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## **Applying Project Management Techniques to a Record-Breaking Ultra-Deepwater Frontier Drilling Operation**

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### **Abstract**

This paper highlights the use of integrated project management techniques, as well as innovative drilling fluids technology, to safely achieve drilling objectives on a frontier exploratory, ultra-deepwater project offshore Uruguay. Drilling in a frontier offshore area adds layers of complexity due to inherent uncertainties and risks associated with these types of operations. The use of project management techniques, combined with application of novel drilling fluids technologies, served to mitigate and reduce project risks. Preparation for this well included regulatory review and HSE compliance procedures, facilities and logistics planning, the operator's understanding of the well complexities, selection of experts for each aspect of the operation, and contingency planning to include displacement and emergency disconnect. A thorough and comprehensive readiness review, coupled with communications processes, reinforced the project management loop. Critical path management and efficiencies of drilling operations dictated managing the logistics of mixing large volumes of drilling fluid at multiple locations. The well design program considered the possibility of encountering extreme sediment compaction arising from mass transport complexes (MTC) in the riserless interval. MTCs are a recognized geologic phenomenon and are typically avoided when drilling in deepwater areas of the world.<sup>1</sup> The novelty of the workflow involved in safely and effectively delivering this record, frontier ultra-deepwater well included thorough planning and execution, in parallel with the use of new drilling fluid technology and facilities.

### **Introduction**

Drilling in deep water environments presents the potential for a variety of operational problems. Wellbore stability, rates-of-penetration (ROP) and pressure management are deepwater operational challenges, and these are exacerbated in ultra-deepwater wells. The inability to control these drilling challenges can result in catastrophic events, which negatively impact operating costs and potentially compromise safety, the environment and project economics. The ideal drilling fluid for deepwater operations is one that satisfies all technical, performance and environmental goals, while also managing costs and non-productive time.

Operations on this record ultra-deepwater well were conducted in a remote frontier area, placing greater importance on thorough pre-well planning and execution to minimize risks. The drilling campaign occurred in an area without an established oil and gas industry, facilities or an infrastructure to support ultra-deepwater drilling programs. Additionally, the well was to be drilled at a water depth approaching the operational limits of the drillship. The drilling fluids service company mobilized and safely installed an offshore supply base equipped with a liquid mud plant (LMP), bulk facilities, a full service laboratory and raw materials for drilling fluids used in the well construction process. Some assets were manufactured locally, while others were deployed from facilities in the Gulf of Mexico, Europe and Brazil. All assets were safely installed and commissioned at the offshore base in Uruguay in a relatively short time frame, and before commencement of drilling operations. The onsite laboratory was staffed with technicians capable of performing a full suite of testing in support of offshore operations and in accordance with API RP 13B1 and API RP 13B2 procedures.

The drilling fluids team used integrated project management techniques in order to safely accomplish all tasks in compliance with the operator's timeline and objectives. Given the inherent uncertainty of frontier operations, combined with a relatively short window to mobilize, install and commission the assets before startup of drilling operations, a rigorous and disciplined approach was used to achieve all project objectives. A key tactic used included the placement of two (2) project managers, having technical and operational experience in deepwater operations in remote locations, to ensure project success. Additionally, two critical paths were identified and integrated into a multi-disciplinary approach for placement of infrastructure (LMP and bulk facilities), and for the selection and use of robust drilling fluid systems designed for ultra-deepwater wells. Given the highly strategic nature of this drilling program, sponsors with corporate authority were employed as a means to drive visibility and commitment to the project. A management of change (MOC) process was used to drive the cultural behavior and approach of the multi-national and multi-disciplinary team.

## Project Management

Design for Manufacturing (DFM) concepts address key issues in the design and construction of best-in-class liquid mud plants.<sup>2</sup> These concepts include process automation for precise repeatability, Lean principles for eliminating waste, and Six Sigma tools for reduced variability. In addition, Lean and automation emphasize safety as well as speed of service. Finally, key performance metrics are suggested for measuring the efficiency of the LMP design. The LMP design objective focuses on process efficiency, which includes increasing capacity, improving functionality, eliminating waste and reducing process variability.

