysis of drilling conditions & proposals of multi services solutions & technologies, that supported in the outcome of improving performance results, reducing non-productive & invisible loss time. Achieving several wells in the top-5 of ROP & delivery time for the field. Complemented with a deep statistical breakdown of well events, identifying opportunity areas & zones of risk prevention.

The use of all the digital tools together, with a detailed build of field data into the software & supported by DMS, is a novel implementation into the region, that served as the baseline work for next jobs in shallow water Argentina & shallow water Mexico to apply the lessons learned here from all these applications.

Introduction

The upstream oil and gas industry continues to face increasing complexity in well construction, particularly in unconventional plays where extended-reach drilling (ERD) and lateral well development are standard practice. In this context, the integration of digital technologies has emerged as a critical enabler for enhancing operational efficiency, reducing non-productive time (NPT), indentification of Invisible Lost Time (ILT) and improving decision-making across the well lifecycle. Digital tools that facilitate real-time data acquisition, centralized data management, and advanced analytics are transforming traditional workflows, enabling multidisciplinary teams to collaborate more effectively and respond dynamically to operational challenges. As the industry seeks to optimize performance under increasingly constrained economic and environmental conditions, the adoption of digital solutions in well engineering is not only advantageous but essential.

The Oil and Gas Industry, from Service Providers to Operators are expanding the digital transformation by incorporating into their analysis frameworks the use of digital twins which leverage in the data aggregation and workflows to enable deeper insights (Bourne, 2024).

The primary objective of this study is to demonstrate the application and impact of an integrated suite of digital tools designed to enhance the planning, execution, and post-analysis of lateral wells in unconventional drilling environments. By leveraging centralized data management, real-time monitoring, and offset well digital twins, the initiative aimed to improve drilling performance, reduce operational variability, and establish a scalable approach for future developments. The case study focuses on production section of ERD pads in Argentina, where a multidisciplinary team employed these technologies to optimize well delivery and identify performance improvement opportunities across multiple assets.

Extended-Reach Drilling (ERD) refers to a form of directional drilling where the horizontal displacement (or step-out) of the wellbore significantly exceeds its vertical depth. Typically, a well is classified as an extended-reach well (ERW) when the ratio of measured depth (MD) to true vertical depth (TVD) is 2:1 or greater. ERD enables operators to access distant reservoir targets from a single surface location, thereby reducing surface footprint, minimizing environmental impact, and optimizing field development economics. The technique is particularly valuable in offshore and environmentally sensitive areas, where infrastructure constraints or surface access limitations exist (Kenupp, 2017).

This study focuses on the application of digital technologies to optimize the planning and execution of lateral wells in unconventional reservoirs, specifically within ERD pads located in the Neuquén Basin, Argentina. The scope encompasses the integration of centralized data platforms, real-time monitoring systems, and offset well digital twins across two pads drilling campaigns, focusing on the 6.75in section (0.1714 m) which drilled more than 50% of each well encompassing the vertical, curve and lateral. First run for Vertical & Curve with motor and M/LWD (Measurement While Drilling (MWD) and Logging While Drilling (LWD)), second run for Lateral with RSS (Rotary Steerable System) and M/LWD. The initiative involved collaboration among multidisciplinary teams from various geographic regions, including engineering, geoscience, and operations personnel. The digital framework developed during this project was designed to be scalable and adaptable, with the intent of replicating its success in other operational contexts, including shallow water developments in Argentina and Mexico.

The integration of digital technologies into well engineering has been a focal point of industry research over the past decade. Despite these advancements, gaps remain in the consistent application of digital tools across diverse operational settings. Many implementations are limited to pilot projects or specific well types, with scalability and integration across services still posing challenges. Furthermore, few studies have documented the application of digital twins and centralized data management in Latin America.

Development

Digital Tools and Software

The digital framework implemented in this study was based on the use of several tools. A Well Engineering software, for comprehensive well planning and engineering platform. With the Offset Analysis capability make informed planning decisions based on historical data in the shortest possible time and with highest certainty of outcomes and Integrated modeling and simulation for well construction applications that minimizes drilling risk, delivers optimal results, and enables rigsite service automation.

A key component of this system is its integrated data management solution (DMS). It enabled all data and projects are centralized in one auditable environment, providing a single source of truth. As opposed to working in a single local file, DMS enables worldwide collaboration between teams from different assets and disciplines and allows for sharing data at all stages of the project, i.e. input data, intermediate and final results. With the DMS user-level security settings, the access level of each user to the data, and the actions each user can perform, is secured.

DMS can store domain objects (e.g. wells, logs, etc.). Being able to track changes of all domain objects enables you to work closely with project teams and provides you with an overview of the decision making process (Figure 1). This feature enabled the seamless work in the project with personnel across the continent (Argentina, Ecuador, Mexico & United States of America).

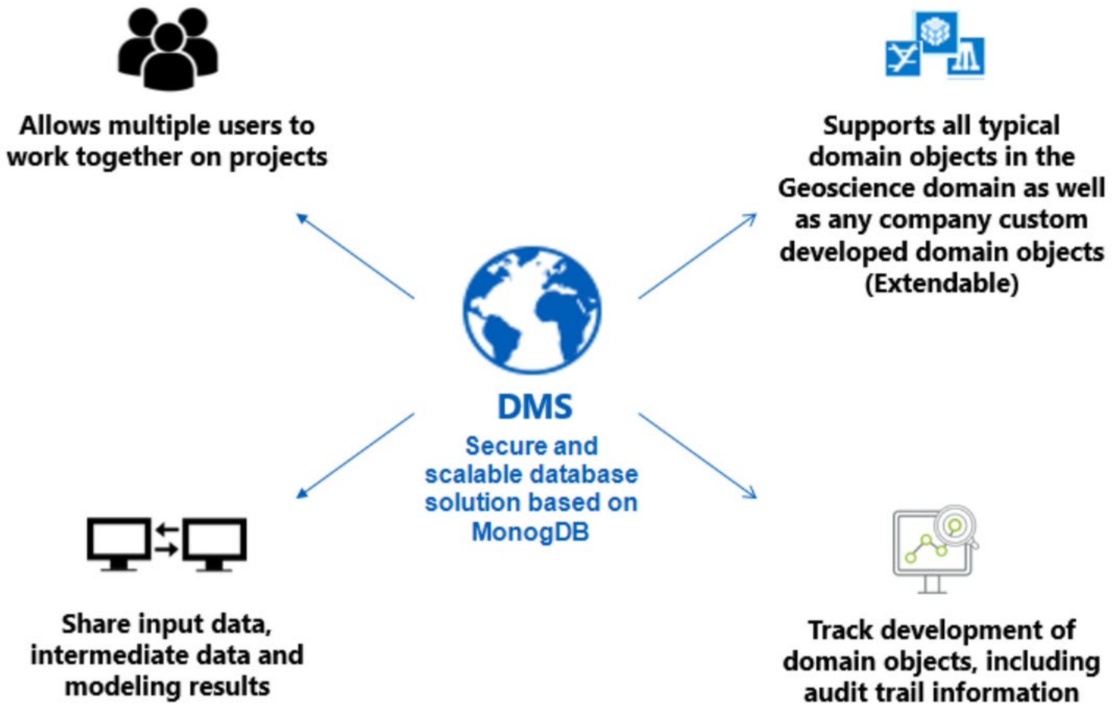

Figure 1 DMS software features

Other digital tools used were the web-based delivery of advanced visualization and analysis capabilities for real-time data, data aggregation and visualization solution. The web-based interface graphically integrates any type of WITSML (well-site information transfer standard markup language) data from diverse sources. Plus a cloud-base platform that provided analytics and data-driven insights that empower informed decisions in real-time via mobile and web.

Data aggregation, standardization, and analysis of engineering and operational data across the well lifecycle was enable with the integration of these tools. The platforms supported the incorporation of offset well data, real-time drilling parameters, and historical performance records into a unified environment. Engineering modules within the software were used for torque and drag analysis, and mechanical risk evaluation, facilitating iterative optimization during the planning phase.

Data Management

At first stage data was collected from hystorical data sets, from previous pads near the reference two future pads that were going to be planned and executed. These datasets were validated and imported. The centralized data environment enabled rapid access to high-resolution information, which was used to construct offset well digital twins. These digital representations were employed to simulate expected drilling behavior and assess operational scenarios, supporting proactive planning and risk mitigation. The selection of best offsets to construct this was key, some considerations were similar well schematics, trajectory, direction, similar strategy of drilling, etc.

The project was executed through a multidisciplinary collaboration involving drilling engineers, applications engineers, geoscientists, and data analysts across multiple regions. The digital environment provided by the engineering platform enabled remote collaboration through shared dashboards, real-time analytics, and engineering models. Operational oversight was maintained via virtual monitoring centers, where subject matter experts provided continuous support based on live data streams and predictive insights. This structure enhanced situational awareness and enabled a closed-loop feedback system between planning and execution. More over when each well of the target pads were finished, that data fed the digital tools for the forecoming wells.

To establish a consistent and structured approach to well planning, the team followed the OASIS process (optimization analysis services implementing solution), a standardized methodology designed to align multidisciplinary teams around a common set of planning principles and execution milestones (Figure 2). This process emphasizes early integration of subsurface and drilling data, iterative scenario evaluation, and continuous feedback loops between planning and operations. The approach has been previously documented as an effective framework for improving well delivery performance (Redshaw, 2007), (Al Dabyah, 2016).

