Drilling Uncertainty Prediction Technical Section (DUPTS)

Jon Curtis

Bay Driller 1983: Slanted Rig (also Morecambe Flame)

DUPTS
Drilling Uncertainty Prediction Technical Section

- 20,000' MD
- 4,000 TVD

Speaker Bio

- Petrolink International
- Wireline Logging Engineer 1978 -1989
- Petrolink 1990 ->
- SPE Member since 1984
- Oxford University, M.A. Metallurgy and Materials Sciences
- Isle of Man, UK
- Specialized in Data Management Services

Drilling Ahead of the Bit

DUPTS
Drilling Uncertainty Prediction Technical Section

Drilling Ahead of Bit

An Upstream Smart Initiative 2014-2018

Establish an environment to host smart and advanced engineering models to monitor, analyze and interpret drilling data to predict key drilling parameters in real-time and proactively predict and mitigate potential drilling troubles.

Examples of potential drilling troubles:

- Difficult trip, high/low drag
- Borehole instability problems
- Stuck pipe (mechanical, differential)
- Hole Cleaning Issues
- Twist off
- Low ROP

8

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DUPTS Timeline

- Saudi Aramco internal initiative called ‘Drilling Ahead of the Bit’
- Aramco wished to establish this as an SPE initiative
- The ‘Drilling Ahead’ name was rejected by the SPE Board
- Initial name proposed by the SPE:
- Drilling Performance Simulation and Prediction Technical Section (DPSP)
- This was approved by the SPE on 24 June 2014.
- DPSP was changed to the Drilling Uncertainty Prediction Technical Section on 3 April 2015,

DUPTS Original Officers

Name	Position	Email	Primary Employer
Mr. Jonathan David Curtis	Chairperson	jon.curtis@petrolink.com	Petrolink International Ltd
Mr. Musab Mohammad Al-Khudiri	Program Chairperson	musab.khudiri@aramco.com	Saudi Aramco Petroleum Engineering Applications Support Division
Mr. Abdulqawi M Al-Fakih Sr.	Membership Chairperson	afakih@slb.com	Schlumberger Saudi Arabia
Mr. William R Chmela	Webmaster	bill.chmela@gmail.com	Motive Drilling
Dr. Fatai Adesina Anifowose	Secretary	fatai.anifowose@aramco.com	King Fahd University of Petroleum & Minerals, Saudi Arabia

DUPTS Current Officers:

Name	Position	Email	Primary Employer
Mr. Jonathan David Curtis	Chairperson	jon.curtis@petrolink.com	Petrolink International Ltd
Mr. Musab Mohammad Al-Khudiri	Director	musab.khudiri@aramco.com	Saudi Aramco PEASD
Mr. Rayed M Al-Arashi	Director	alarashi@adma.ae	Abu Dhabi Marine Operating Co. (ADMA)
Dr. Rolv Rommetveit	Program Chairperson	rr@edrilling.no	eDrilling Solutions
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Dr. Abdennour Seibi	Content Development Co-Chair	acs9955@louisiana.edu	University of Louisiana At Lafayette
Dr. Serkan Dursun	Membership Chair	sdursun@hotmail.com	
Mr. Salem Hamoud Gharbi	Sponsorship Chair	salem.gharbi@aramco.com	Saudi Aramco PEASD
Mr. William R Chmela	Webmaster	Bill.Chmela@motivedrilling.com	Motive Drilling Technologies
Mr Rollyn S Reyes	Treasurer	rollyn.reyes@gmail.com	Cenergy International Services

DUPTS 2017 Update

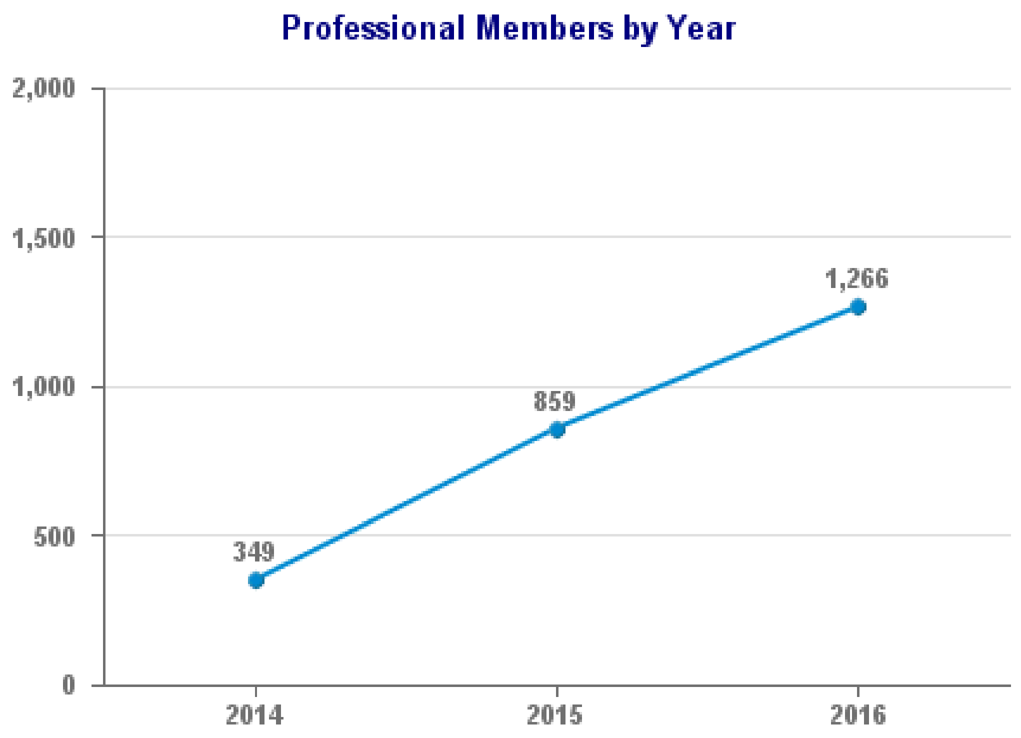
- List of events with a DUPTS Presentation :
  - SPE Young Professionals , Villarhermosa, Mexico, 25 Nov 2016
  - SPE Mumbai Section, Mumbai, India, 28 July 2016
  - SPE Mexico, CMP in Monterrey, Mexico, 9 June 2016
- Special Events for DUPTS
  - DUPTS Special Session at ATCE, Dubai, 26 Sept 2016
  - Drilling Ahead of the Bit Workshop, Saudi Arabia, 20 April 2015
- Other Events where the DUPTS was promoted :
  - SPE - Drilling Best Practices, Dubai , 18-19 April 2016
  - SPE EAGE Geosteering and Well Placement Workshop, Dubai, 8-10 Feb 2016
  - SPE Oil & Gas India Conference and Exhibition , Mumbai, 24–26 November 2015
  - SPE - Intelligent Oil & Gas Abu Dhabi 15-16 September 2015
  - SPE – Drilling Window Prediction and Real-Time Management – Getting it right the first time, Kuala Lumpur, 17-20 May 2015
  - SPE - Mumbai Technical Meeting, Mumbai, 22 Aug 2014
- Future Events:
  - Joint Special Session with DSATS Scheduled at ATCE San Antonio. Saudi Aramco is sponsoring a 1-day DUPTS workshop ahead of ATS&E 2017
  - Summer workshop in Houston 2017

Webinars

- Drilling Real-time Prediction Environment In Saudi Aramco, by Salem Gharbi, on 26 July 2016
- Assessing and Improving Data Quality for more Effective Data Analytics, by David Johnson, on 14 Sept 2016
- Automation: Kick Detection Solutions Example, by Dr. Abdullah Yami, on 30 Nov 2016
- Drilling Optimization, Risk and Uncertainty Reduction, and Future Workforce Education Using Big Data Analysis, by Dr. Eric van Oort, on 22 Feb 2017

- Your Data…Streamlined. Faster. Easier. Trusted... And With Less Turbulence, by Ross Philo and Jay Hollingsworth, Energistics, 11 April 2017
- May: Robello Samuel, title and date to be confirmed
- June: Rolv Rommervelt, title and date to be confirmed

