AADE AMERICAN ASSOCIATION of DRILLING ENGINEERS
HOUSTON CHAPTER
"The Industry forum for Drilling practices and technology"

Field Operations Results and Experience with Inline Drilling Fluid Property Measurement

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This Presentation is Based on AADE-20-FTCE-111

"Field Operations Results and Experience with Inline Drilling Fluid Property Measurement - Zafar Kamal, Richard Frazier, Doanh Ho, and Lauren Miller, OFI Testing Equipment; Paul Scott, ConocoPhillips; Pradipto Bhattacharya, Rheology Solutions"

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Agenda

- Motivation and purpose
- The system, location, layout and operational introduction
- Data Integration and visibility
- Representative Data
- Initial and Current System Performance
- Lessons Learned and Future Plans
- Acknowledgement
- Conclusion

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Motivation ➔ Drilling Automation

The drilling industry is aggressively pursuing automation

Driven by,

- Safety - reducing risk by reducing human intervention
- Lifecycle Cost Reduction - To do more with less
- Life of well considerations
- Accurate and reliable data for operations and the enterprise

Automation provides intangible benefits (e.g., safety and license to operate), and tangible benefits (e.g., reduced costs and higher efficiency)

A Scalable System for Autonomous Measurement of Drilling Fluid Properties

- **Continuous Measurement**
  Transitioning from intermittent lab measurement to autonomous measurement

- **Real-Time Trending**
  - Immediate and relevant feedback
  - Data availability for real-time modeling and optimization
  - Better analytics and KPIs

- **Remote Monitoring** and Enabling Automation

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AADE fmg FLUIDS MANAGEMENT GROUP

This work resulted from the introduction of OASYS – OFITE Automated Systems for Real-Time Fluid Monitoring

Where 3 technologies were combined on a Skid deployed on an active drilling rig for the automated, real time measurement of fluid properties.

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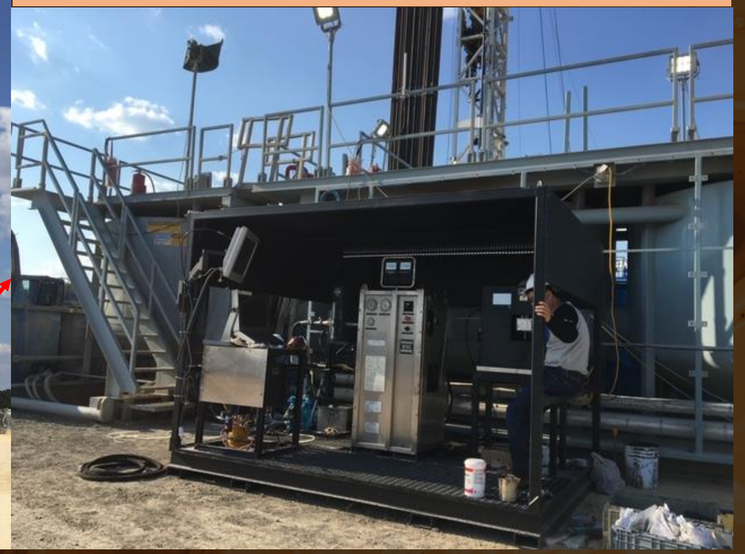
South Texas Deployment

Continuous measurement of Drilling Fluid properties:

- Density
- Apparent Viscosity
- API Rheology
- Online Rheometer (G', G" and Viscosity Flow Curve)
- ES (emulsion/electrical stability)



THE OASYS SYSTEM

The OASys System utilizes 3 proprietary technologies to monitor rig fluid properties in real time, physically and functionally integrated on a Skid

MUD AID

MUD WATCHER

OLR | ON-LINE RHEOMETER

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Mud-Sampling and Data Flow

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REPRESENTATIVE DATA

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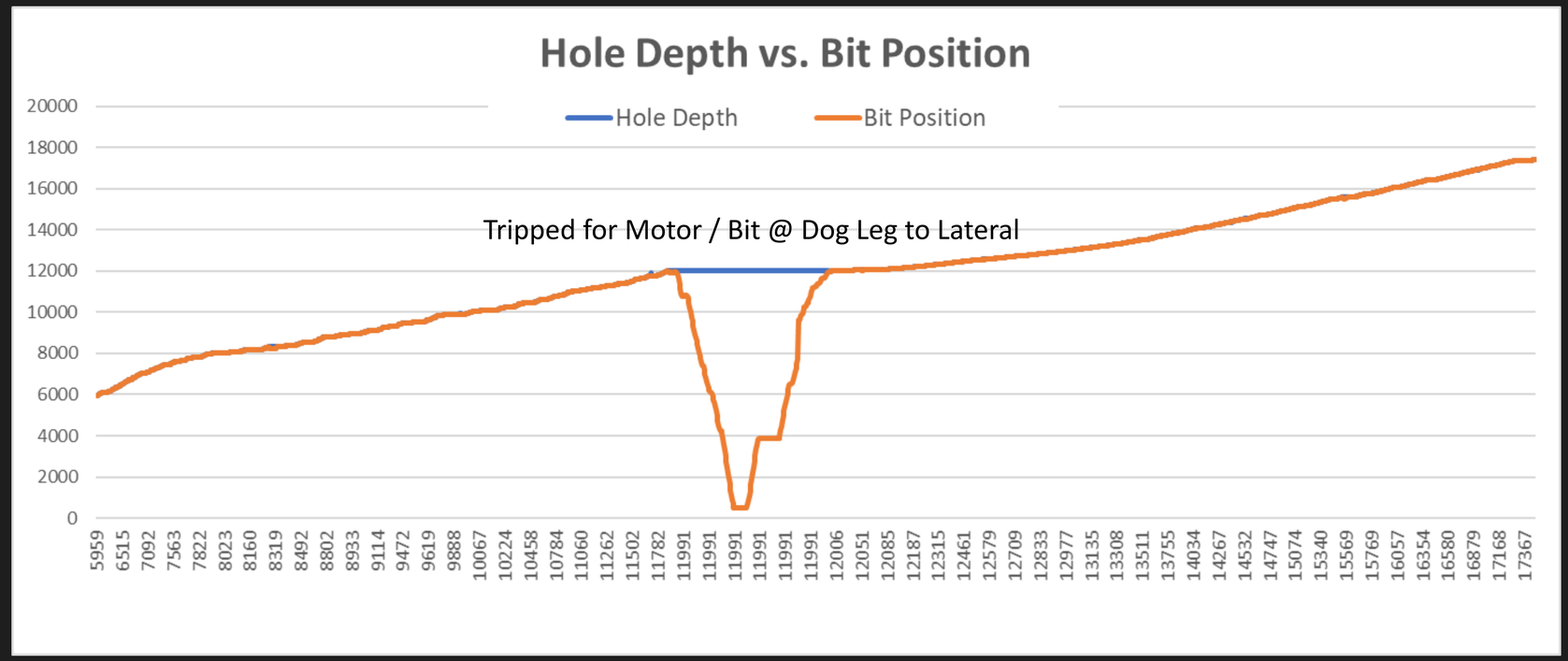
Context