The application of project management techniques was particularly important in this drilling campaign, in an area without an established infrastructure or a material number of offset wells. A critical path and risk analysis was conducted to identify pathways to navigate through areas of uncertainty and to manage risks inherent to projects of this nature. A Voice of the Customer (VOC) process was used with the operator to identify and rationalize requirements and capabilities of facility assets on the offshore base following award of the contract. A process known as Value Stream Mapping (VSM) was used to identify critical paths on several tasks of the chronogram which were identified as key areas of risk and attention. This allowed the team to apply Design for Manufacturing (DFM) concepts to address issues during the construction phase of the facility, and while manufacturing drilling fluids at the liquid mud plant (LMP). A communications program was implemented to ensure visibility and clarity of key roles and responsibilities for team members. A risk analysis was performed for each item and a critical path developed in order to observe the impact on items identified on the VSM. Risks inherent to each activity were identified and a mitigation program was developed and implemented. Lastly, activities were identified which could be conducted in parallel to drive further efficiencies in the facility construction process.

A key decision in the use of project management is to identify and mitigate project-related risks. Risks referred to as "above-ground risks" are often straightforward, and can be managed with well-known and

understood mitigation measures.<sup>3</sup> However, drilling projects in frontier markets are often characterized as having complex above-ground risks, which include:

- Policy and regulatory uncertainties
- Managing community expectations
- Lack of established supply chain
- Transparency in local partners
- Mitigation measures

Project management techniques were used in the planning and management of the project with consideration to these risks. A global, multi-disciplinary team of drilling fluid technical and operational professionals was mobilized and deployed to ensure successful and timely completion of the well. This team had experience in deepwater projects in Brazil and the Gulf of Mexico. The breadth and depth of experience of this team included over 300 deepwater & ultra-deepwater wells, a number of which were in ultra-deepwater, frontier markets and at water depths above 2,500 meters (8,200 feet). This team was also familiar with the application of novel drilling fluids solutions to mitigate risks inherent to these types of wells. Language was recognized as a potential barrier with the local labor force and this was addressed by staffing the project management team with members having fluency in Spanish. Additionally, the team on the ground was familiar with the local Mercosur Common nomenclatures, as well as the local administrative and taxation process. Being in a frontier location, Uruguay lacked a mature regulatory structure for the oil & gas industry, and extra care was required to ensure compliance with regulatory requirements that were not fully developed when the project began. Lastly, the project management team was experienced and knowledgeable in supplier approval and management in support of the operation.

A project kick off meeting was held with the operator to outline the project plan, workflow, key deliverables and timelines. Key decisions and outcomes of the meeting included:

- Initiation of civil work on foundation for placement of the LMP facility roughly six (6) months prior to spudding of the well
- Implementation of Health, Safety and Environment (HSE) procedures, training and competency programs for all personnel involved in the civil work and construction process
- Submission of documents and procedures to local authorities to ensure regulatory compliance
- Use of scenario planning to rationalize raw materials used for preparation of drilling fluids while seeking final regulatory approval
- Use of scenario planning for base oil selection during the environmental regulatory approval process

Figure 1 shows the progression of the LMP design following use of Voice of the Customer (VOC) and Design for Manufacturing (DFM) principles with the customer and contractor on the project. Additional elements of the project management plan were implemented to address challenges inherent to initiation of a scope of work in a new, frontier country. On the administrative side, this included securing a legal entity and company registration. Additionally, research of local labor laws was conducted to understand entry requirements for project management personnel (expatriates), and to ensure regulatory compliance. Lastly, inter-company agreements were established to allow for initiation of back up plans for assets, materials and personnel as required.