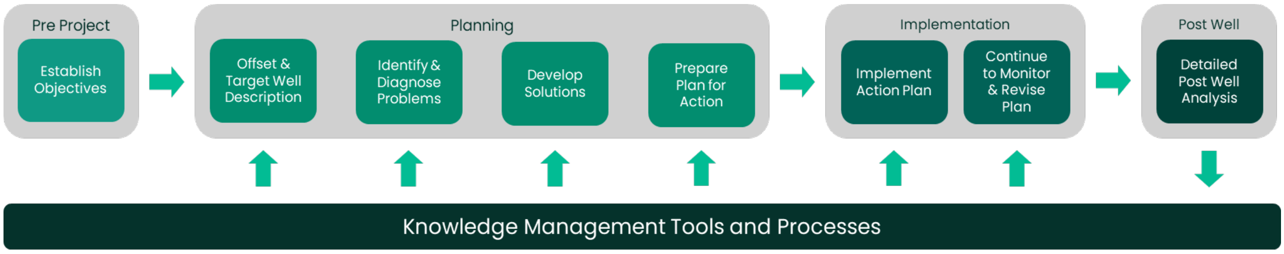

Figure 2 Structured approach to well planning, OASIS process, a standardized methodology designed to align multidisciplinary teams

Case Study

The project involved a field were the bits and directional drilling tools had previously experienced, but it was the first introduction of the drilling fluid into the region. The digital twin offset analysis was built with 4 previous pads (Pad A, Pad B, Pad C, Pad D; the C & D being the best offset due to similitudes in well schematic, lenghts, trajectories, rig used and recent performance), for a total of 20 horizontals wells plus 1 vertical exploratory. The first target plan pad was “Pad Target E” with 5 wells drilled to south direction. After executing it, the rig was going to move to the second target plan pad the “Pad Target F” with 6 wells drilled to north direction (Figure 3). The target was the unconventional shale formation of Vaca Muerta, each well at an expecific layer. The study focused only on the 6.75in (0.1714 m) production section of each well, which involved majority and more demanding part of the wells (more than 50% of the lenght drilled, plus directional work).

The planning process also incorporated lessons learned from previous campaigns, enabling the identification of high-risk intervals and the proactive design of mitigation strategies. Leveriging the past experience of bits, directional drilling tools and reservoir geomechanics expertise to optimize the learning curve of fluids. During execution, real-time data streams from rig sensors were monitored through a remote digital environment. Drilling parameters were continuously compared against offset well digital twins to detect deviations and optimize performance. The integration of engineering models with live data enabled rapid decision-making and reduced the need for reactive interventions.

These digital models captured key drilling behaviors, including rate of penetration (ROP), torque and drag trends, and vibration signatures. By benchmarking real-time performance against these digital twins, the operations team was able to identify anomalies early and adjust parameters accordingly. The use of digital twins also facilitated post-well analysis, allowing for the refinement of planning assumptions and continuous improvement across the drilling campaign.

The project took advantage of the integrated multiple service domains alligning efforts and expertise executing solutions addressing all the challenges with a holistic approach to risk mitigations, in a deep collaboration with all parts involved from rig, service companies and operator. This approach was particularly effective in managing the complexity of ERD wells, where coordination across disciplines is critical to success.

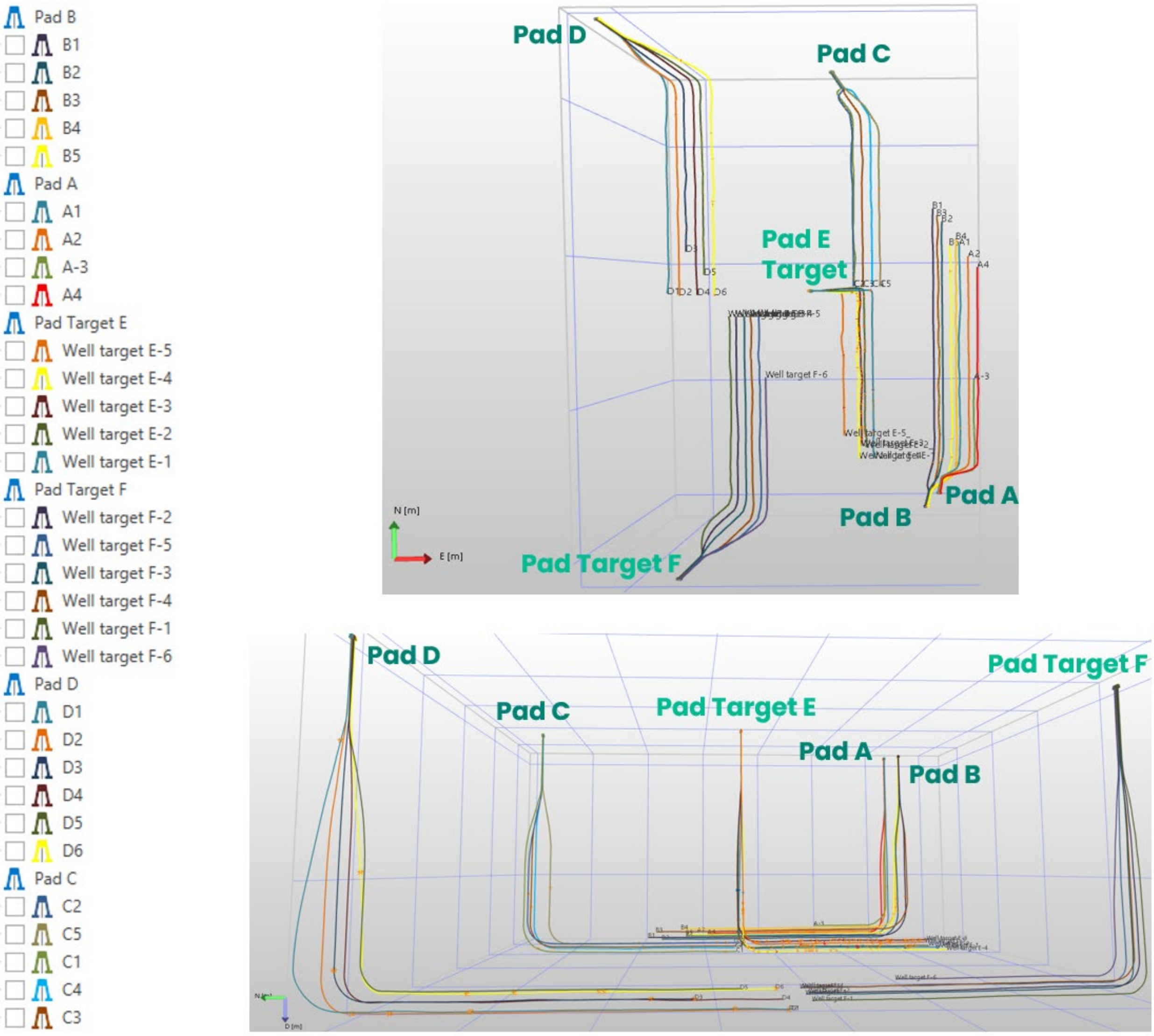

Figure 3 Data base of Pads

The strategy to execute the section was 2 runs, both with PDC (polycrystalline diamond compacts) bits. First run to drill Vertical and Curve with motor BHA (bottom hole assembly). Second run with RSS BHA to continue the lateral until the TD (total depth). In the Figure 4 a resume of the bits implemented in the target pads. Depending in the layer to be drill the selection varied. For Motor runs the DD405 offered consistency in previous experience in field passing through Quintuco formation and landing in Vaca Muerta, and the DD405W offered anti-walk feature, useful to continue drilling laterals with motor (1 outliyer case on 2nd target pad-F where this strategy was applied). For RSS runs the DD405VS offered consistent performance in previous experience in field for Organic layer (more interbedded, tends to have lower performance and more geosteering and vibrations & Stick Slip (VSS) events), similar case for DD505 but for Cocina layer (more homogenous, tends to have higher performance and more temperature as is deeper). In the Figure 5 & Figure 6 the visualize BHAs for each of the runs are represented. The motor output was 0.75 or 1 rev/gal depending available option.

The AKO (adjustable kickoff) was set to 1.8° to be able reaching the demanding BUR (build up rates) of planned trayectories (DLS, plan dog leg severities of approximately 8.6°/30m in curve).