DUPTS Membership to end 2016



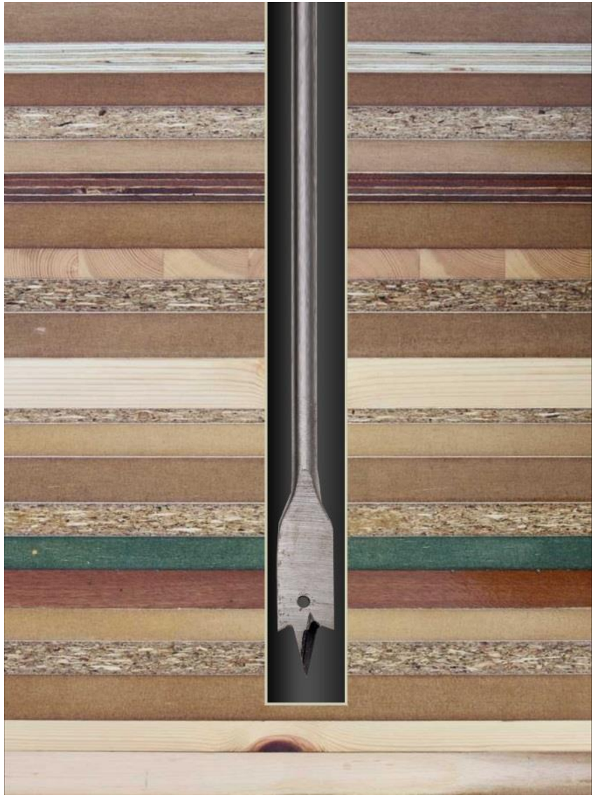
DUPTS Membership 2017

DUPTS Charter : connect.spe.org/dupts/home

The Drilling Uncertainty Prediction Technical Section will address major challenges affecting the cost and efficiency of drilling operations.

By integrating resources and experience from both the Drilling and Subsurface worlds, the primary aim will be to ensure accurate and safe well placement while addressing the needs of the Industry to reduce Invisible Lost Time and mitigate or in some cases even eliminate Non-Productive Time through accurate predictions of geo-hazards.

‘Road Map’

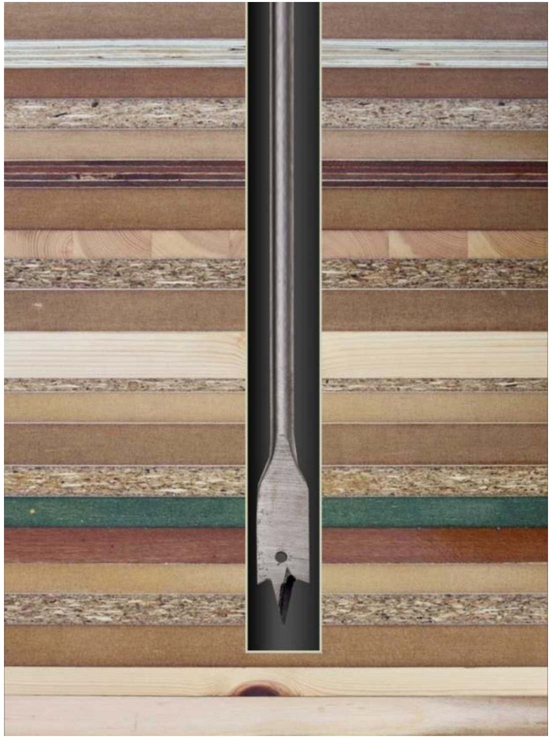


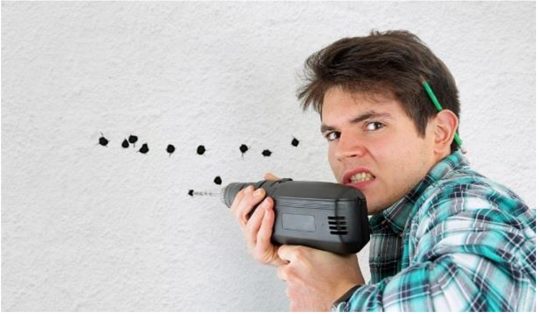
- Best type of Drill Bit
- Best Speed to Drill a certain type of wood
- Best Weight to put on the Drill Bit
- Best Lubrication to use
- How often to apply the lubrication

- Where EXACTLY are the different layers ??
- Here you can see those layers from the side

Commercial Pressures…

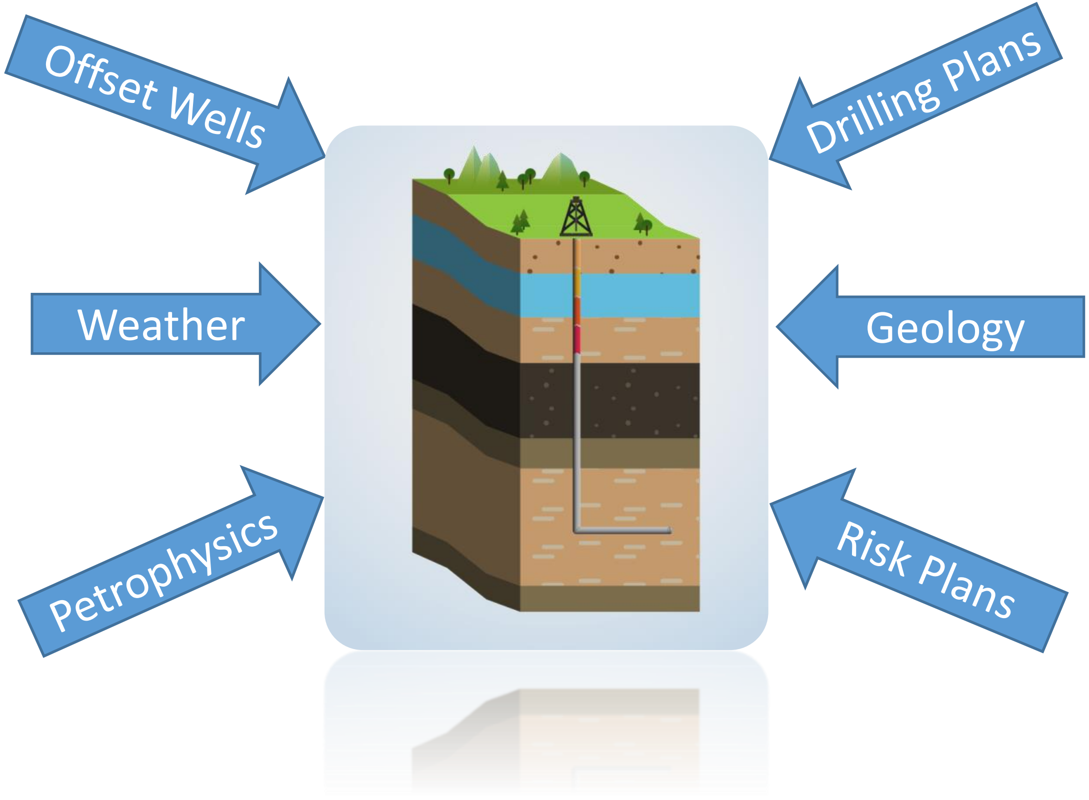
- Drill Faster, even ‘Blind’
- Drill Cheaper, even ‘Blind’