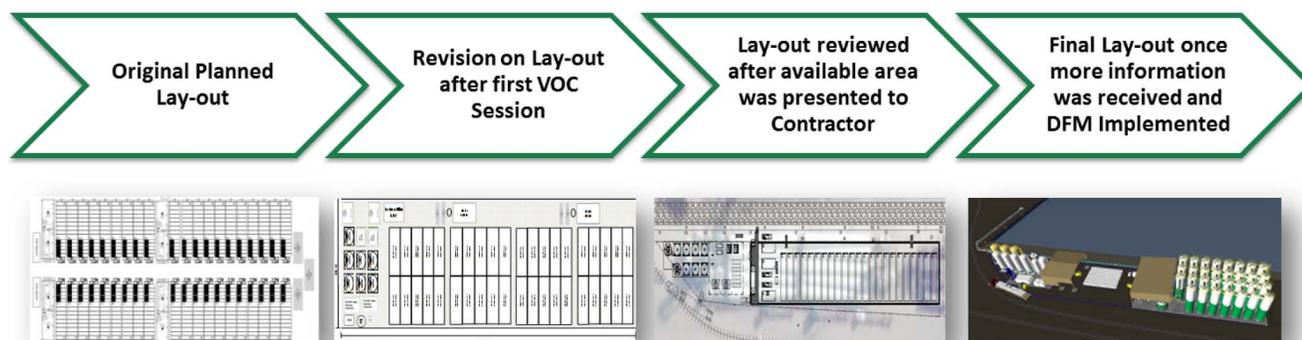


Figure 1—Progression of layout of offshore base following project management

The project management team was also tasked with management of the supply chain for all materials required to support the project. This included identifying and approving all suppliers of products, good and services in support of the drilling campaign. Due to the location of the offshore supply base and distances from the Gulf of Mexico or Brazil, lead times for shipment of materials were identified as an area requiring attention, oversight and control. A process was implemented to provide forecast estimates of key materials, and lead times for each were identified and included in the supply chain program. Finally, all specific requirements for international transactions for products targeted for use were identified, and the appropriate controls were implemented.

Lastly, the quality system of the drilling fluid company was replicated to Uruguay, and all management and operational procedures were adapted and implemented in the project workflow. This allowed for timely and accurate responses to local authorities, particularly when documentation was required in the licensing process, and when communicating with local authorities. Additionally, quality control and assurance activities for all drilling fluid products were managed in accordance with company QC/QA procedures at support laboratories in Macae and Houston.

## Facilities

A key enabler in the drilling fluids value chain is facility placement, capability and capacity. Operators leverage best-in-class facilities, distribution and logistics to improve project efficiencies and economics. Understanding the logistical and operational challenges associated with deepwater projects, the drilling fluids supplier invested in an offshore supply base in Montevideo, Uruguay to address the deliverability requirements for the ultra-deepwater campaign. The supply base was designed to manufacture and safely offload large volumes of drilling fluids and bulk materials to supply vessels, at rates surpassing the operator's expectations.

The location for placement of the offshore base was cleared by local regulatory authorities in order to begin civil work less than 3 months prior to the planned date to spud the well. As per the risk analysis performed during the planning stages, civil work was identified as a critical path, so a series of actions were taken to mitigate risks. Designs considering various types of equipment and area configurations were developed by the engineering team. Each one was carefully analyzed in order to run average and worst case scenarios for foundation design.

Key deliverables of the project management program included safe and compliant construction of the liquid mud plant (LMP) and bulk material plants at the offshore supply base from which offshore activities would be supported. This required designing and installing an LMP with sufficient capacity for water-based muds (WBM), as well as the flat-rheology, non-aqueous fluid (FR-NAF). The combined capacity of these two facilities was over 20,000 bbls, and with roughly 14,500 dedicated to the FR-NAF. The design also addressed the distance from the LMP to the designated pier, and the need to transfer drilling

fluids at distances over 100 meters to an offshore supply vessel. Additionally, the design workflow of mixing hoppers, valves, mixing and shearing systems significantly reduced mixing times and improved the quality control of the fluid preparation process. These mixing and shearing techniques, along with reconfigured piping and pump arrangements, allowed for parallel processing and advances in both lead time and service capacity. The mixing and storage tanks were designed to minimize dead volumes and to facilitate achievement of HSE objectives during loading and offloading operations. Load rates for both liquid and bulk materials to offshore supply vessels met or exceeded operator requirements. Lastly, the LMP was designed with the ability to operate stand-alone, and to be independent of electrical (power) support from the port authority power supply.