Hole Depth vs. Bit Position
Hole Depth
Bit Position
Tripped for Motor / Bit @ Dog Leg to Lateral
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
5959
6515
7092
7563
7822
8023
8160
8319
8492
8802
8933
9114
9472
9619
9888
10067
10224
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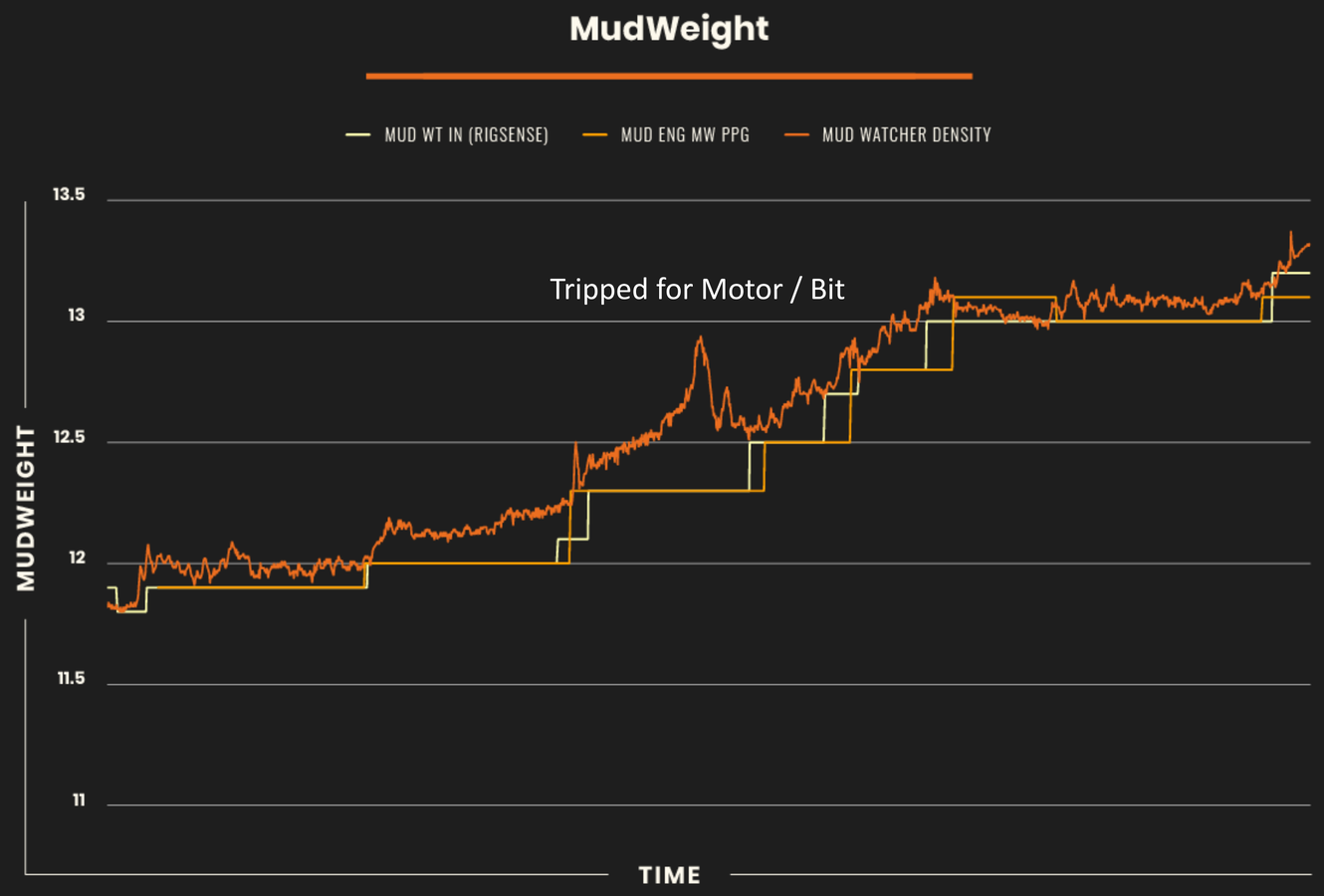
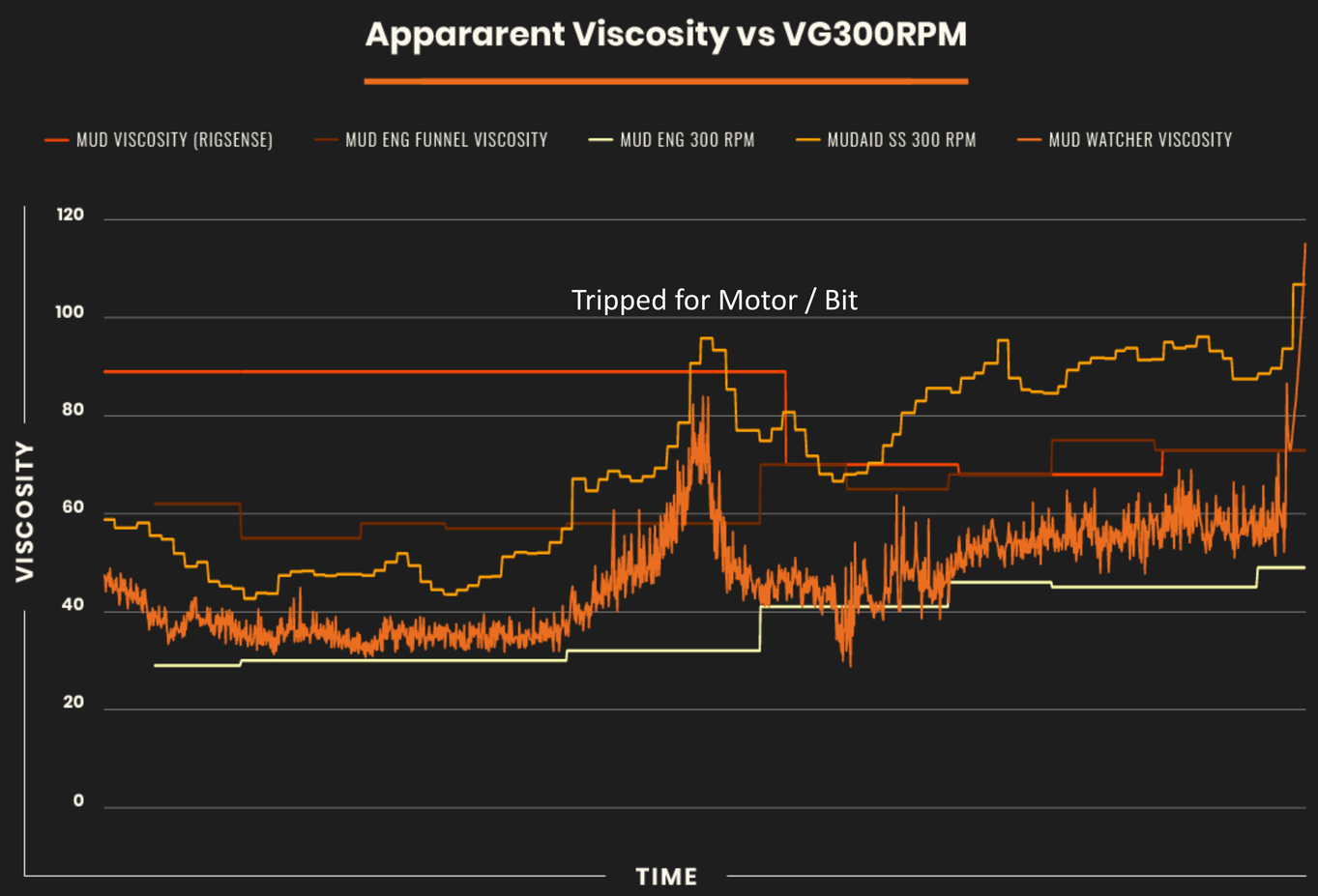
Representative Data