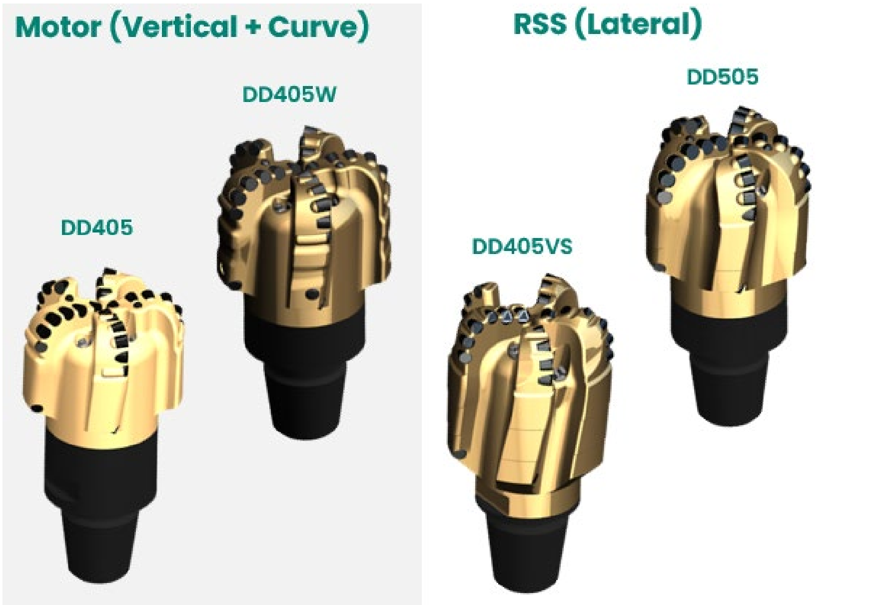

Figure 4 Bits used in target pad-E & target pad-F

#	Descripción	Compañía	Cantidad	Cuerpo			Conexión				Longitud	Longitud Total	Peso	Peso Flotado	Peso Flotado Total
				Max OD	OD	ID	Abajo	Arriba	OD	ID					
				in	in	in			in	in	m	m	lb/pies	tons	tons
11	DP	YPF	327		4 1/2	3.83	uXT40	uXT40	5 1/4	2 4/5	3048.00	3271.97	19.62	69.16	79.42
10	HWDP 4½" x 21	YPF	21		4 1/2	2.81	uXT40	uXT40	5 1/4	2 3/4	196.35	223.97	37.54	8.52	10.26
9	4¾ XO	YPF	1		4 3/4	3.00	NC38	uXT40			0.82	27.62	36.2	0.03	1.74
8	4¾ Filter Sub	BH	1		4 3/4	2.63	NC38	NC38			2.00	26.80	39.18	0.09	1.71
7	Prensa	YPF	1		4 3/4	2.25	NC38	NC38			1.16	24.80	45.46	0.06	1.61
6	4¾ Float Sub	YPF	1		4 3/4	2.25	NC38	NC38			1.15	23.64	43.93	0.06	1.55
5	Prensa	YPF	1		4 3/4	2.25	NC38	NC38			1.24	22.49	45.46	0.07	1.50
4	4¾ Float Sub	YPF	1		4 3/4	2.25	NC38	NC38			1.17	21.25	43.93	0.06	1.43
3	NaviGamma	BH	1		4 3/4	2.69	NC38	NC38			10.37	20.08	61.42	0.74	1.37
2	MDF DuraMax	BH	1	6 1/4	5 1/8	3.76	3 1/2 Reg	NC38			9.50	9.71	56.61	0.62	0.63
1	6¾"PDC	BH	1	6 3/4	6 3/4	0.00	0	3 1/2Reg			0.21	0.21	50	0.01	0.01

Figure 5 BHA plan example of Motor + MLWD run for Vertical+Curve

#	Descripción	Compañía	Cantidad	Cuerpo			Conexión				Longitud	Longitud Total	Peso	Peso Flotado	Peso Flotado Total
				Max OD	OD	ID	Abajo	Arriba	OD	ID					
				in	in	in			in	in	m	m	lb/pies	tons	tons
16	DP 4½	YPF	309		4 1/2	3.83	uXT40	uXT40	5 1/4	2 4/5	2902.70	6272.09	19.62	65.32	146.00
15	HWDP 4½" x 18	YPF	18		4 1/2	2.81	uXT40	uXT40	5 1/4	2 3/4	168.30	3369.39	37.54	7.25	80.68
14	DP 4½	YPF	336		4 1/2	3.83	uXT40	uXT40	5 1/4	2 4/5	3151.98	3201.09	19.62	70.93	73.43
13	HWDP 4½" x 3	YPF	3		4 1/2	2.81	uXT40	uXT40	5 1/4	2 3/4	28.05	49.11	37.54	1.21	2.51
12	4¾ XO	YPF	1		4 3/4	3.00	NC38	uXT40			0.81	21.06	36.2	0.03	1.30
11	4 3/4" Filter Sub	BH	1		4 3/4	2.63	NC38	NC38			1.85	20.25	36.2	0.08	1.26
10	Prensa	YPF	1		4 3/4	2.25	NC38	NC38			1.06	18.40	45.46	0.06	1.19
9	4¾ Float Sub	YPF	1		4 3/4	2.25	NC38	NC38			0.86	17.34	43.93	0.04	1.13
8	Prensa	YPF	1		4 3/4	2.25	NC38	NC38			0.93	16.48	45.46	0.05	1.09
7	4¾ Float Sub	YPF	1		4 3/4	2.25	NC38	NC38			1.13	15.55	43.93	0.06	1.04
6	4 3/4 NMSub Stop	BH	1		4 3/4	2.81	T2	NC38			0.81	14.42	39.11	0.04	0.98
5	BCPM	BH	1		4 3/4	2.81	T2	T2			3.27	13.61	57.1	0.21	0.95
4	STB Modular	BH	1	6 3/8	4 3/4	2.50	T2	T2			1.02	10.34	50	0.06	0.73
3	Ontrak	BH	1	5	4 3/4	2.50	T2	T2			6.15	9.32	65.32	0.46	0.67
2	AutoTrak Exact	BH	1	6 5/8	5	1.02	3 1/2Reg	T2			2.93	3.17	59.59	0.20	0.21
1	6¾"PDC	BH	1	6 3/4	6 3/4	0.00	0	3 1/2Reg			0.24	0.24	50	0.01	0.01

Figure 6 BHA plan example of RSS + MLWD run for Lateral

The fluid strategy for the production section was a low pressure impact drilling fluid of oil base mud (OBM) designed to extend the critical drilling window. The non-aqueous fluid aimed to optimize hole cleaning with control viscosity at different depths. It also avoids sag by keeping solids suspended even when pumps are off. In addition, the fluid prevents pressure spikes at startup and surge pressure during casing runs to avoid fractures and mud losses. On top of the base fluid, wellbore streghtening products were advised, enhansing stability of the hole and sealing off weak formations. Developed from a designed nanotechnology formulation, the wellbore sealing solution delivers superior wellbore integrity when drilling through sensitive shales formations. Another factor noted from offsets analysis well events, was the importance of an optimal solid control equipment. During the execution, not only a precise control of mud properties was carry out, but also recommendations, audits and improvements to the solid control equipment. In the Figure 7 is represented the general resume example of mud properties.

Properties		(OBM)
Length	m	2327 - 6296
Density	g/l	1800
Marsh Viscosity	SEG 1/4gal	50-65
Plastic Viscocity	cP	20-35
Yield Point	lbf/100ft^2	7-14
Yield Stress	lbf/100ft^2	6 - 8
Gels (10s / 10min)	lbf/100ft^2	6-12 / 12-20
Filtrate HTHP (300 °F-500 psi)	Cc/30 min	<6
Oil Water Ratio (OWR)	-	90-95 / 10 - 5
ESTABILIDAD ELECTRICA	V	>750
Water Phase Salinity (WPS)	Ppm	190000 - 220000
Drilling Solids	%	<5
Excess Lime	kg/m^3	>7

Figure 7 Baseline resume example of mud properties

Integrate with bits, drilling tools and drilling fluids, the geomechanics team enhanced the analysis providing their inputs evaluating the offset wells events in pro to select best mitigations actios to reduce drilling risk. It complemented with real-time data and geomechanical modeling that delivered insights during drilling operations. Drilling pressure management, by pore pressure and ECD monitoring, and wellbore risk management, by proactive decision-making through daily diagnostics and risk mitigation recommendations, particularly valuable in narrow-margin or extended-reach wells. By introducing formations tops, the software then can create horizons across the field (Figure 8), then synthetic or pseudologs can be create to plan trajectories. Previous well events were loaded into the digital twin, to considere what could happen and when/where. Plus in real time updating the events of target wells correlating to hystorical data, which provided an stadistical view of the operations (Figure 9).

Other capabilities of the digital offset analysis is build well views templates showcasing data in depth with the curve that the user customize (formation logs, parameters, vibrations levels, etc.), plus the well schematic, formations tops, well events and hyperlinks in case wants to attach a file. In the case this enble intuitive comparisons for quick decisión making, build of parameters roadmaps or analysis. (Figure 10).

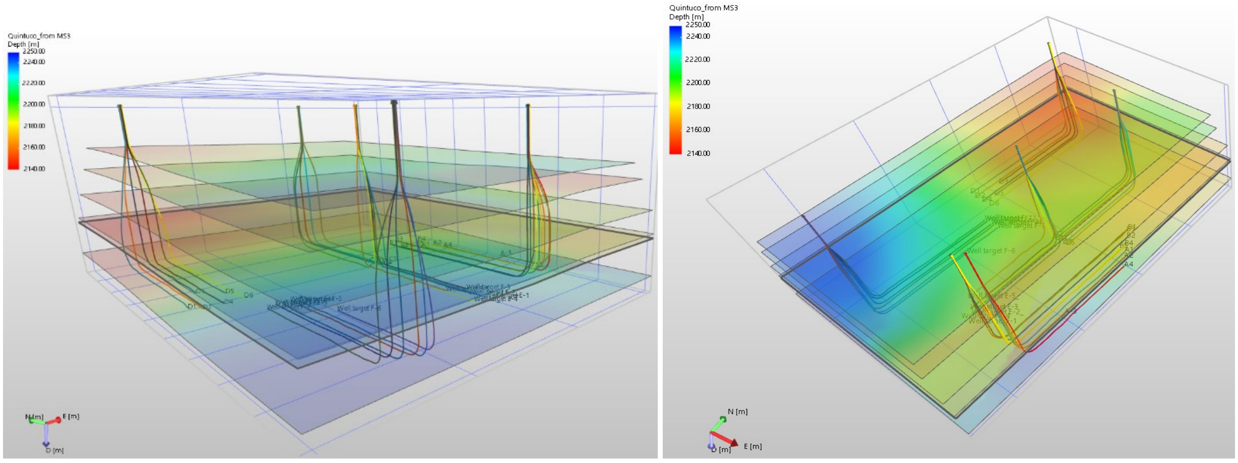

Figure 8 Field data with formations tops horizons (color code indicating shift in depth of top)