The bulk facility was also designed to convey bulk materials at distances of over 100 meters to an offshore supply vessel, and had storage capacity for over 300 MT of barite and 50 MT of calcium carbonate. The facility was equipped to filter and capture particulates from materials pumped from the bulk plant to the supply vessel. Additionally, the bulk plant was equipped with dust collectors to minimize particulates within the pneumatic system. The bulk facility was also designed to operate stand-alone from the port authority power supply. [Figure 2-5](#) show the liquid mud and bulk plants which were completed on schedule and in accordance with the project plan, as an outcome of the use of project management techniques.



Figure 2—Tank positioning (LMP)



Figure 3—Mixing equipment & tanks (LMP)



Figure 4—Exterior of liquid mud plant (LMP)



Figure 5—Bulk materials plant

## Drilling Fluids

A unique fluid selection and delivery process was used to meet all operational and logistical goals, in compliance with local environmental regulations, and to satisfy the significant technical and operational objectives of this challenging deepwater well. Two innovative fluid systems were used to achieve all operational objectives. An inhibitive, aqueous fluid was used to facilitate delivery of drilling, casing running and cementing objectives in the riserless interval. This fluids was chosen based on prior use in offshore Northeast Brazil, where the system provided excellent wellbore stability when drilling the highly reactive and unconsolidated Calumbi shale. This system was also considered to be an appropriate solution for the control of problematic sediments arising from mass transport complexes (MTC). The riserless interval was successfully drilled and a pad mud was placed in the open hole to provide wellbore stability during casing running and cementing operations.

Deepwater drilling fluid design challenges are exacerbated by the operational environment encountered in the drilling process. Pressure control is particularly important in deepwater operations, where a narrow operating window exists between the pore pressure and the fracture gradient. These narrow margin wells are abnormally pressured and the design characteristics of drilling fluids for deepwater wells are unique, and can differ significantly compared to normally pressured wells. The cooling effects of the water column opposite the riser creates a negative geothermal gradient, where static temperatures are often reduced to as low as 1°C (34°F) at the seafloor. The geothermal gradient then increases with increasing depth, and bottom-hole static temperatures increase to levels often above 150°C (300°F). Increasingly, the fluids-of-choice for deepwater, and ultra-deepwater operations are non-aqueous fluids (NAF), designed to exhibit a flat (constant) rheological profile which is nearly independent of downhole temperature and pressure conditions.<sup>4,5,6,7,8</sup>

The potential for formation of gas hydrates is a well-recognized hazard due to the high pressure and low temperature conditions at the seafloor.<sup>9</sup> Testing and modeling techniques were used in the pre-well planning phase of this well to predict the potential for gas hydrate formation. Due to the expected pressure and temperature conditions on this well, the risks associated with use of an aqueous drilling fluid were deemed significant and the decision was made to drill the well with a non-aqueous fluid (NAF). Following a rigorous qualification program, the decision was made to use a new and innovative flat-rheology, non-aqueous fluid (FR-NAF). The use and relevance of a FR-NAF was particularly important given that the well of interest was a record in terms of water depth, which was in excess of 3,400 meters (11,152 feet). Robust fluid formulations were designed using novel and proprietary emulsifiers, rheological modifiers, suspension agents and fluid loss additives. Variations in rheological properties such as plastic viscosity, yield point, as well as viscometer dial readings of 3 rpm and 6 rpm and gel strengths, were minimized to safely achieve drilling, tripping and casing running objectives without incidents of fluid-related NPT. Table 1 shows the formulation of the FR-NAF designed for use in this well and the near-independence of temperature and pressure on the flow properties and gel strengths of the fluid. Figure 6 presents these results in graphical form and one can clearly see that API yield point, as well as the gel strength measurements (10s, 10m & 30m) are nearly flat (constant) with changing temperature and pressure conditions.