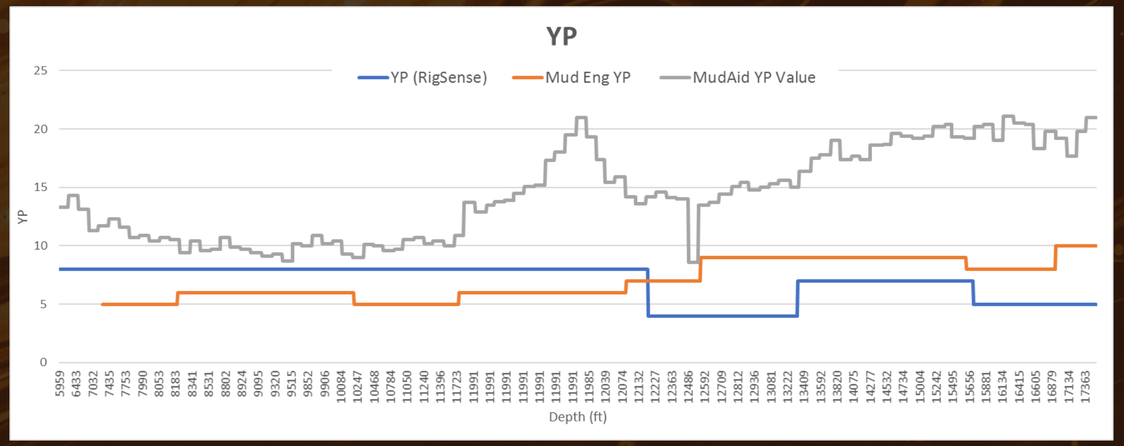
Real time and continuous measurement provides information traditional field measurement misses.