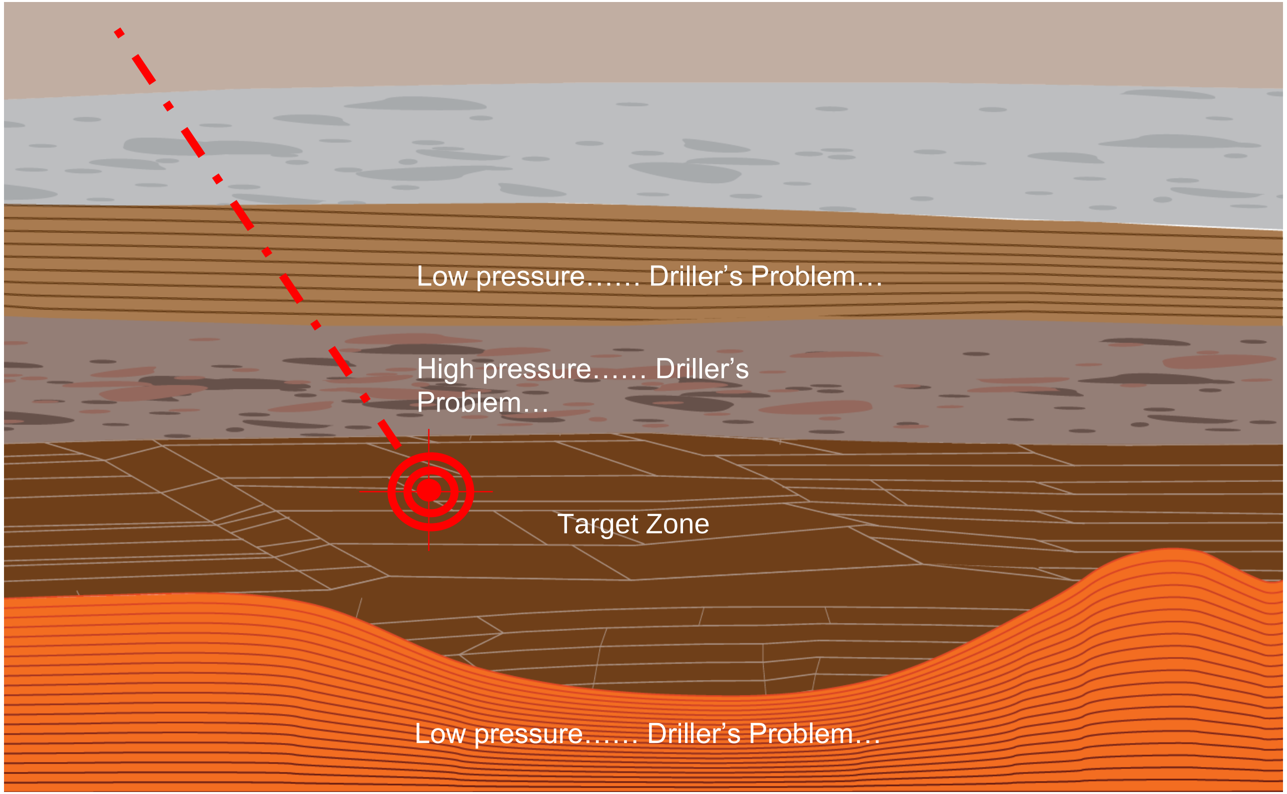


- Accurate Well Placement
- Maximum Reservoir Contact

Planning Data Related to Drilling Activities

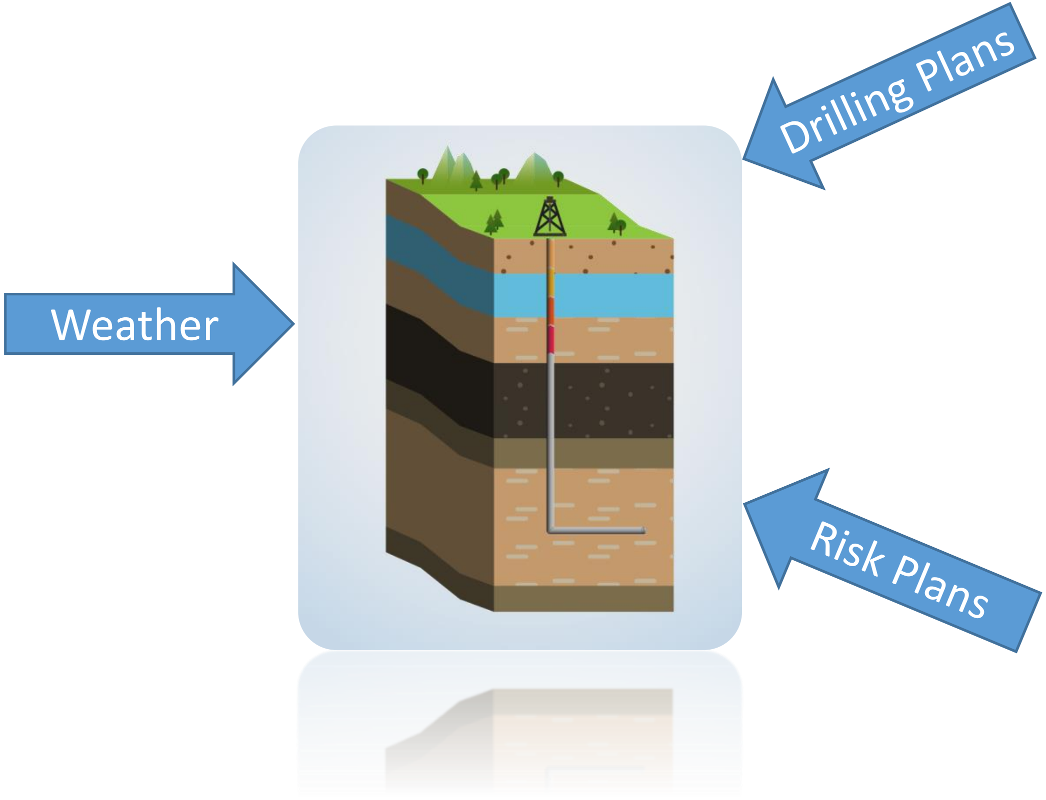


Geologist's View of the Well



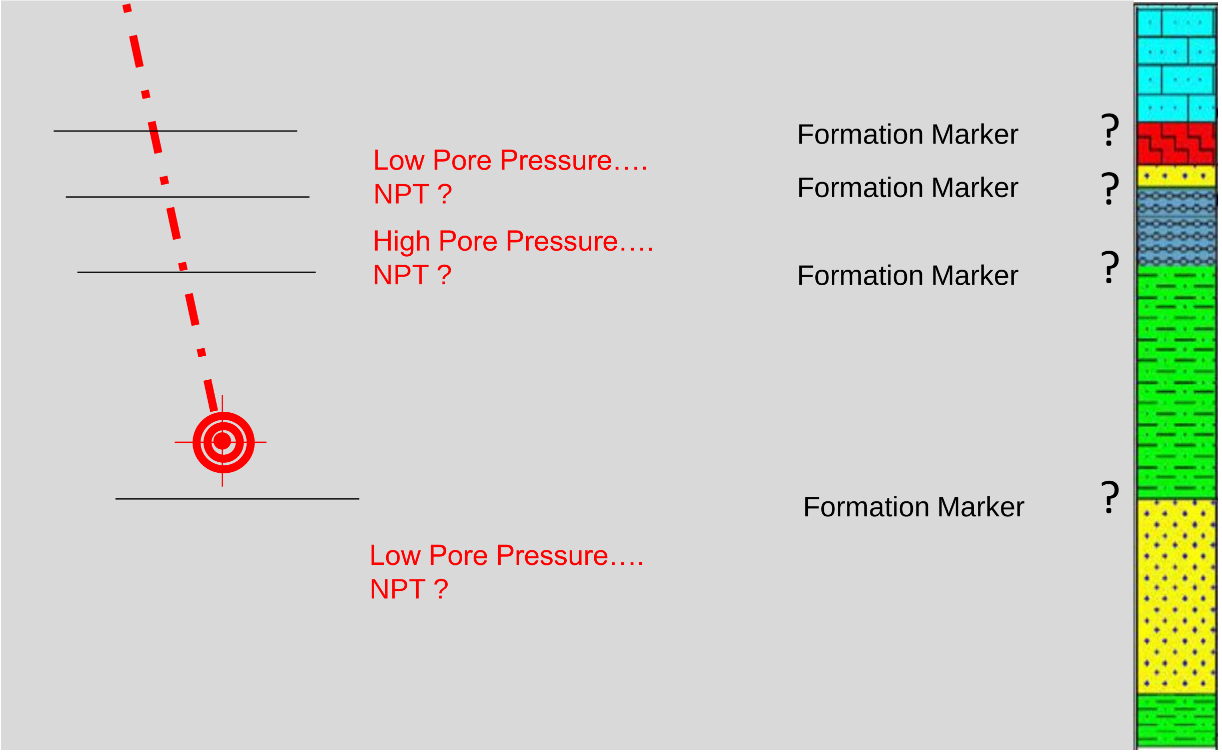
"…I hope that the Driller does not use the wrong Mud Weight and damage my reservoir…"