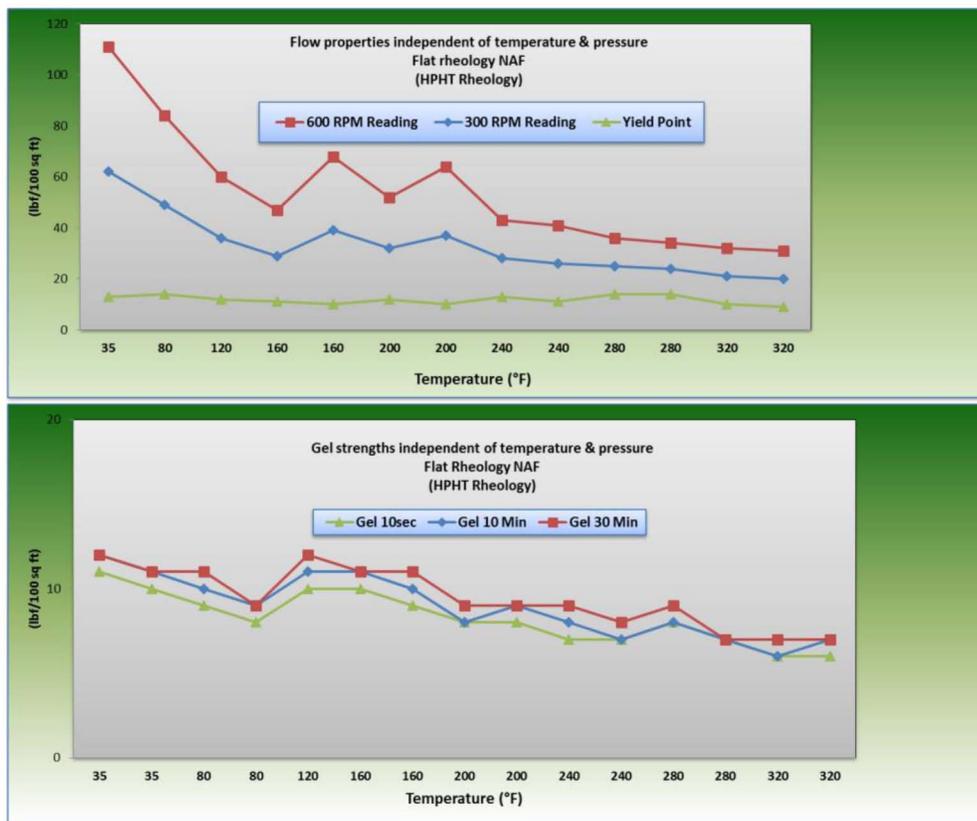


Figure 6—HPHT Flow Properties of FR-NAF

Table 1—HPHT Flow Properties of FR-NAF

Test Conditions		RPM Readings @						Plastic Viscosity (cP)	Yield Point (lb/100 sq ft)
Temp (°F)	Pressure (psi)	600	300	200	100	6	3		
35	5,500	111	62	44	33	9	8	49	13
80	5,500	84	49	34	26	10	9	35	14
120	5,500	60	36	24	17	9	8	24	12
160	5,500	47	29	22	16	8	8	18	11
160	10,000	68	39	29	21	9	8	29	10
200	10,000	52	32	23	17	9	9	20	12
200	13,000	64	37	29	20	10	9	27	10
240	10,000	43	28	22	16	8	8	15	13
240	13,000	41	26	20	14	8	7	15	11
280	10,000	36	25	18	14	9	8	11	14
280	13,000	34	24	17	15	8	7	10	14
320	10,000	32	21	16	14	7	6	11	10
320	13,000	31	20	14	11	7	7	11	9

An important drilling fluid design consideration is to minimize filtrate invasion to the porous rock matrix in order to reduce the risk of stuck pipe, downhole losses, formation damage and excessive filter cake.<sup>10</sup> A proprietary, internal software program was used to identify the appropriate bridging additives for this well, using the Ideal Packing Theory (IPT), as shown in Figure 7. This approach was used to formulate an engineered bridging solution, designed to seal pore fractures between 100-200 microns, which was used to eliminate downhole mud losses.