Representative Data

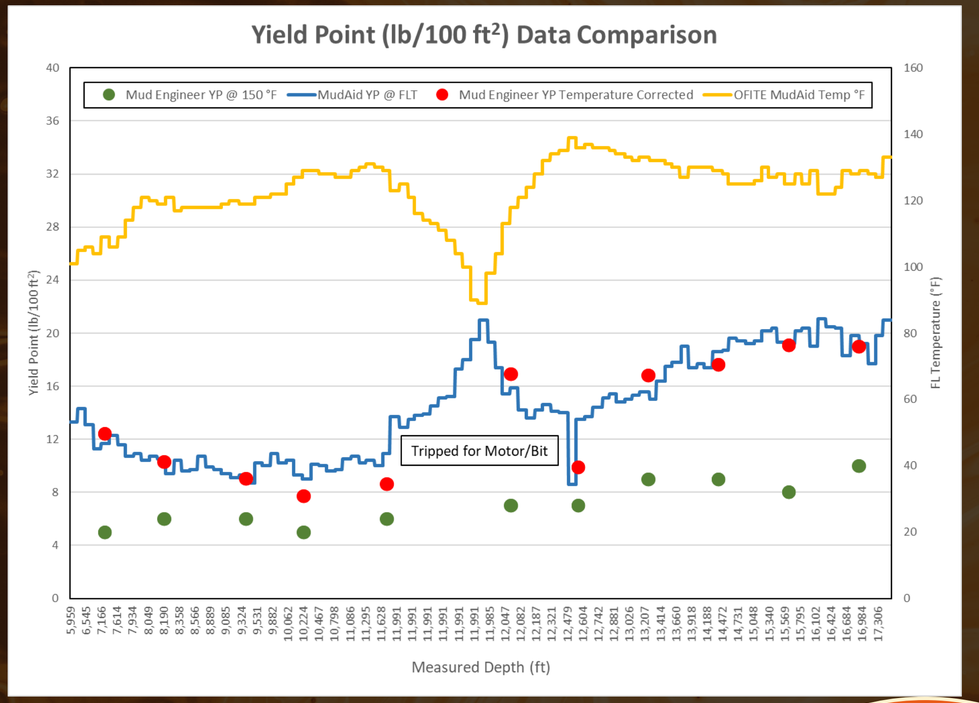


Detailed data enables informed decisions

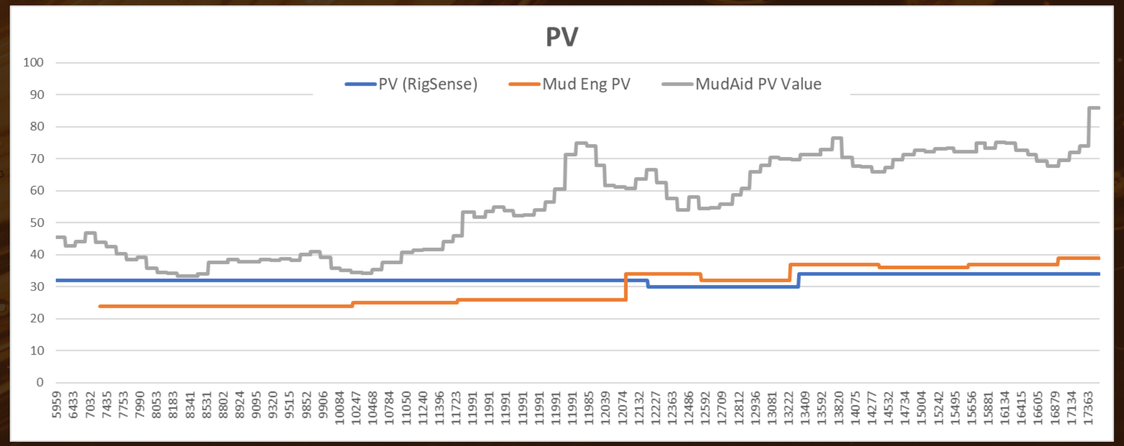
Derived Data



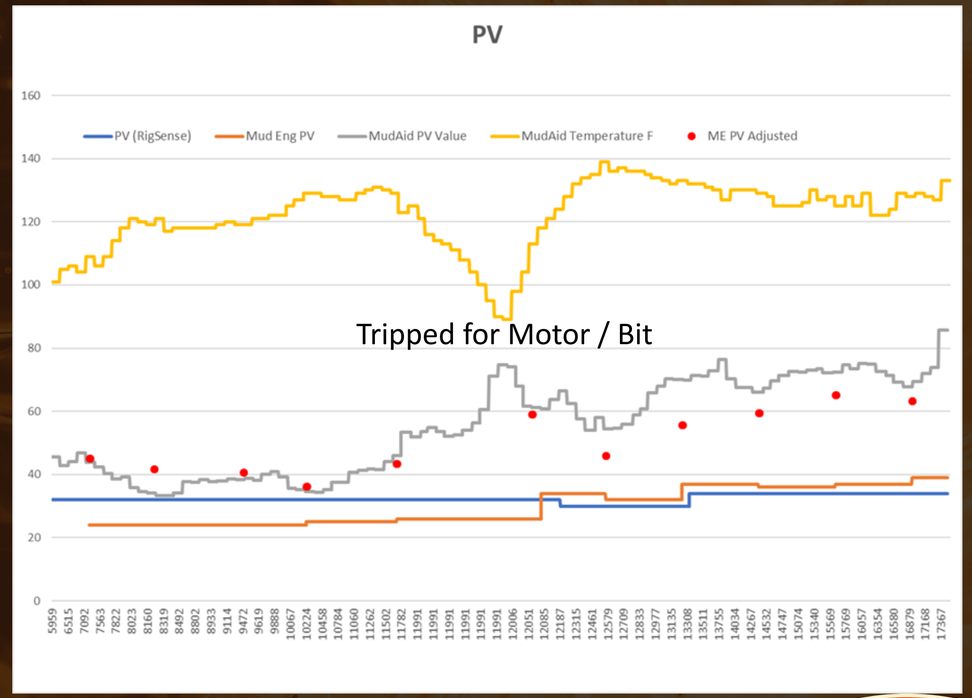
A linear adjustment to the YP (red dots) at the time the mud engineer reported