Data usually available on the Wellsite



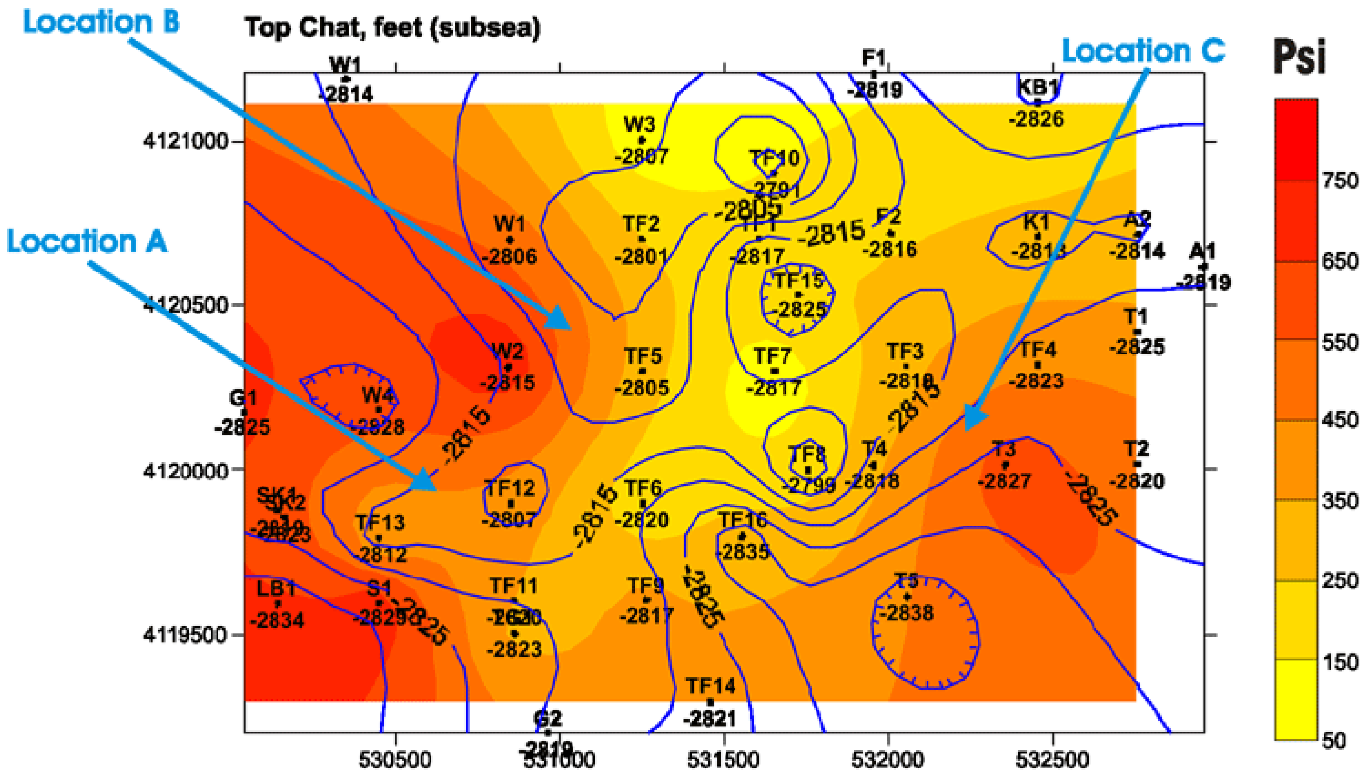
Drillers' View of the Well

"…I wish I knew exactly where I was…..can I reach the Geologist at this time of the morning ….?"



1-D Drilling Plan

Variable Pore Pressures: Mud Weight Window

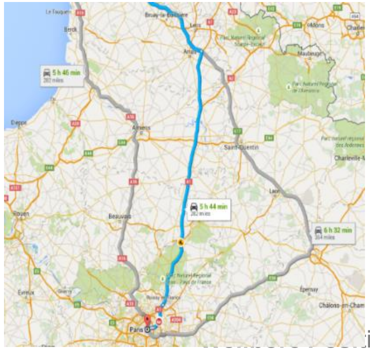


The Driller cannot see the Road Ahead…

Would you put on the Cruise Control in Fog?...................DSATS……………

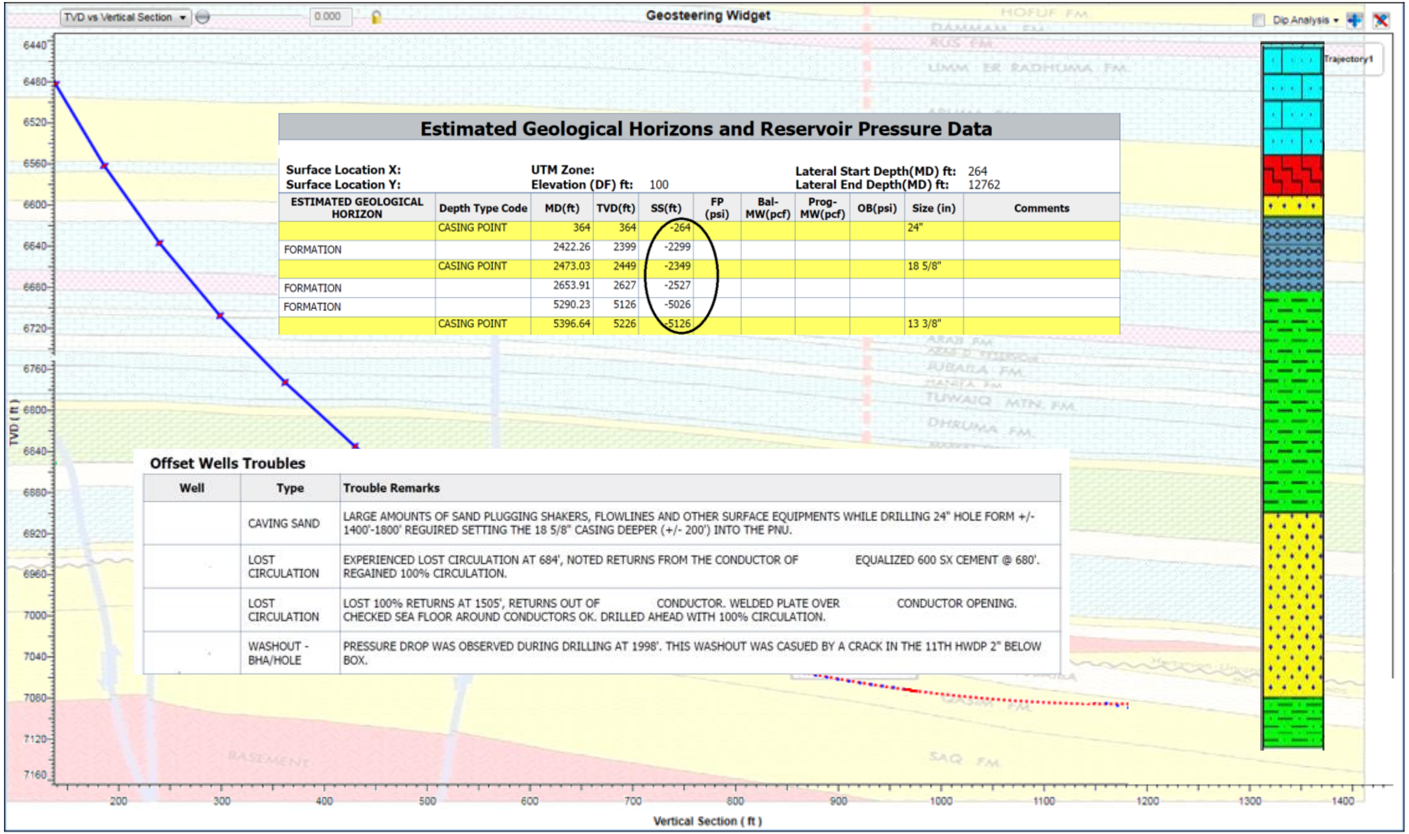
Lack of Prediction

Integration of Sensors and Road Maps



- Time to Target
- Traffic Warnings
- Alternative Road Map
- Weather Events

Curved '1-D' Drilling Program



Estimated Geological Horizons and Reservoir Pressure Data

Surface Location X:
Surface Location Y:
UTM Zone:
Elevation (DF) ft: 100
Lateral Start Depth(MD) ft: 264
Lateral End Depth(MD) ft: 12762