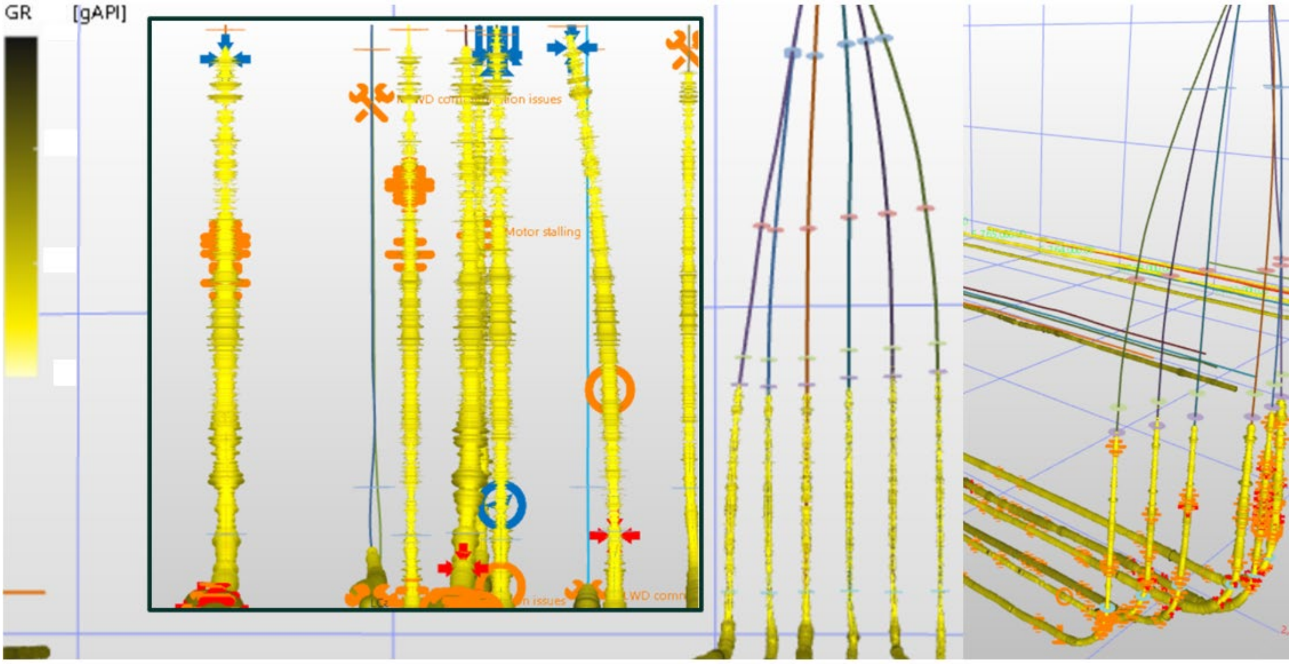

Figure 9 Well events example loaded into the software, plus feature of graphicating and correlating 3D log of Gamma Ray

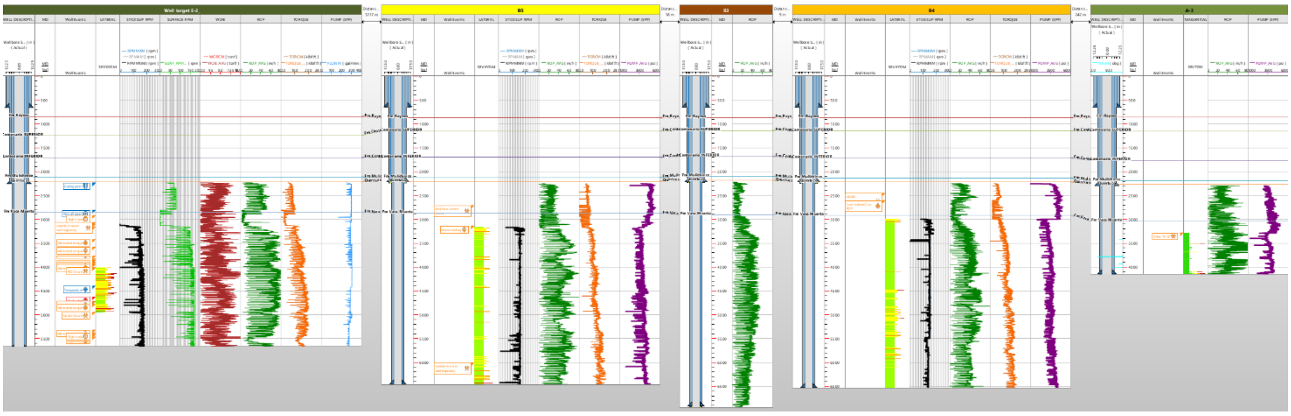

Figure 10 Offset well templates views

An example in the Figure 11 of building synthetic pseudologs with the software from the offset data. This estimation give an overview of what to expect. During execution real data can compared. The curve that were simular to reality were influence by selecting the appropiate source data.A critical factor were distance, target formation layer and similar well schematic (bit diameter).

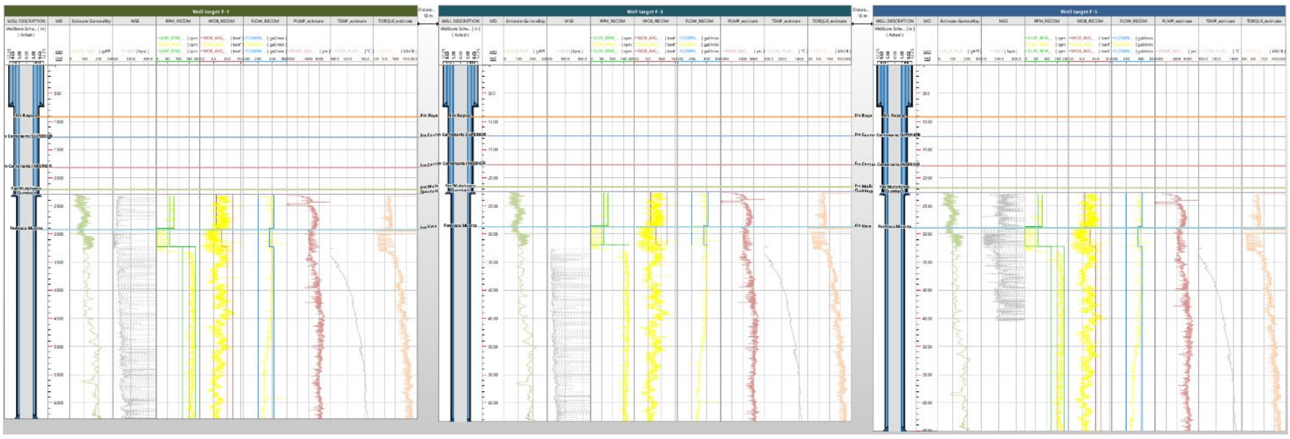

Figure 11 Example estimated pseudologs for target wells (F-1, F-3, F-5) with recomended drilling parameters envelops

In the digital ecosytem, now in the geomechanics application, an analysis of offsets events recorded during the drilling of these wells was conducted to understand the geological context of the area in terms of operational risks, as well as to identify poor drilling practices in these wells. This information aims to reduce the likelihood of undesirable events occurring in future operations. Finally, a list of drilling challenges was compiled based on these reference wells, which includes: Tight hole (tripping in/out), influx, stuck pipe, high torque, gas, partial and total losses sorted by occurrence (Figure 12). With the data sets (trajectories, logs, drilling events, calibration data, etc.) a geopressure profile was generated (defining the operational window limits, Figure 13) through a structured workflow. This workflow includes steps such as: lithology definition, log analysis, rock mechanical property estimation, overburden gradient, pore pressure interpretation, fracture gradient and collapse pressure estimation. Typically, only exploratory wells contain sufficient data for accurate geomechanics modeling; therefore, for the target PAD E, a well (Well X-1) located farther from the correlation PADs was used. It is important to note that Managed Pressure Drilling (MPD) is employed during the drilling of the target formation due to the extremely narrow operational window.