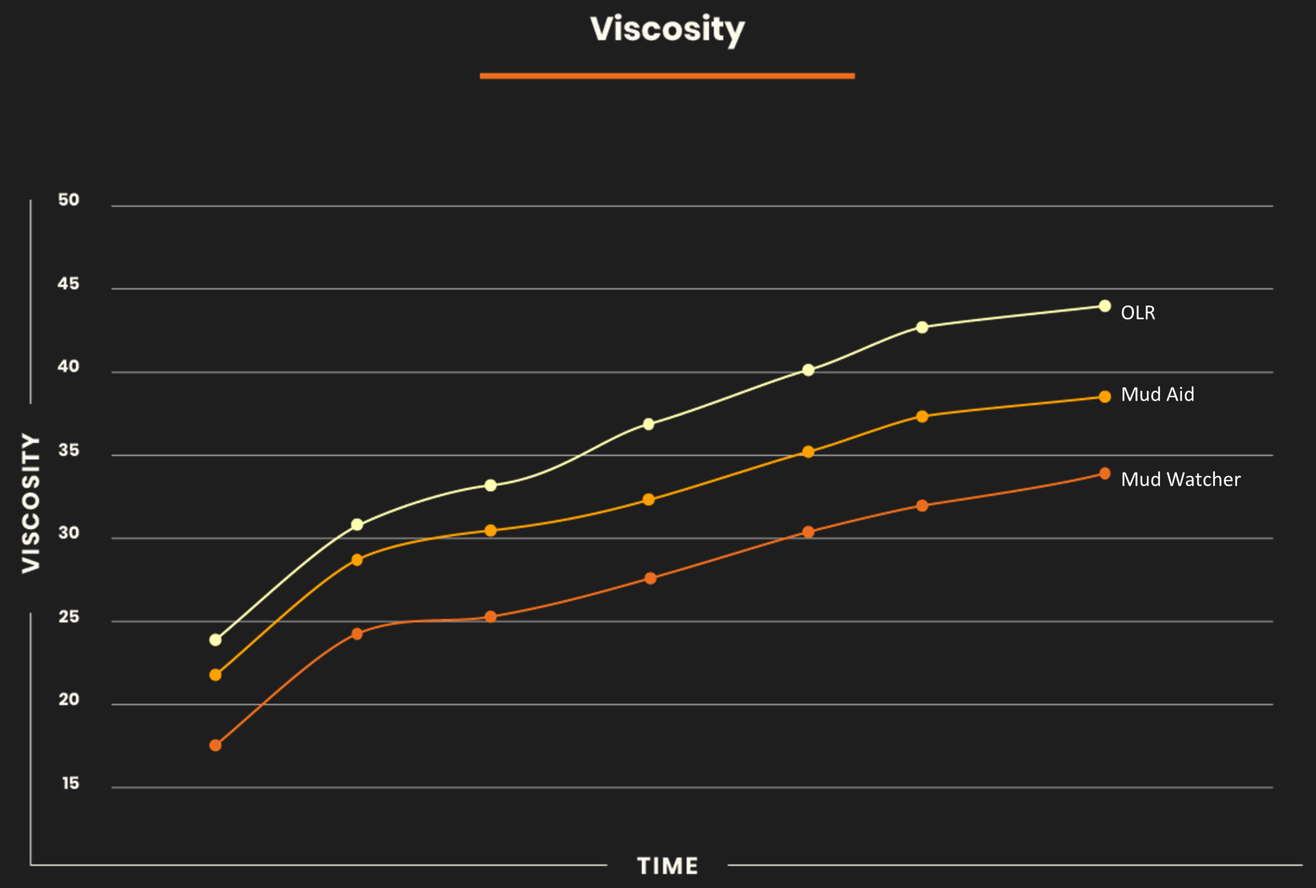
Derived Data



A linear adjustment to the PV(red dots) at the time the mud engineer reported

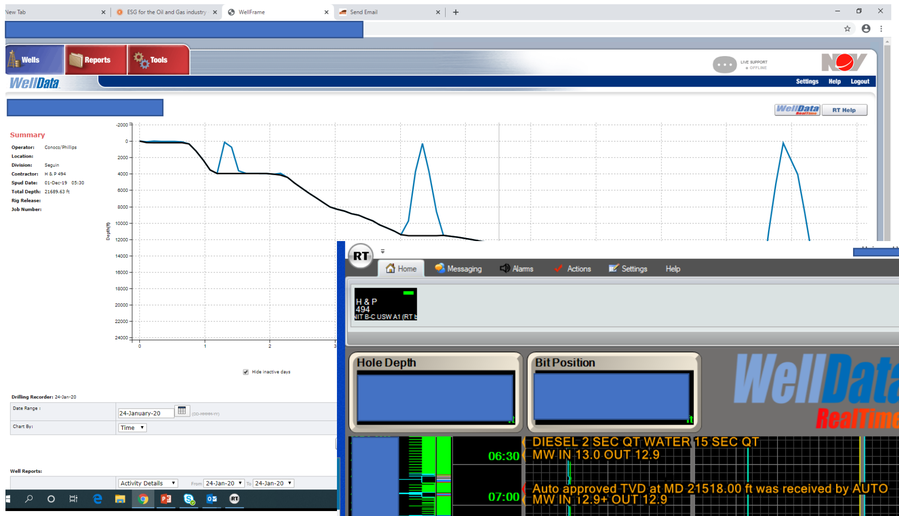


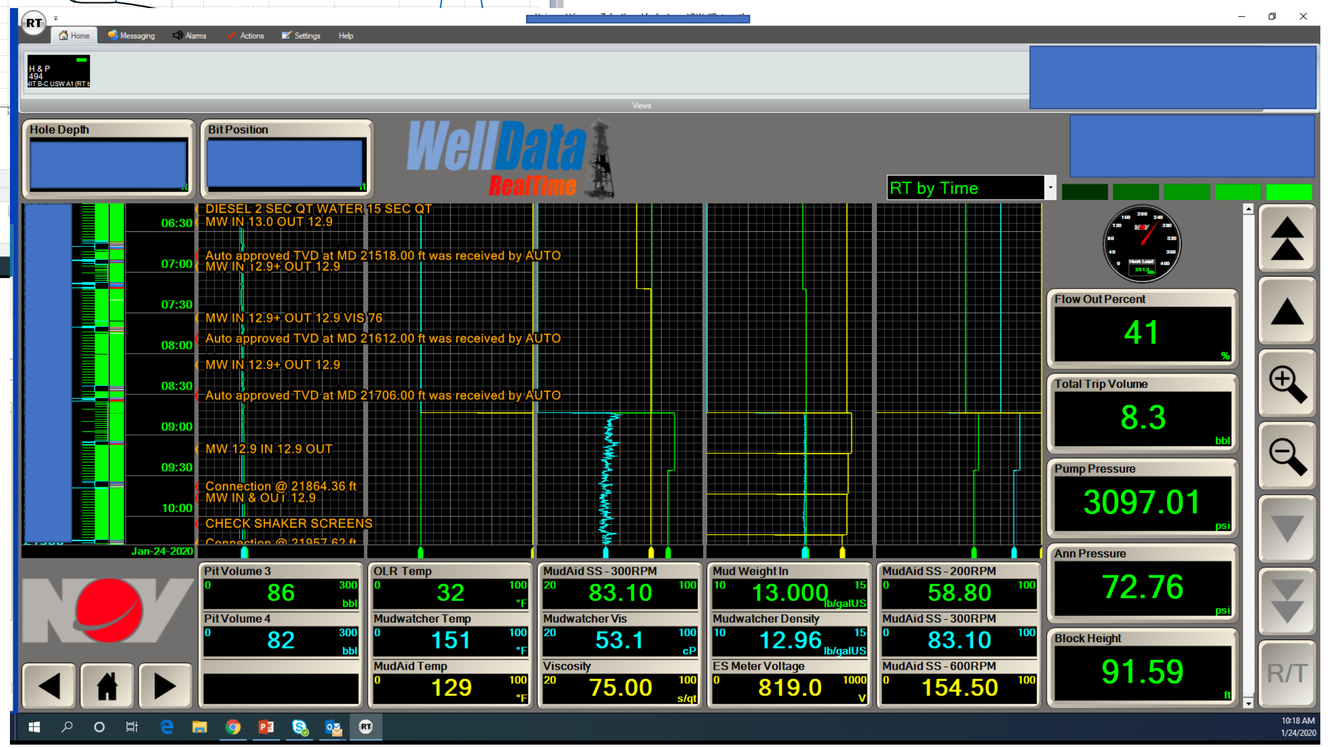
Comparative Data

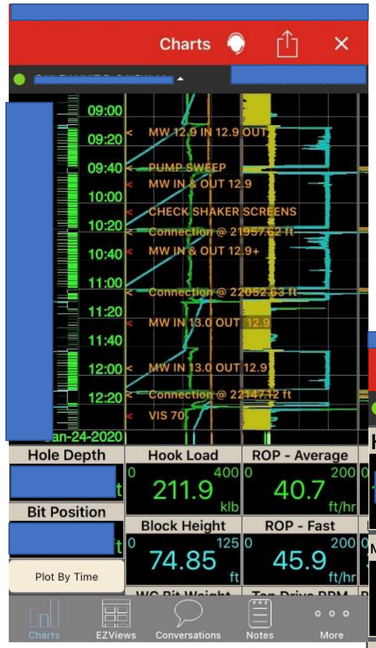