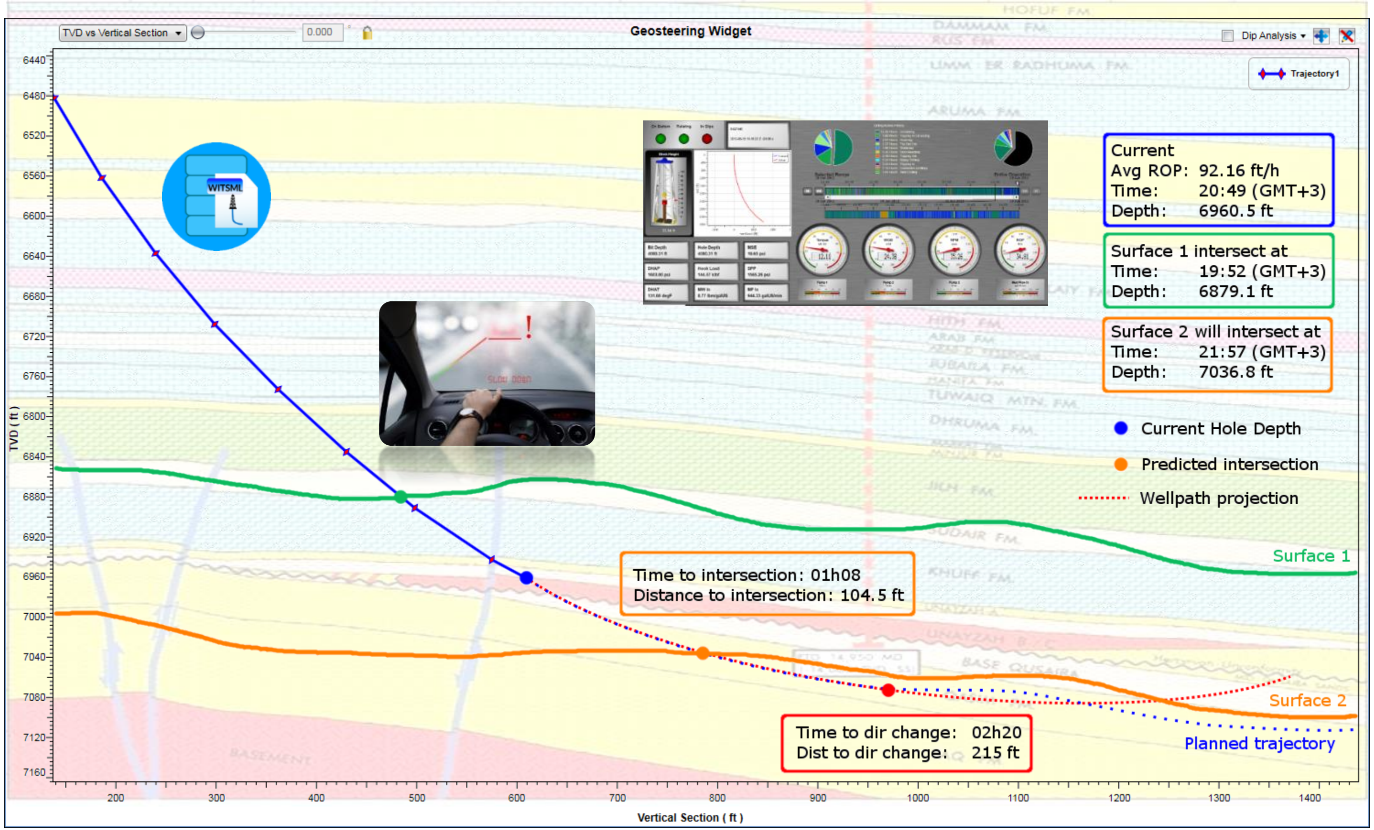
ESTIMATED GEOLOGICAL HORIZON	Depth Type Code	MD(ft)	TVD(ft)	SS(ft)	FP (psi)	Bal-MW(pcf)	Prog-MW(pcf)	OB(psi)	Size (in)	Comments
	CASING POINT	364	364	-264					24"	
FORMATION		2422.26	2399	-2299						
	CASING POINT	2473.03	2449	-2349					18 5/8"	
FORMATION		2653.91	2627	-2527						
FORMATION		5290.23	5126	-5026						
	CASING POINT	5396.64	5226	-5126					13 3/8"	

Offset Wells Troubles

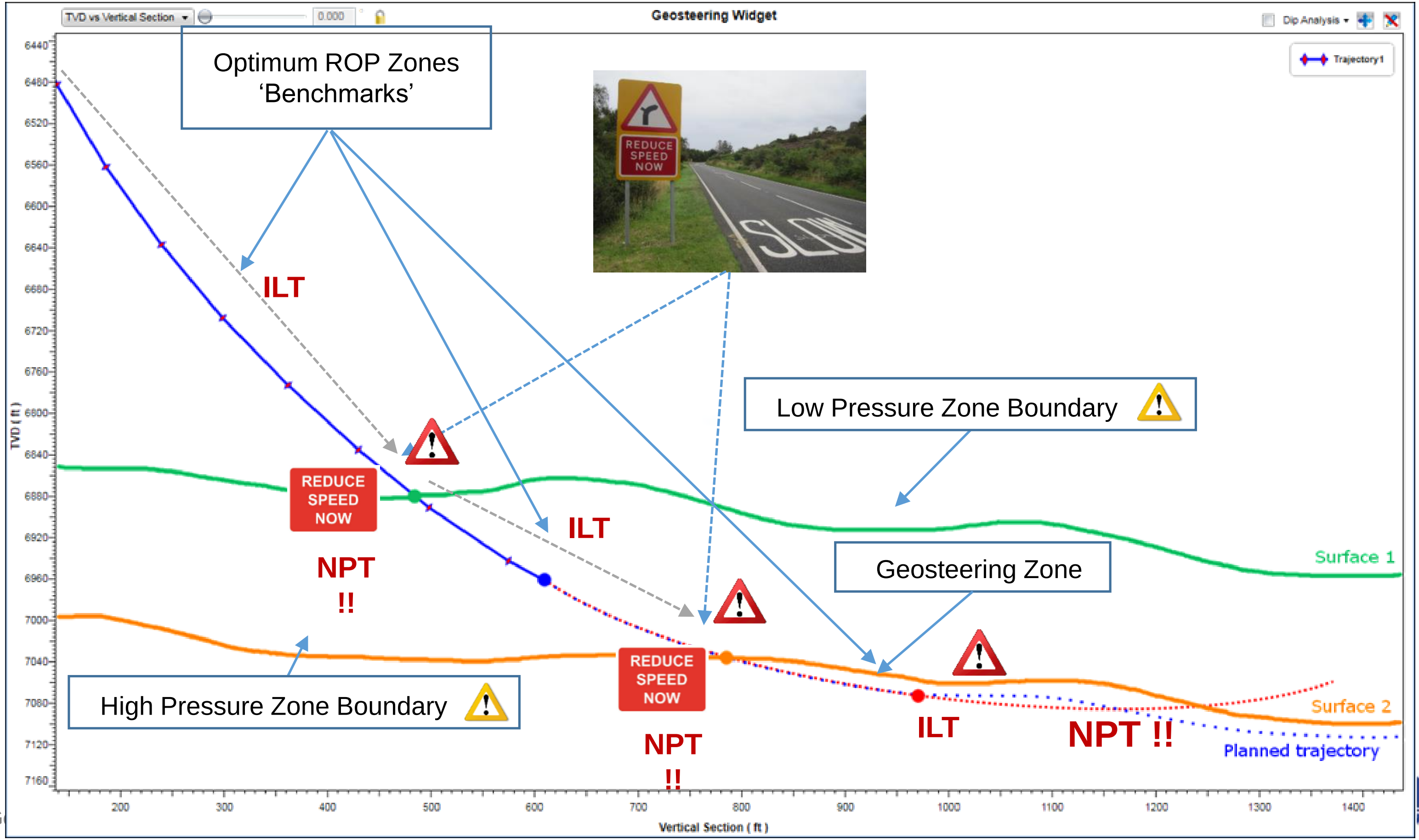
Well	Type	Trouble Remarks
	CAVING SAND	LARGE AMOUNTS OF SAND PLUGGING SHAKERS, FLOWLINES AND OTHER SURFACE EQUIPMENTS WHILE DRILLING 24" HOLE FORM +/- 1400'-1800' REGUIRED SETTING THE 18 5/8" CASING DEEPER (+/- 200') INTO THE PNU.
	LOST CIRCULATION	EXPERIENCED LOST CIRCULATION AT 684', NOTED RETURNS FROM THE CONDUCTOR OF EQUALIZED 600 SX CEMENT @ 680'. REGAINED 100% CIRCULATION.
	LOST CIRCULATION	LOST 100% RETURNS AT 1505', RETURNS OUT OF CONDUCTOR. WELDED PLATE OVER CONDUCTOR OPENING. CHECKED SEA FLOOR AROUND CONDUCTORS OK. DRILLED AHEAD WITH 100% CIRCULATION.
	WASHOUT - BHA/HOLE	PRESSURE DROP WAS OBSERVED DURING DRILLING AT 1998'. THIS WASHOUT WAS CASUED BY A CRACK IN THE 11TH HWDP 2" BELOW BOX.