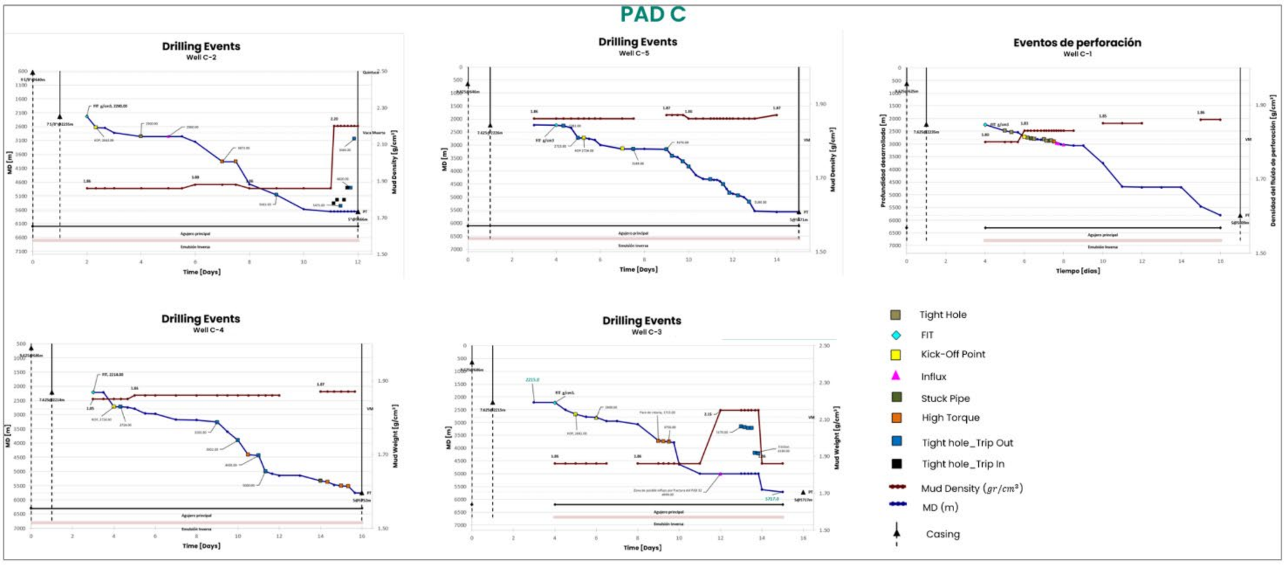

Figure 12 Offsets events example Pad C in days vs depth view

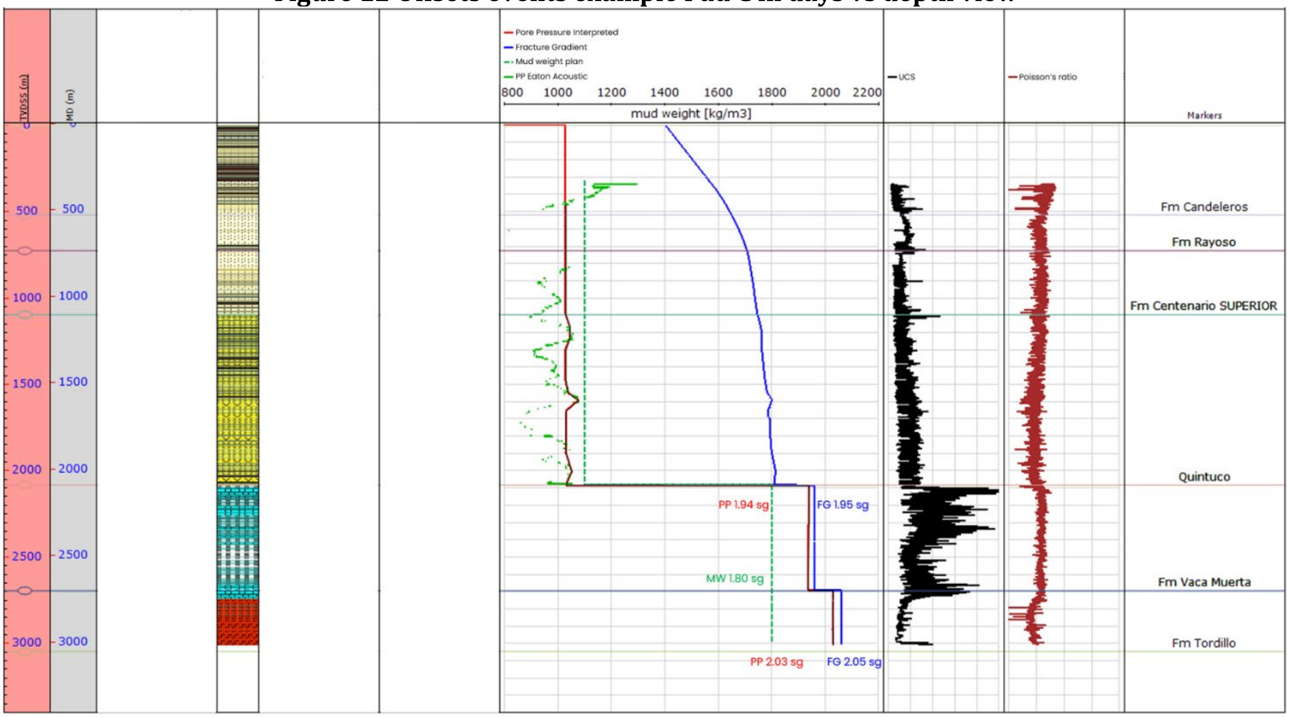

Figure 13 Geopressure profile estimated for field (mud operational window)

For real time (RT) monitoring and data agregation examples of other digital platforms were used accesible via cloud base or internet. In the next Figure 14 example of the templates and dashboards that were taken applied.

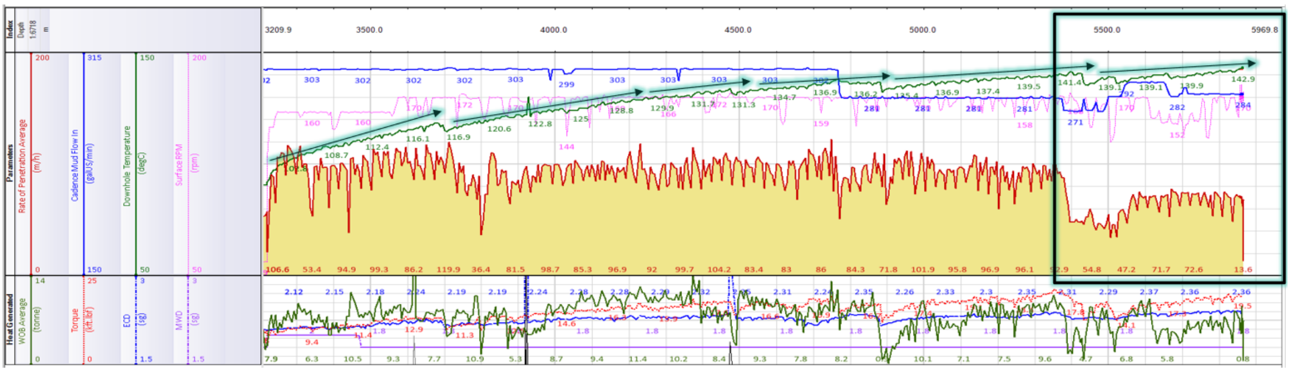

Figure 14 Template addressing temperature behaviour while adjusting parameters to mitigate its increase and effects on rate f penetration (ROP)

In Figure 15 are examples of other visualizations of cloud applications addressing well performance development, with days vs depth graphs, ROP (rateo of penetration) performance per day and per crew (day and night), rig activities discretize (combine and separate by crew day and night), graphic plan trajectory vs real trajectory. ROP heatmap parameters recomendation and drilling times (example with weight to weight times of connections)

In Figure 16 other examples of visualizations templates focus on optimization and hazard avoidance, with parameter comparison graphs, customizables crossplots. Motor dedícate application targeting toolface vs measure depth which provide information about the accuracy of each slide drilling stand, enable reaction in case of erratic toolface or confirming the good operation. Finally broomstick plots that automatically generates take the reference weights and compare with models, this trend analysis gave additional inputs while addressing hole quality (example with hookload and a tripping operation).

Figure 15 Dashboard with examples applications addressing well performance development

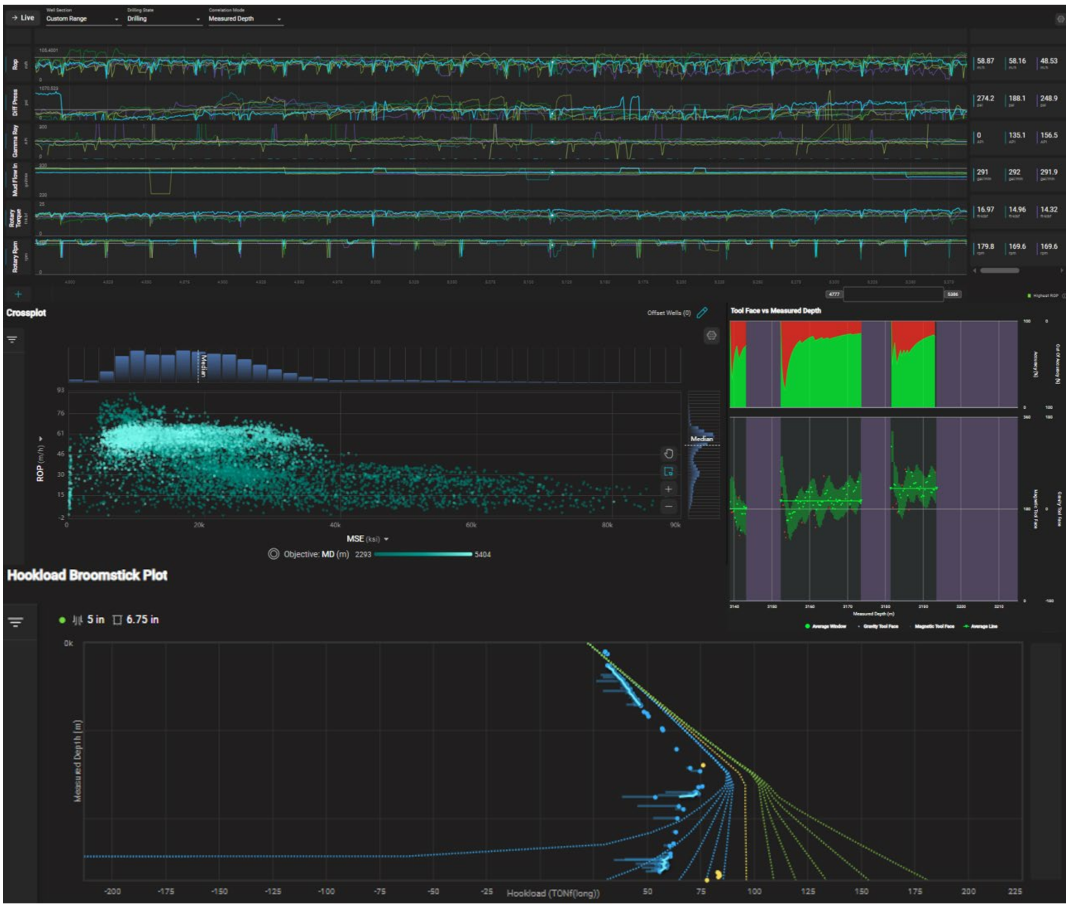

Figure 16 Dashboard with examples applications addressing optimization

The benchmarking with the digital tool gave an extra layer of depth, by not only comparing bit runs, dull grade or average ROP, now adding the possibillity in a performance chart to compare with any data acquire, such as ROP per depth, drilling parameters per depth, downhole sensors like temperature or formation evaluation or vibrations (Figure 17).