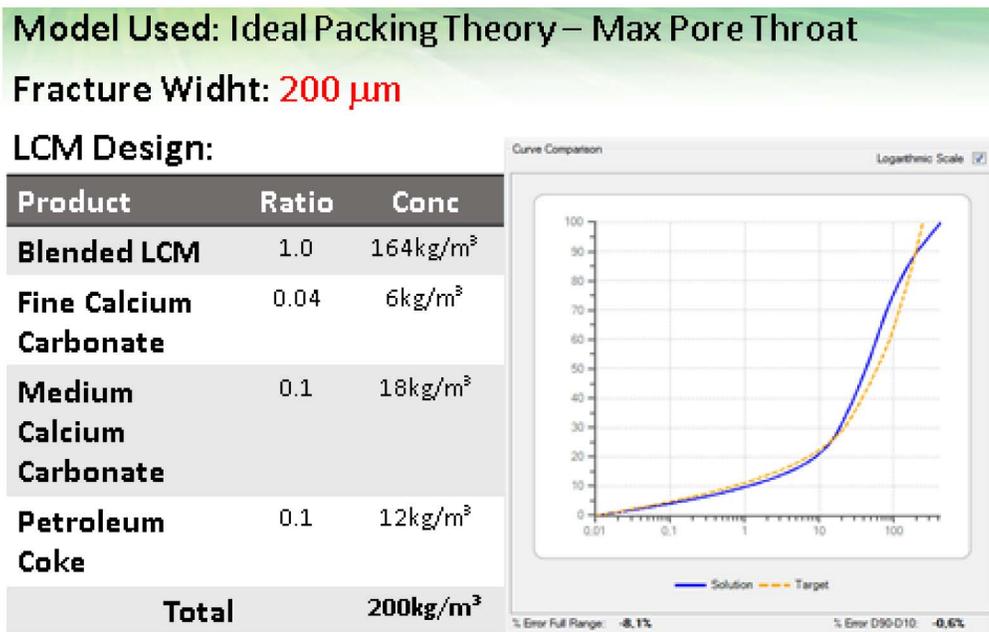


Figure 7—Bridging design for FR-NAF

## Results, Conclusions and Lessons Learned

Use of novel, deepwater drilling fluid solutions allowed for achievement of all drilling objectives in this record ultra-deepwater well. All planned operational objectives were safely achieved in accordance to the project plan. Risks identified in the riserless interval included the potential for encountering mass transport complexes (MTCs), compacted sediment deposits that often creep, slide and slump into one another. This risk was identified in the well planning process and appropriate controls were put into place to mitigate the risk through a rigorous drilling fluid selection process. Additional risks associated with pressure management and lost circulation were also identified due to the large variations in downhole temperature and pressures

inherent to ultra-deepwater operations. Fluid properties were maintained within specifications throughout the drilling of this well and novel techniques, including use of a meter to measure the activity of the internal phase, were employed to manage properties within specification. A rigorous analysis of expected downhole temperatures and pressures was conducted in the pre-well planning process using sophisticated hydraulics software. The technical solutions proposed, coupled with detailed planning, allowed the operator to stay within planned days despite having to displace the riser to a completion brine on numerous occasions in anticipation of poor weather conditions. Figure 8 presents a comparison of planned versus actual drilling days and a demonstration of the operational performance of the FR-NAF, as well as the execution capability of the offshore and onshore operational personnel.