2-D Drilling Plan with Surfaces from an Earth Model

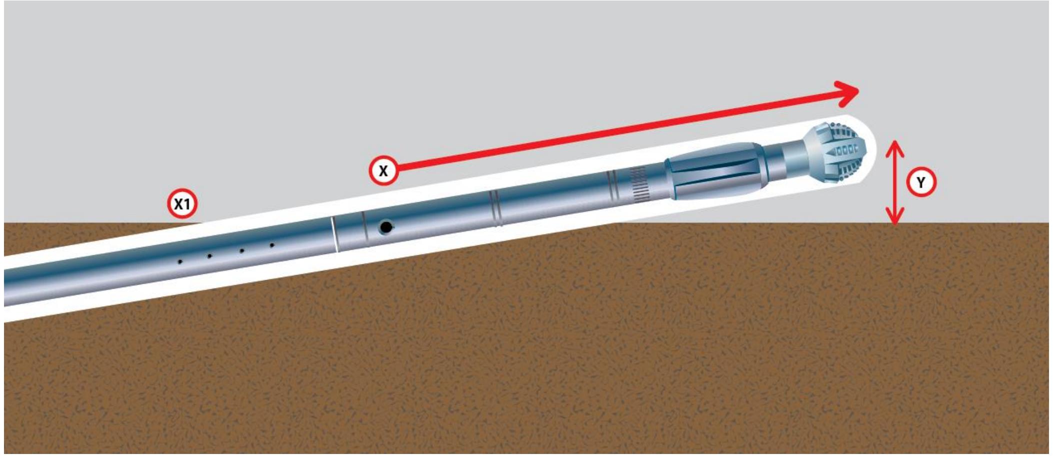
Interactive Arrival Time at Boundaries



Drilling Efficiency : ILT and NPT avoidance

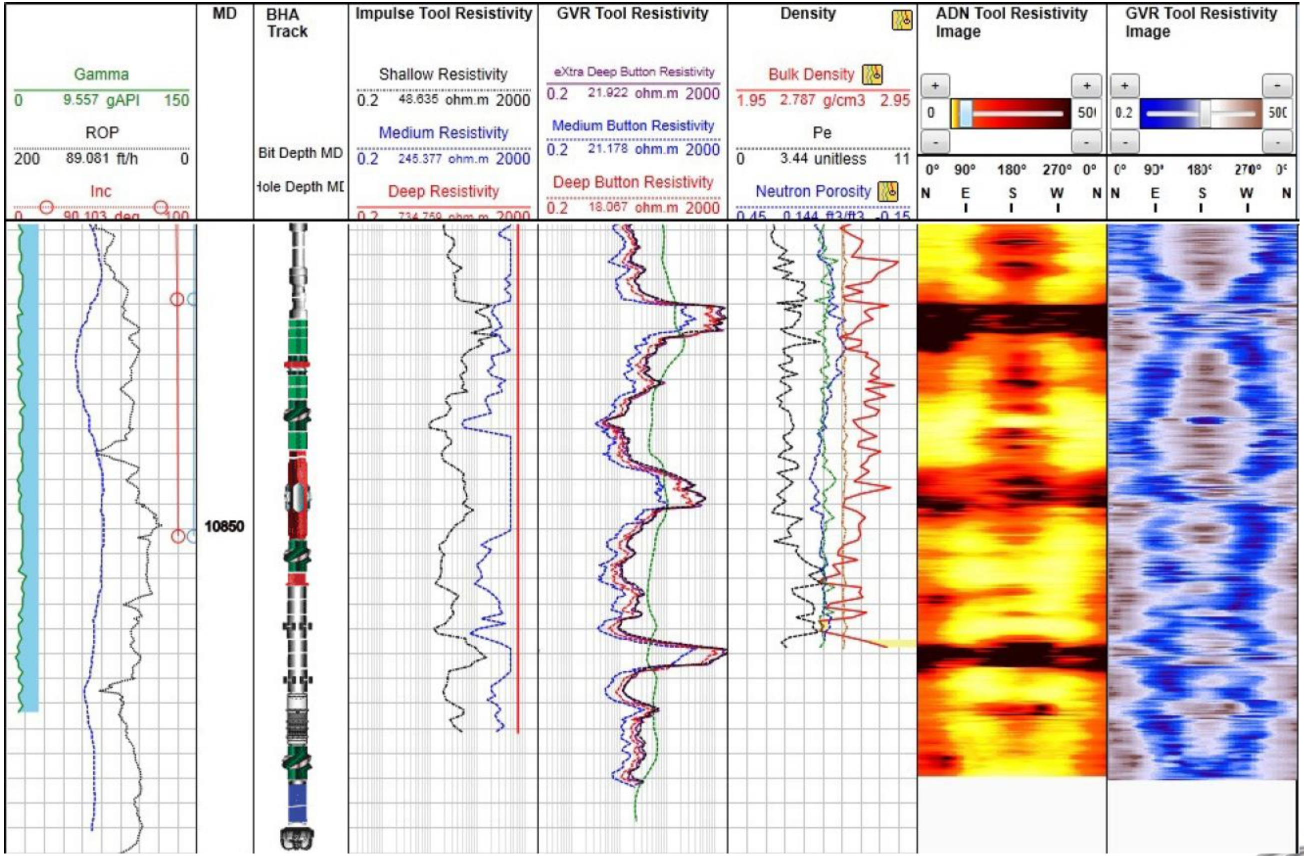


Sensors Behind the Bit



Sensor Offset		
Normal Gamma Ray	**Near Bit Gamma Ray**	**Resistivity**
13 ft	No Sensors	21 ft
59 ft	6 ft	35 ft
46 ft	Not Enabled	64 ft
12 ft	No Sensors	106 ft
35.94 ft	Not Enabled	30 ft
No Sensors	10.93 ft	67 ft
18.64 ft	6.3 ft	25 ft