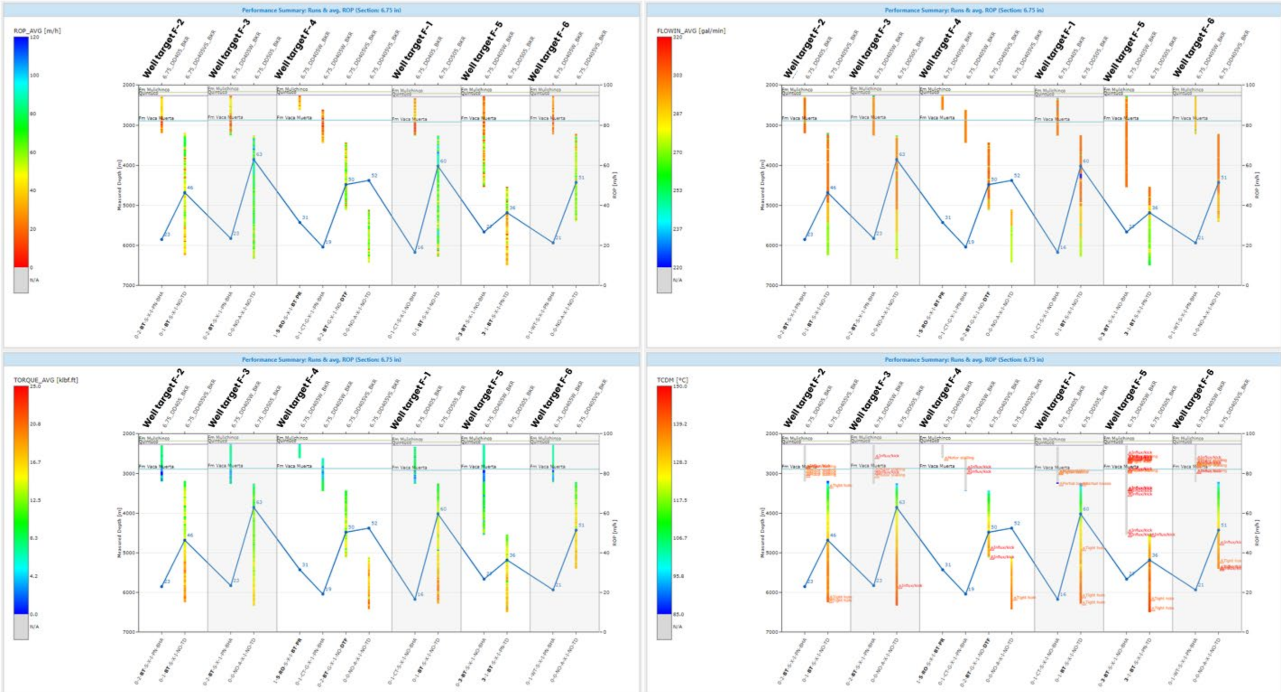

Figure 17 Benchmarking with the digital tool

Real time geomechanics follow up was implemented to monitor the well drilling process, issue alerts regarding potential risk events. The Figure 18 exemplifies the monitoring of Well Target F-6. Multiple operational parameters, events, and key notes are displayed, including MPD readings and fluid losses, which are used to calibrate the operational window. A summary of drilling operations, drill string and casing running operations. In the case of a stuck pipe incident, an analysis is performed using a decision matrix to determine the most probable sticking mechanism and to implement the best possible mitigation practices.

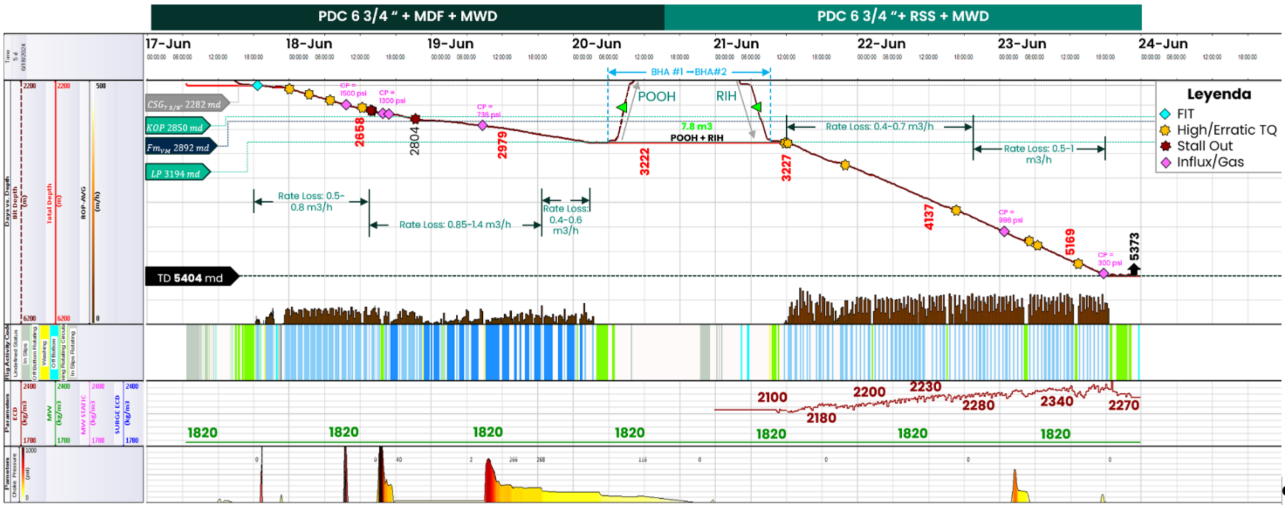

Figure 18 Real time geomechanics follow up example Well Target F-6

Results

A comprehensive statistical analysis was conducted on the operational data collected from the 2 targets pads. Key performance indicators (KPIs) were benchmarked against offset wells. A database was progressively developed to evaluate various aspects aimed at improving the performance of each well. This process enabled the accumulation of quantifiable experience in the area, particularly regarding geological risks and best/worst drilling practices (Figure 19 & 20).

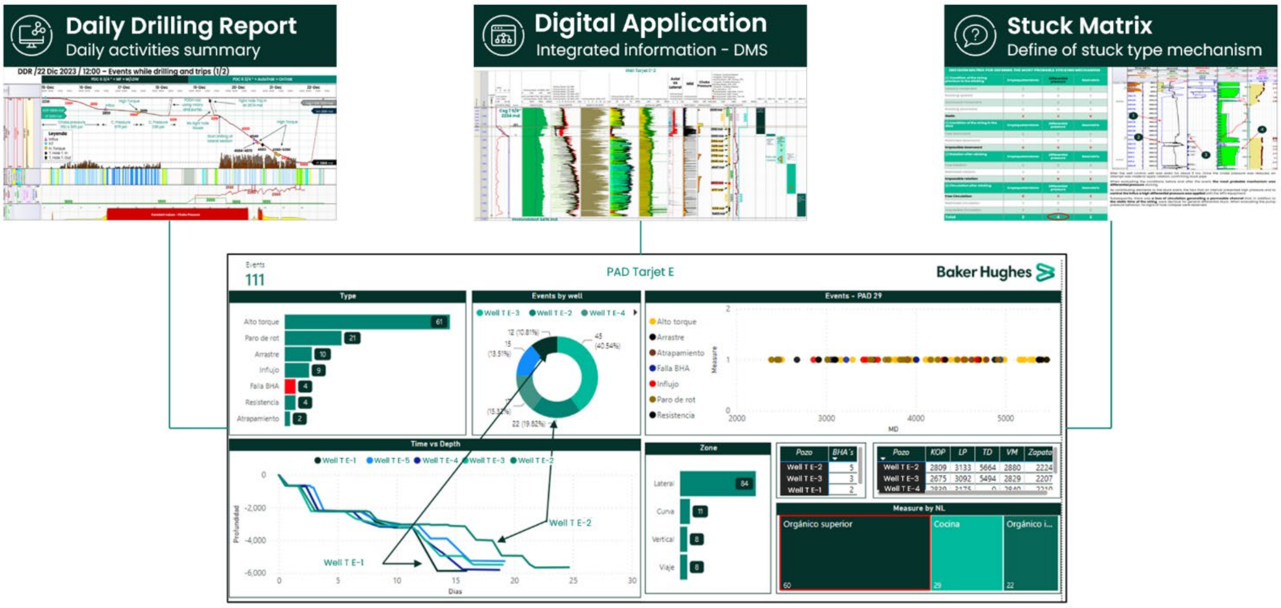

Figure 19 Data input for Data Analysis (PAD Target E)

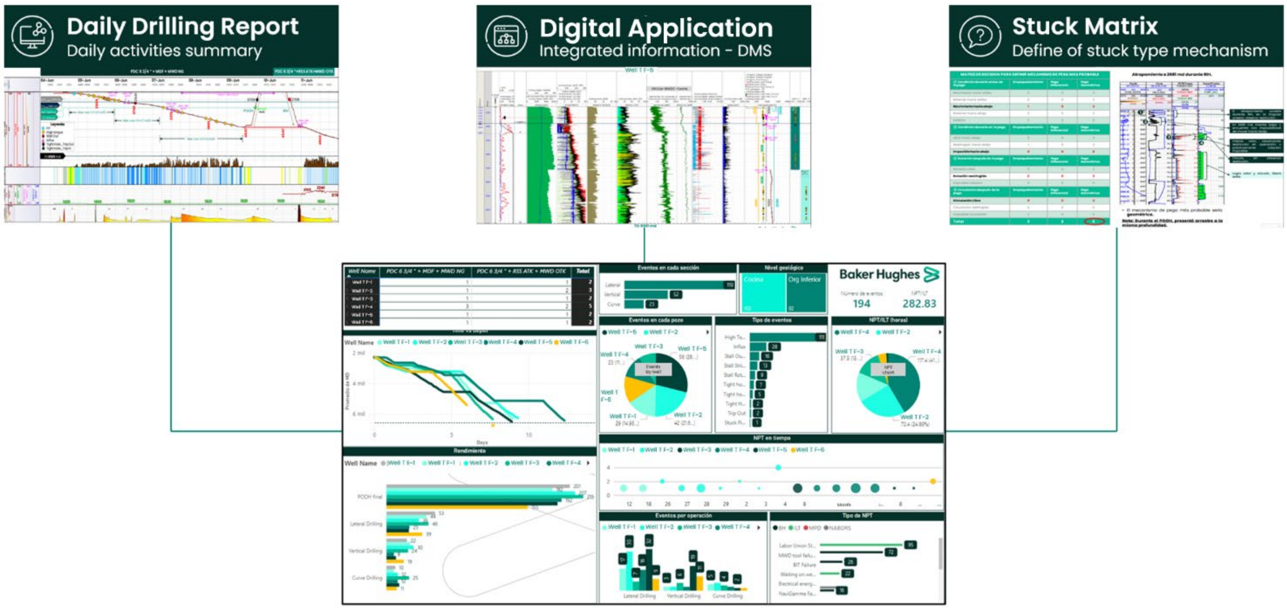

Figure 20 Data input for Data Analysis (PAD Target F)

In general, the most relevant aspects for each PAD from a data analysis perspective are:

PAD Target E:

- Well Target E-1 had the lowest number of events (12) and the best time vs. depth of the pad.
- Well Target E-2 had a high number of events (22) and the worst time versus depth due to 3 BHA failures.
- Organic Superior Formation (geosteering level) had the highest occurrence of events related to: High torque, influx, stuck pipe, tight hole and partial losses.