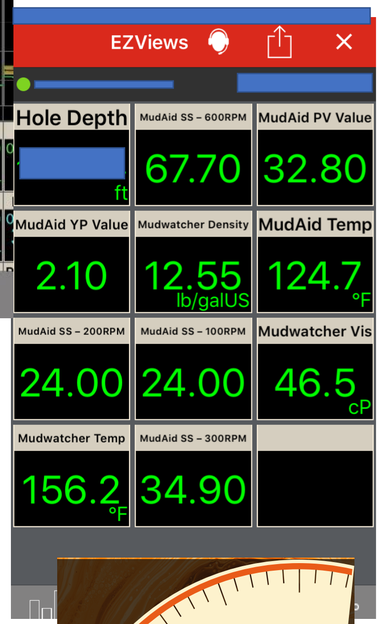
Consistent measurement data across the entire system.

WellData Integration and Visibility









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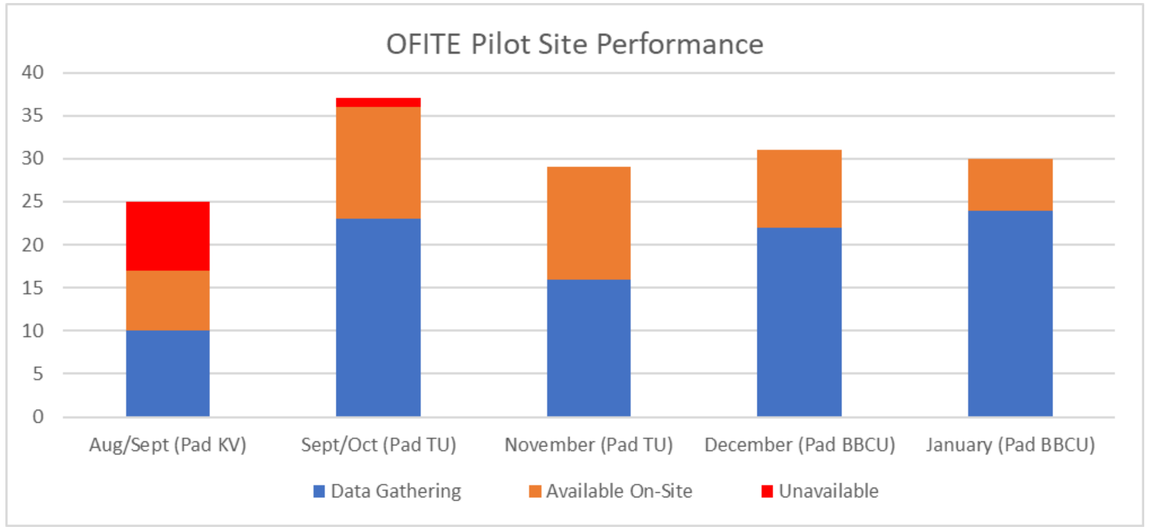
Performance – Phase 1