Sensors Behind the Bit



45th General Meeting
March 17th, 2017
The Hague, The Netherlands

Wellbore Positioning Technical Section

The Industry Steering Committee on Wellbore Survey Accuracy (ISCWSA)

Well Abandoned – 100% NPT

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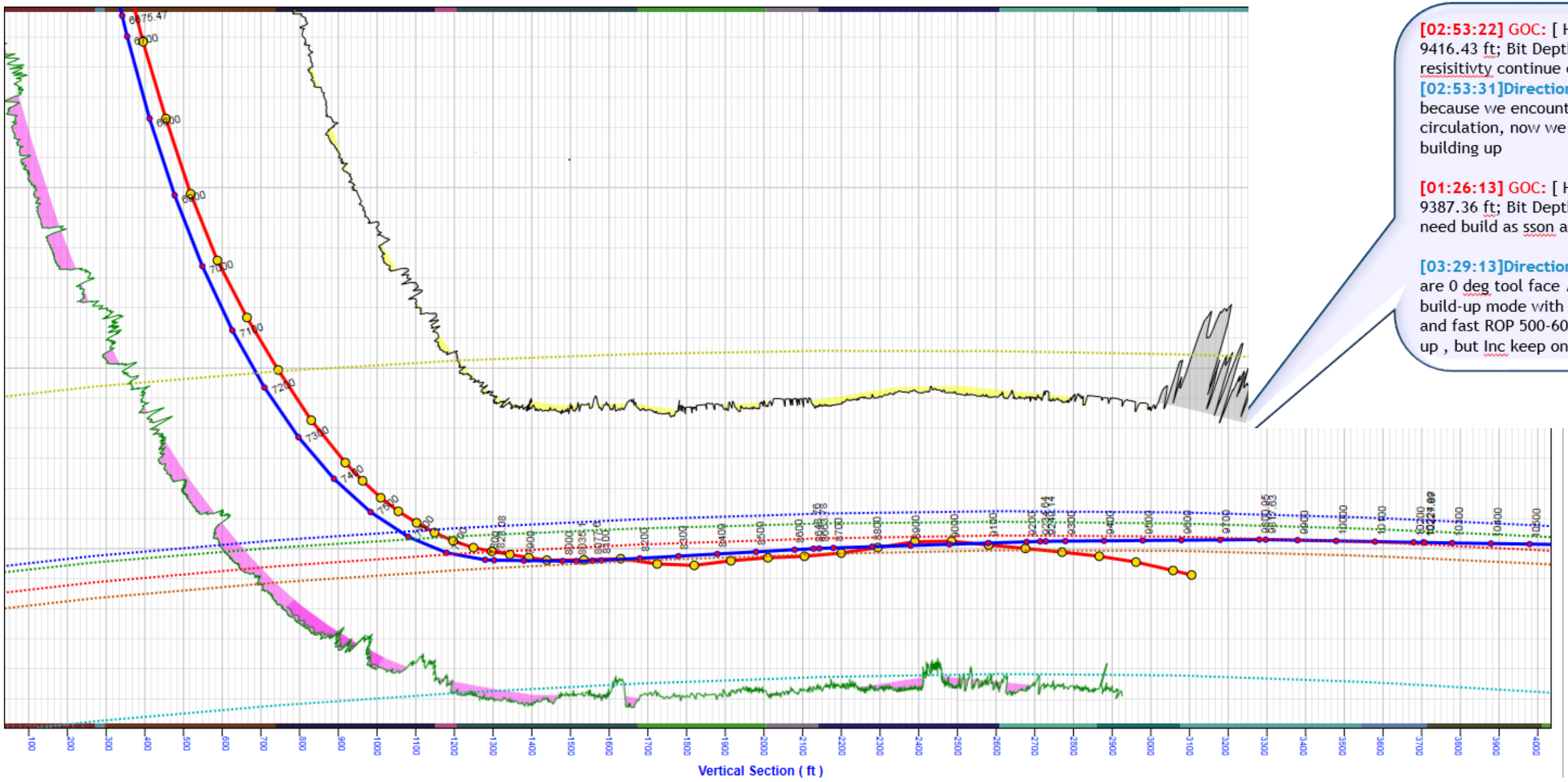
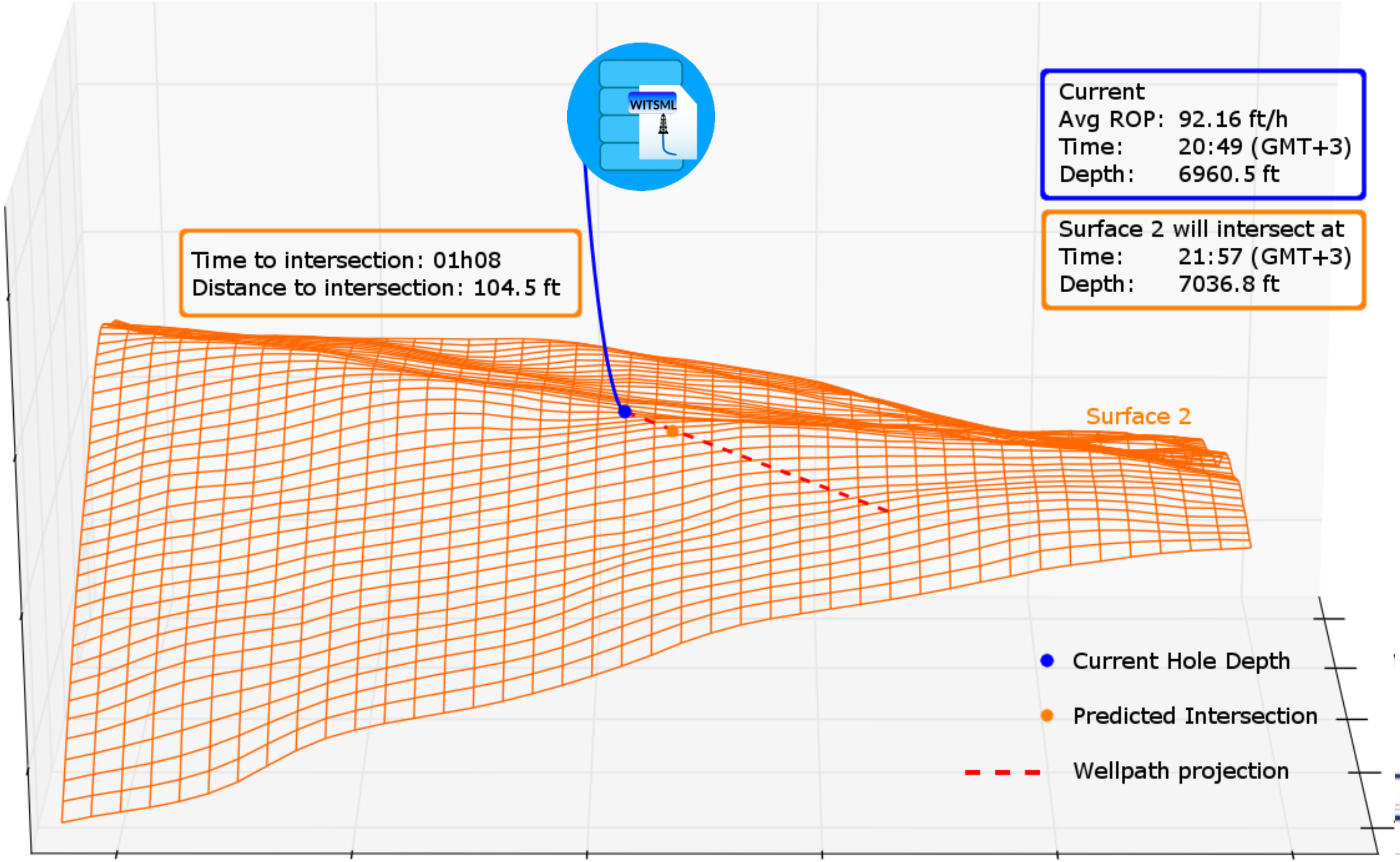