- 81.5% events occurred in lateral section.
- 10.5% events occurred in curve section.
- 8% events occurred in vertical section (started at +/- 2200 md).

PAD Target F:

- Well Target F-3 had the lowest number of events (7) and the best time vs. depth of the pad
- Well Target F-5 had the highest number of events (33) and the lowest ROP performance due to different plannified strategy of drilling by extending the use of motor BHA 1 into the lateral. Because this strategy this is an Outlyer well/more difficult scenario, and still got Good comparable results in ROP and times to wells of previous pads.
- Geosteering levels were similar in events related to: High torque, influx and tight hole. 102 Cocina and 92 Orgánic Inferior.
- 61.3% events occurred in lateral section.
- 26.8% events occurred in vertical section (started at +/- 2200 md).
- 11.8% events occurred in curve section.

From the geosteering level perspective, analysis focuses solely on the lateral section, where quantitative correlations are observed in the behavior of Gamma Ray and Rate of Penetration. These may be associated with either a homogeneous formation (characterized by high GR and continuous behavior) or a formation with numerous interbeddings (characterized by low GR and discontinuous behavior).

Cocina layer (Figure 21):

- Well Target F-3: 62.84 m/h; GR Very High; Continuous GR curve; 7 events (6 High T, 1 Influx).
- Well Target F-1: 49.5 m/h; GR Medium-High, Continuous GR curve; 17 events (12 High T, 5 Stall Rot).
- Well Target F-5: 35.17 m/h; GR High; Non-continuous GR curve; 32 events (21 High T, 6 Influx, 3 Stall Rot, 2 Tigh hole). Note: BHA Motor drilled a part of lateral section, Outlyer well/more difficult scenario and still got good comparable results.
- PAD Target E (Well Target E-1): ROP 81.84 m/h; GR Very High; Continuous GR curve.
- Well Target F-3 show the best performance of the PAD Target F, sharing similarities with Well Target E-1 in GR behavior and low number of events

Organic Inferior layer (Figure 22):

- Well Target F-6: 50.69 m/h; GR Medium-Low; Continuous GR curve; 11 events (5 High T, 3 Stall Rot, 3 Influx).
- Well Target F-4: 49.43 m/h; GR Medium, Non-continuous GR curve; 16 events (9 High T, 5 Stall Rot, 1 Influx, 1 Tigh hole).
- Well Target F-2 46.1 m/h; GR Low; Non-continuous GR curve; 30 events (23 High T, 5 Stall Rot, 1 Influx).
- PAD E (Well Target E-2): ROP 49.98 m/h; GR Very low.
- The 3 Wells for PAD F were similar, with small differences in ROP, which is consistent with the number of events.
- Well Target F-1, Well Target F-6, Well Target F-4 and Well Target F-5 were similar, showing consistently satisfactory results.