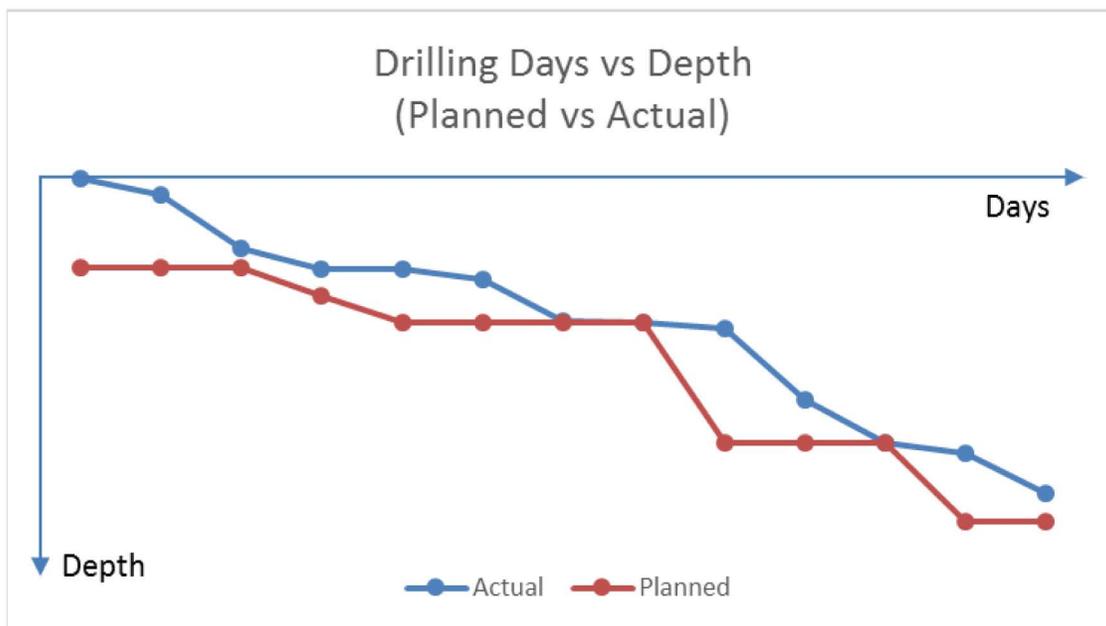


Figure 8—Drilling Days vs Depth for Well (Plan vs Actual)

This engineered approach facilitated delivery of drilling objectives without incidents of fluids-related non-productive time (NPT). Additionally, all logistical objectives were achieved on time, and in an environmentally compliant manner. All fluid volumes were safely prepared and delivered to the 7<sup>th</sup> generation drill ship without incident. The ability to quickly mobilize and deploy assets, as well as experienced, multi-functional and multi-nation team of drilling fluids professionals, greatly impacted the success of this project.

Notable milestones from this project included:

- Excellent safety record, with no recordable incidents in the construction process or in support of the drilling operation
- 5,032 bbl (800m<sup>3</sup>) WBM facility operational in ~ 60 days, including commissioning
- 849 bbl (135m<sup>3</sup>) bulk facility operational in ~ 60 days, including commissioning
- 14,467 bbl (2,300m<sup>3</sup>) FR-NAF facility operational in ~ 75 days, including commissioning
- Timeframe between receiving permit to start civil work and delivering area back to Port Authority with civil work removed, back to original state within 11 months
- Project achieved local content objectives

- Successfully completed riserless interval, conductor and ran and cemented casing (through MTC formation)
- Successfully drilled the well without incidents of fluids-related NPT
- Project was completed on time and within planned cost

## Conclusions

- Project management techniques were instrumental in delivering operational success of a record ultra-deepwater well, offshore Uruguay
- Operations on this record ultra-deepwater well were conducted in a remote frontier area, placing great importance on thorough pre-well planning and flawless execution to minimize risks
- A key enabler in the drilling fluids value chain is facility placement, capability and capacity
- The novelty of the workflow involved thorough planning and execution, in parallel with the use of new and innovative drilling fluid technology and facilities
- A Voice of the Customer (VOC) process aided in identifying and rationalizing requirements
- The use of new and innovative drilling fluids delivered significant gains in operational performance