- Data **collected** on multiple wells
- Data **transmitted** to operator via Rig system
  - visually available on rig monitors
  - office PC and mobile apps
  - with Excel downloads
- Data **integrated** by operator for hydraulics models, e.g., to predict ECD and annular pressure

Multiple well pads, 14 wells, almost 200K feet of drilling in OBM sections



Phase I - Performance Enhancements

- Enhanced safety and fluid containment
  - Cut off valves, fluid routing, cut-off timers, and direct remote monitoring
- Sample management and flow routing
- Better components and standard parts configuration
- Local data logging

Summary of Phase I

- Successfully provided edge sensing/measurement with
  - Robust, industrial grade instruments
  - Proved technology, sample management, and integration.

- Democratization of Data / Technology - scalability and accessibility to drilling operations

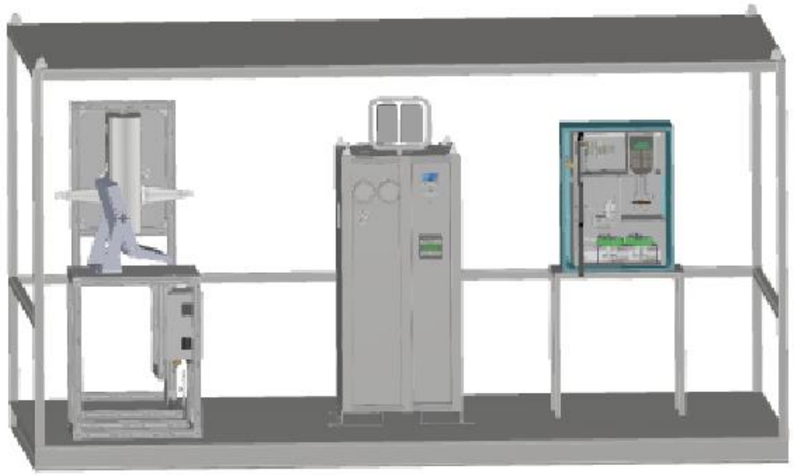
- Rig operations and corporate staff benefitting from available data

Lessons learned and future priorities

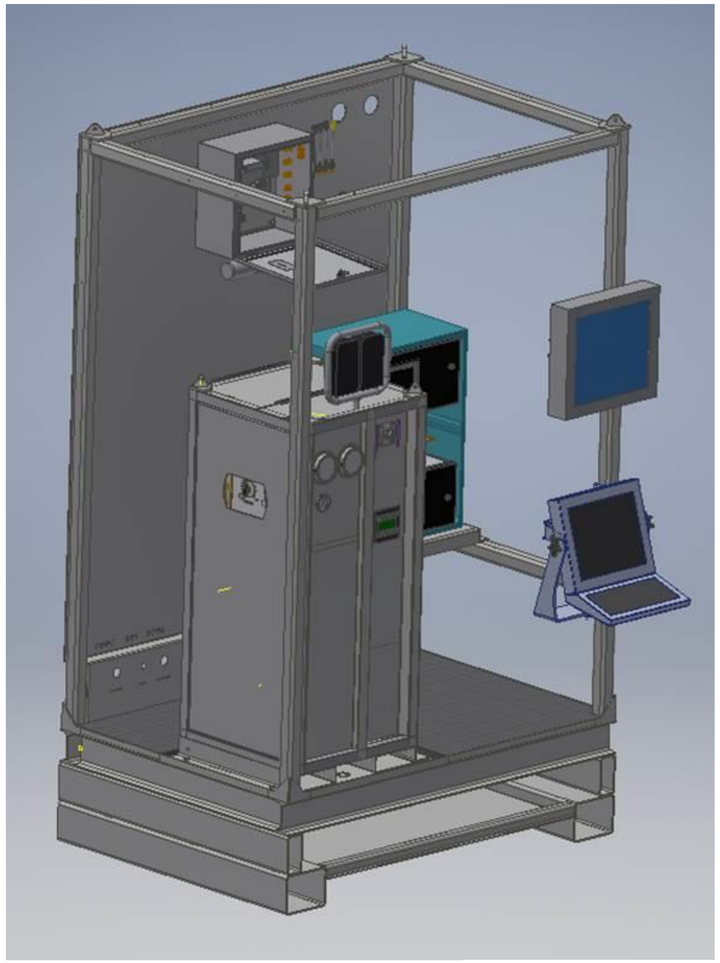
- Sample management – sampling, sampling, …
- Operational (people and process) integration to enhance local and remote “user value”
- Scalability
- Data → information → decisions
- Temperature management
- Safety certifications

Compact Skid

Phase 1 Skid



10’ x 8’ base



5.5’ x 4’ base

OASys – Autonomous HWD "Hydraulics While Drilling"