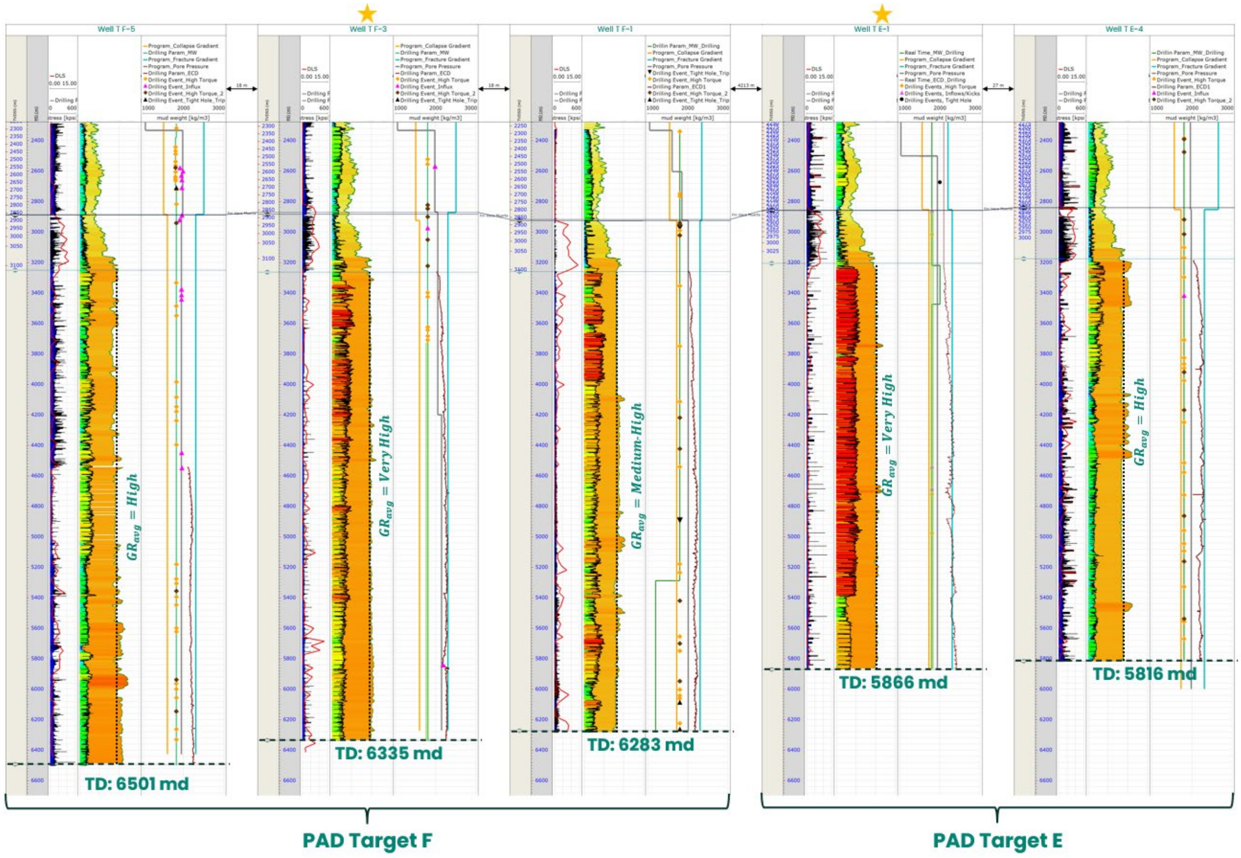

Figure 21 Wells drilled at Cocina geosteering layer

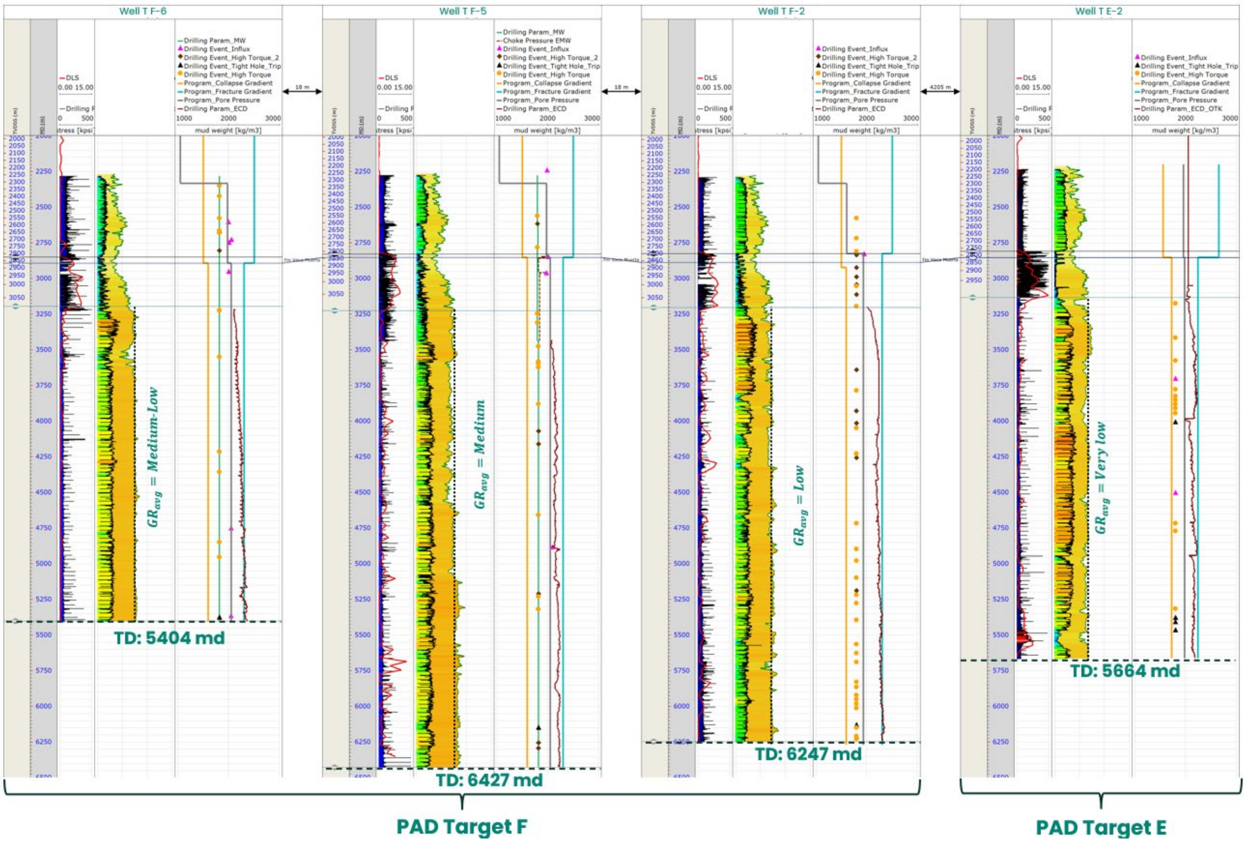

Figure 22 Wells drilled at Organic inferior geosteering layer

In terms of performance improvement the implementation of the integrated digital framework resulted in measurable improvements in drilling performance across the ERD pads (Figure 23). As previously noted, on-bottom ROP is affected by the geosteering layer is drilled. The highlight of the first Pad target E is that the target well E-1 got the highest on bottom ROP in the lateral section for the field with 81.84 m/hr. Along the continuity of the case study, in the second target pad the consistency of performance improvement was achieved. Taking into account not only this field, but all of the Operator fields in this basin, for specific wells with long laterals (between 3000 m - 3500 m), the ROP of the entire well the Top-1 (414 m/day) well is the target well F-3 & and the Top-3 (378 m/d) is the target well F-5 (Figure 24). In terms of entire well delivery time the target well F-3 got the record Top-1 (15.3 days) & the target well F-5 got the Top-5 (17.2 days) (Figure 25). Data snapshot at end of project (2024 Q3).

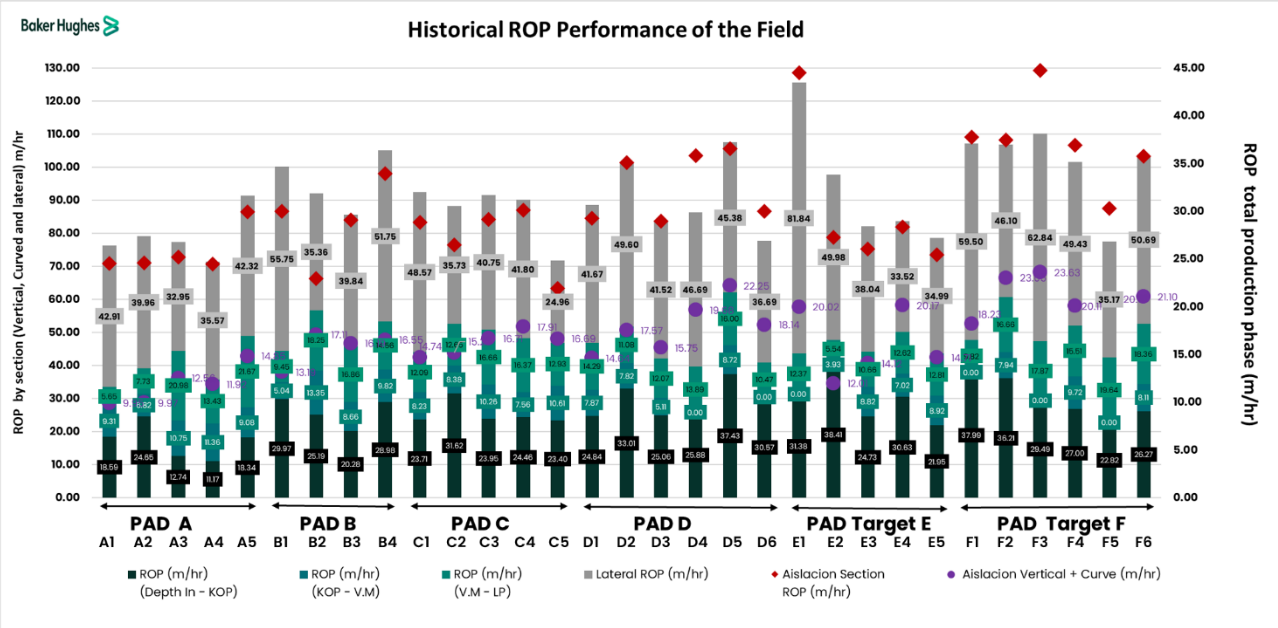

Figure 23 Historical ROP performance of the case field

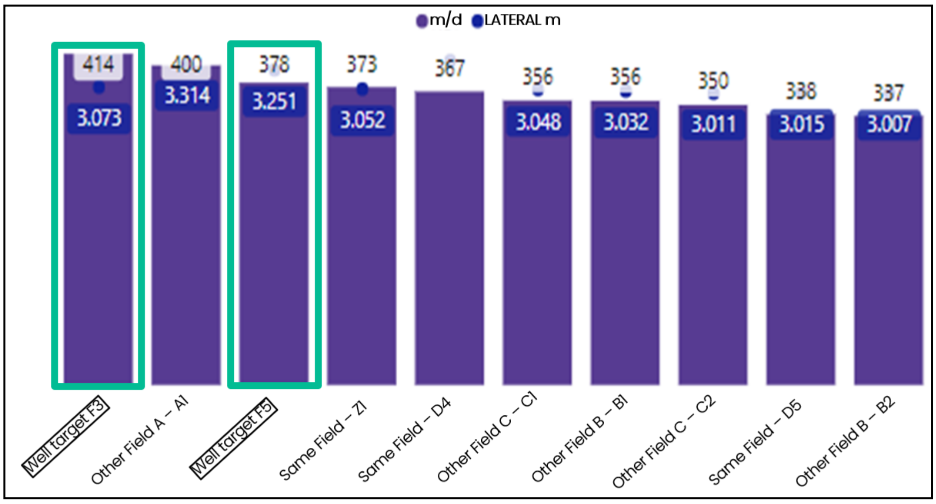

Figure 24 Best performances (m/days) operator all fields with long laterals (3000m – 3500m), two target wells with the Top-1 and Top-3 records

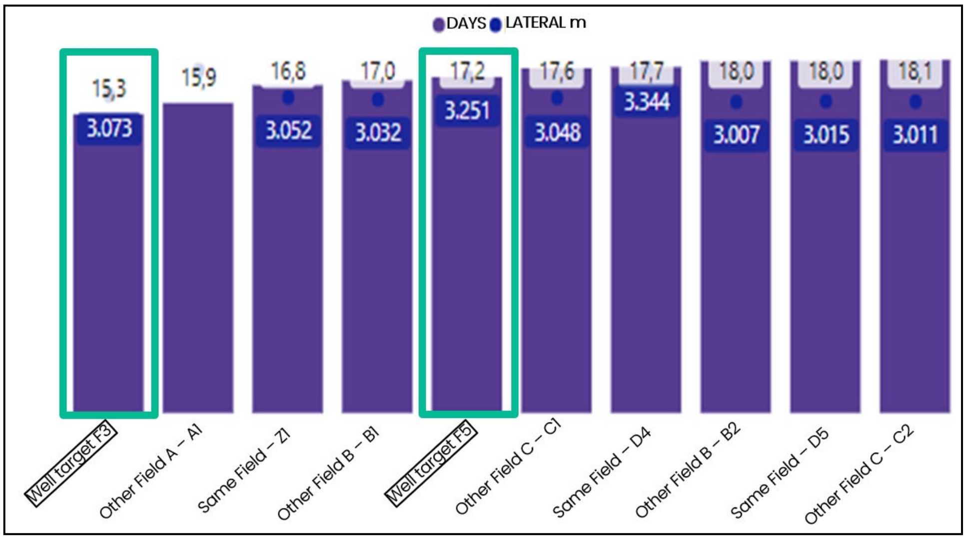

Figure 25 Best delivery time (days) operator all fields with long laterals (3000m – 3500m), two target wells with the Top-1 and Top-5 records

Conclusions

The deployment of an integrated digital framework for well planning and execution in unconventional ERD pads in Argentina demonstrated clear operational and performance benefits. By leveraging centralized data management, offset well digital twins, and real-time monitoring, the project achieved significant improvements in rate of penetration, drilling time, and operational consistency. The structured planning approach, supported by a standardized process and collaborative digital environment, enabled multidisciplinary teams to align effectively and respond dynamically to operational challenges.

The use of digital twins and statistical performance analysis provided actionable insights that informed both real-time decisions and future planning cycles. The top-performing wells validated the effectiveness of the approach, highlighting the value of early data integration and continuous feedback loops.

This case study contributes to the growing body of evidence supporting the scalability of digital solutions in complex drilling environments. The methodology developed and applied in this campaign was later being adapted for use in shallow water projects in Argentina and Mexico, demonstrating its potential for broader application across diverse operational contexts.

Enhancements to the digital twin models are planned, incorporating machine learning algorithms to improve predictive accuracy and automate anomaly detection. Additionally, integration with drilling automation systems is under evaluation to further reduce manual intervention and enhance execution consistency. Continued refinement of the planning process, supported by structured feedback from post-well reviews, will contribute to the development of a continuously evolving knowledge base to support future well delivery optimization.

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Nomenclature

Adjustable kickoff (AKO)
Bottom hole assembly (BHA)
Build up rates (BUR)
Data management solution (DMS)
Dog leg severity (DLS)
Extended-reach drilling (ERD)
Extended-reach well (ERW)
Invisible Lost Time (ILT)
Key performance indicators (KPI)
Logging While Drilling (LWD)
Managed Pressure Drilling (MPD)
Measured depth (MD)
Measurement While Drilling (MWD)
Non-productive time (NPT)
Oil base mud (OBM)
Optimization analysis services implementing solution (OASIS)
Polycrystalline diamond compacts (PDC)
Rate f penetration (ROP)
Real time (RT)
Rotary Steerable System (RSS)
Total depth (TD)
True vertical depth (TVD)
Vibrations & Stick Slip (VSS)
Well-site information transfer standard markup language (WITSML)

CV

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