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## Nomenclature

MTC	- Mass transport complexes
ROP	- rate of penetration
LMP	- liquid mud plant
bbls	- oilfield barrel, 42-gallons
m <sup>3</sup>	- cubic meters
NPT	- non-productive time, hours
VOC	- voice of the customer
VSM	- value stream mapping
DFM	- design for manufacturing
HSE	- health, safety and environmental
WBM	- water-based mud
MT	- metric tons
NAF	- non-aqueous fluid
FR-NAF	- flat rheology, non-aqueous fluid
QC/QA	- quality control/quality assurance
C	- Temperature, Celsius
F	- Temperature, Fahrenheit
10s	- 10 second gel strength
10m	- 10 minute gel strength
30m	- 30 minute gel strength

## References

1. B.A. Elieff, C.G. Page, and V. Gupta, "Successful Drilling Management of Mass Transport Complexes (MTC's) in Deepwater Angola," IADC/SPE 112633, 2008 IADC/SPE Drilling Conference, Orlando, Florida, U.S.A., 4-6 March, 2008
2. J. Huggins, A. Amer, B. Pahlkotter and JW Cross, "Leveraging Design for Manufacturing Principles in Liquid Mud Plant Design," 2017 AADE National Technical Conference and Exhibition held at the Hilton Houston North Hotel, Houston, Texas, April 11-12, 2017
3. "Above-ground Risk in Frontier Markets," *Oil & Gas Monitor*, July 25, 2012
4. Rojas, J.C., B. Daugherty, D. Renfrow, P. Bern, B. Greene, R. Irby, B. Gusler, P. Grover, N. Trotter, B. Dye, "Increased Deepwater Drilling Performance Using Constant Rheology Synthetic-based Mud," AADE-07-NTCE-20, 2007 AADE Drilling Fluids Conference, Houston, Texas, 10-12 April, 2007
5. Rojas, J.C., Bern, P., Jacobsen Plutt, L., Romo, L, Greene, R., Irby, R., Trotter, N., Dye, B and Sharma, N., "New Constant-Rheology Synthetic-Based Fluid Reduces Downhole Losses in Deepwater Environments," SPE 109586, presented at the 2007 SPE Annual Technical Conference and Exhibition held in Anaheim, California, U.S.A., 11-14 November 2007
6. Burrows, K, D. Carabajal, J. Kirsner, B. Owen, "Benchmark Performance: Zero Barite Sag and Significantly Reduced Downhole Losses with the Industry's first Clay-Free Synthetic Based Fluid," IADC/SPE 87138 presented at 2004 IADC/SPE Drilling Conference, Dallas, March 2-4, 2004.
7. van Oort, E., J. Lee, J. Friedheim and B. Toups; "New Flat Rheology Synthetic-based Mud for Improved Deepwater Drilling," SPE 90987, SPE Annual Technical Conference and Exhibition, Houston, Texas, Sep. 26-29, 2004.
8. "Flat rheological fluid system safely achieves drilling objectives," *Hart Energy Exploration & Production*, February 2018, pp (62–64)
9. Ebeltoft, H., Yousif, M., and Soergaard, E., "Hydrate Control during Deep Water Drilling: Overview and New Drilling Fluids Formulations," SPE 38567, presented at the 1997 SPE Annual Technical Conference and Exhibition, San Antonio, Texas, 5-8 October 1997
10. A. Amer, B. Carter, E. Hudson II, H. Du, and C. Judd, "Revisiting the Ideal Packing Theory with a Novel Particle Size Measurement Approach," SPE-182487, SPE Asia Pacific Oil & Gas Conference and Exhibition held in Perth, Australia, 25-27 October 2016