Well Data Inputs

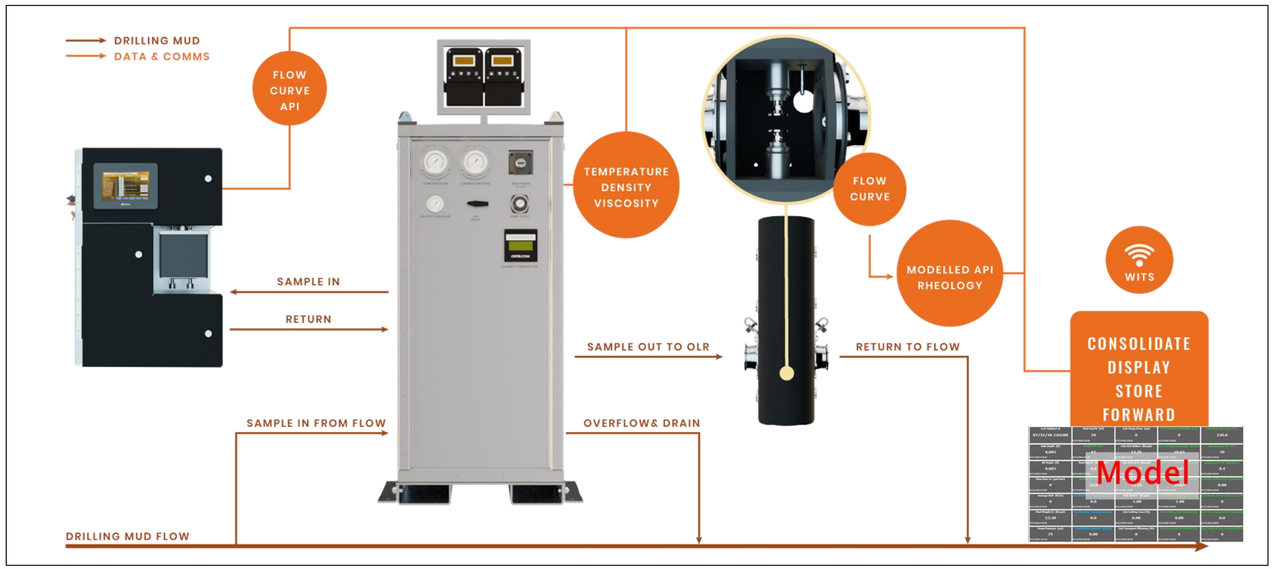
- Static Well Information
- Real Time Drilling Data
- Real Time Fluids Data

HWD Model

HWD Outputs

- ECD
- Pressure Drop
- Cuttings Removal Efficiency
- Surge and Swab

Simulated Results



In conclusion

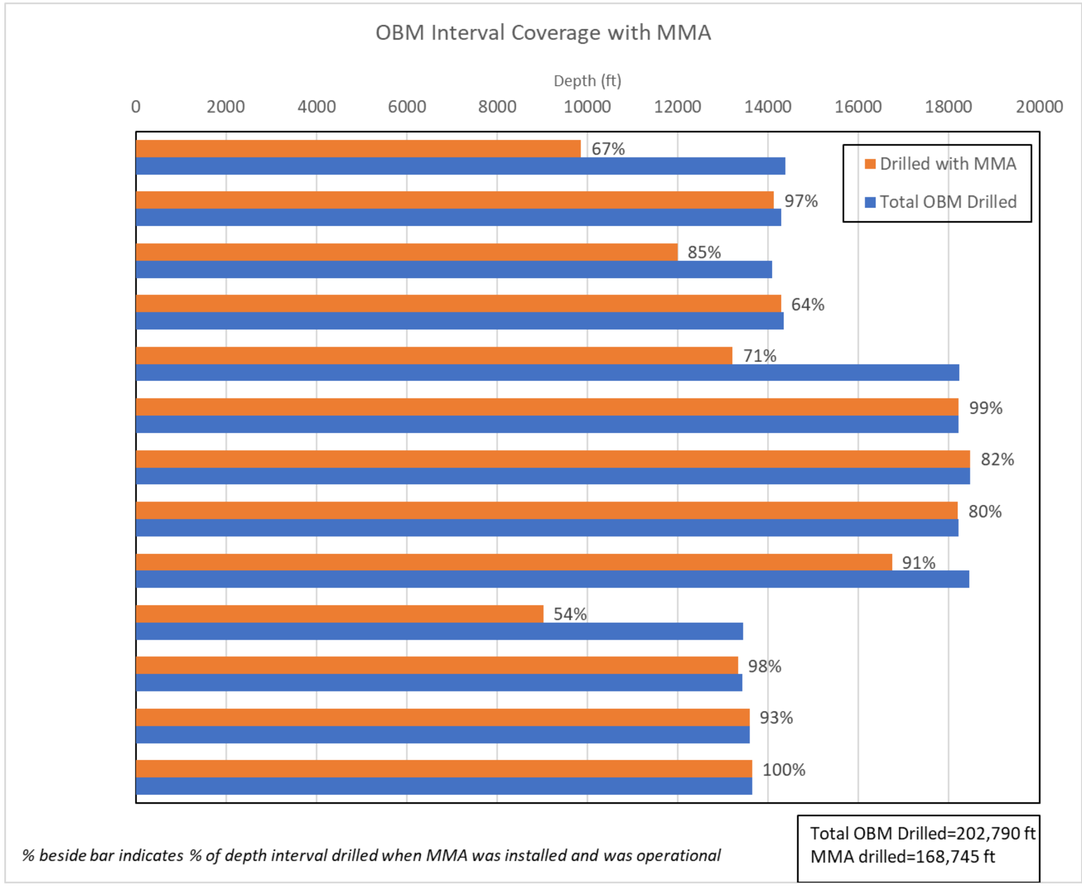
We have deployed our system at multiple pads, over 40 wells with over 500K feet of OBM sections drilled.

We have been able to show field worthiness in terms of robustness, reliability and operational effectiveness

We look forward to sharing more results as they are published this year, e.g., with real-time hydraulics, ECD, pressure drop and hole cleaning metrics.

Additional work on temperature control, ATEX/IECEx, and scalability in deployment for support of different drilling processes, e.g, MPD, is ongoing

Last 13 wells drilled.



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In addition to the authors, we would like to recognize the OFITE technical support and engineering team, specially Sanjit Roy, the ConocoPhillips rig staff, NOV solids handling staff on-site, and NOV corporate staff

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Questions and Discussion

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