[02:53:22] GOC: [Hole Depth= 9416.43 ft; Bit Depth= 9416.43 ft] the resisitivty continue decreasing
[02:53:31]Directional Driller yes, because we encountered total loss circulation, now we are 100% to building up

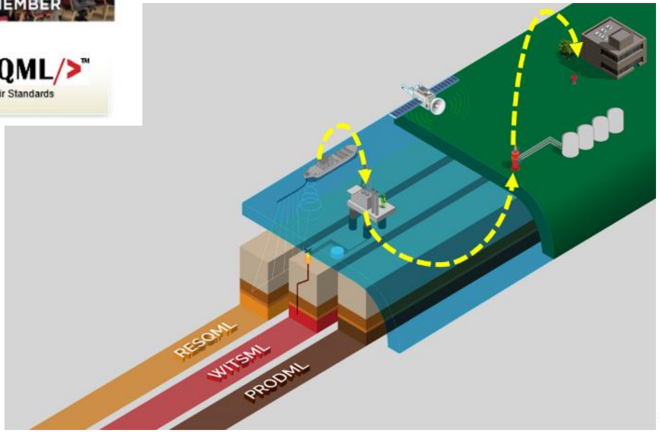
[01:26:13] GOC: [Hole Depth= 9387.36 ft; Bit Depth= 9384.35 ft] we need build as sson as possible to 90.5

[03:29:13]Directional Driller GOC, we are 0 deg tool face / 100% deflection build-up mode with 10-20 wight on bit and fast ROP 500-600ft/hr try to build up , but Inc keep on drop from 88-86,

3-D 'Drilling Ahead of the Bit'



Open Standards : Energistics.org



Reduction of Drilling Uncertainty: Correlation at the Bit

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Drill Time Algorithm

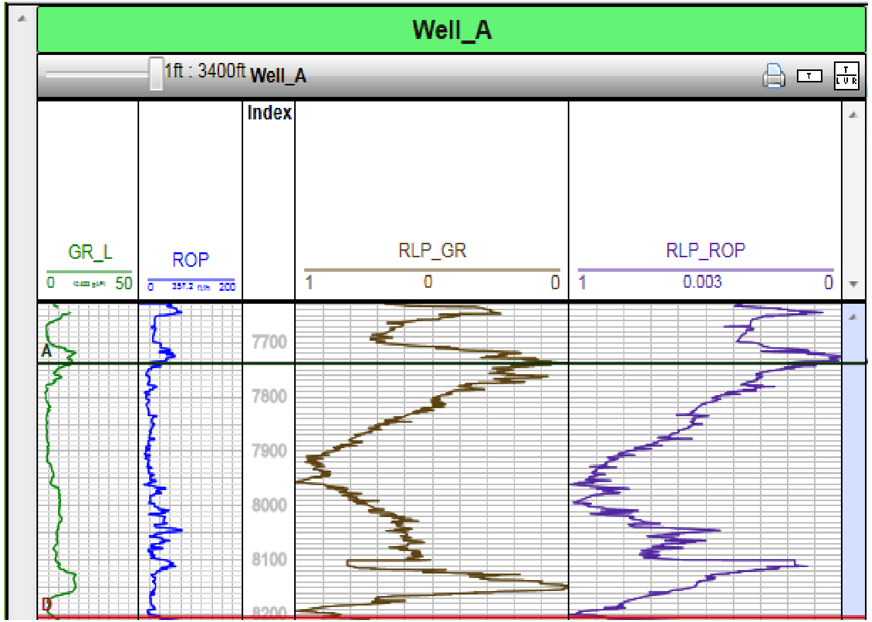
- ROP is the original 'formation log', but drilling breaks are sensitive to mechanical variables: WOB / RPM / SPP
- DT is the Time taken to Drill every 5 ft re-indexed by Depth, using Time / Depth / ROP / RPM
- Reduces sensitivity to mechanical variables
- Produces Formation 'Signatures' that correlate from Well to Well
- Allow remote picking of Casing Points

The Formation Curve

- Advanced Mathematical Algorithms predict the next value and compares with the actual value to create the 'Prediction Error'
- The integration of these Prediction Errors generates trends that may be correlated to sedimentary sequences
- Cross-correlation of the responses allows immediate identification of formation changes at the bit
- Immediate identification should permit Auto-Correlation

Source : SPE 167402 Impact of WITSML Drilling Surveillance on Shallow Casing Shoes

The Bit as a Sensor



- The trends match between logging data and surface sensors
- Correlations picked on the Drilling Sensor Integrated Prediction Errors are later validated by the Subsurface Logging tool trends
- The trends are predictable : 'Drilling Ahead of the Bit'

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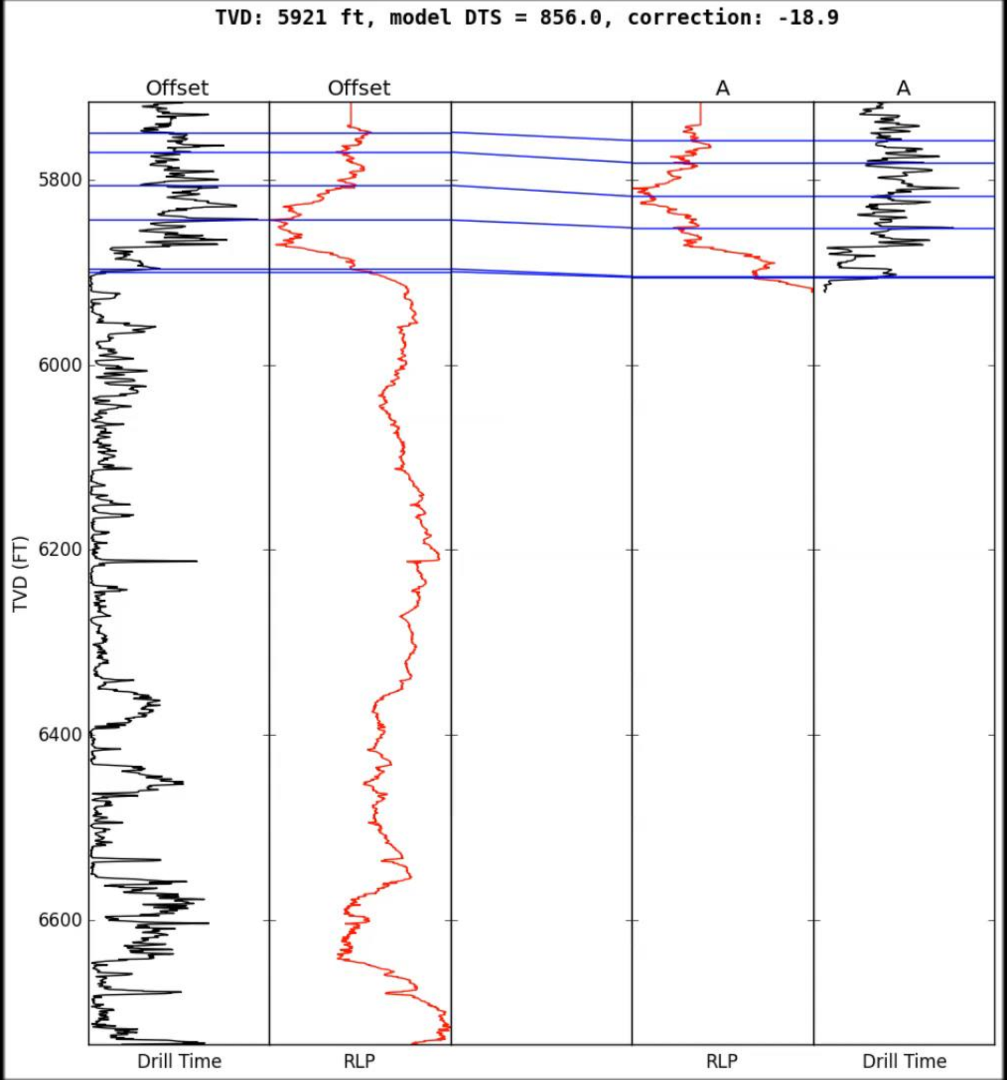
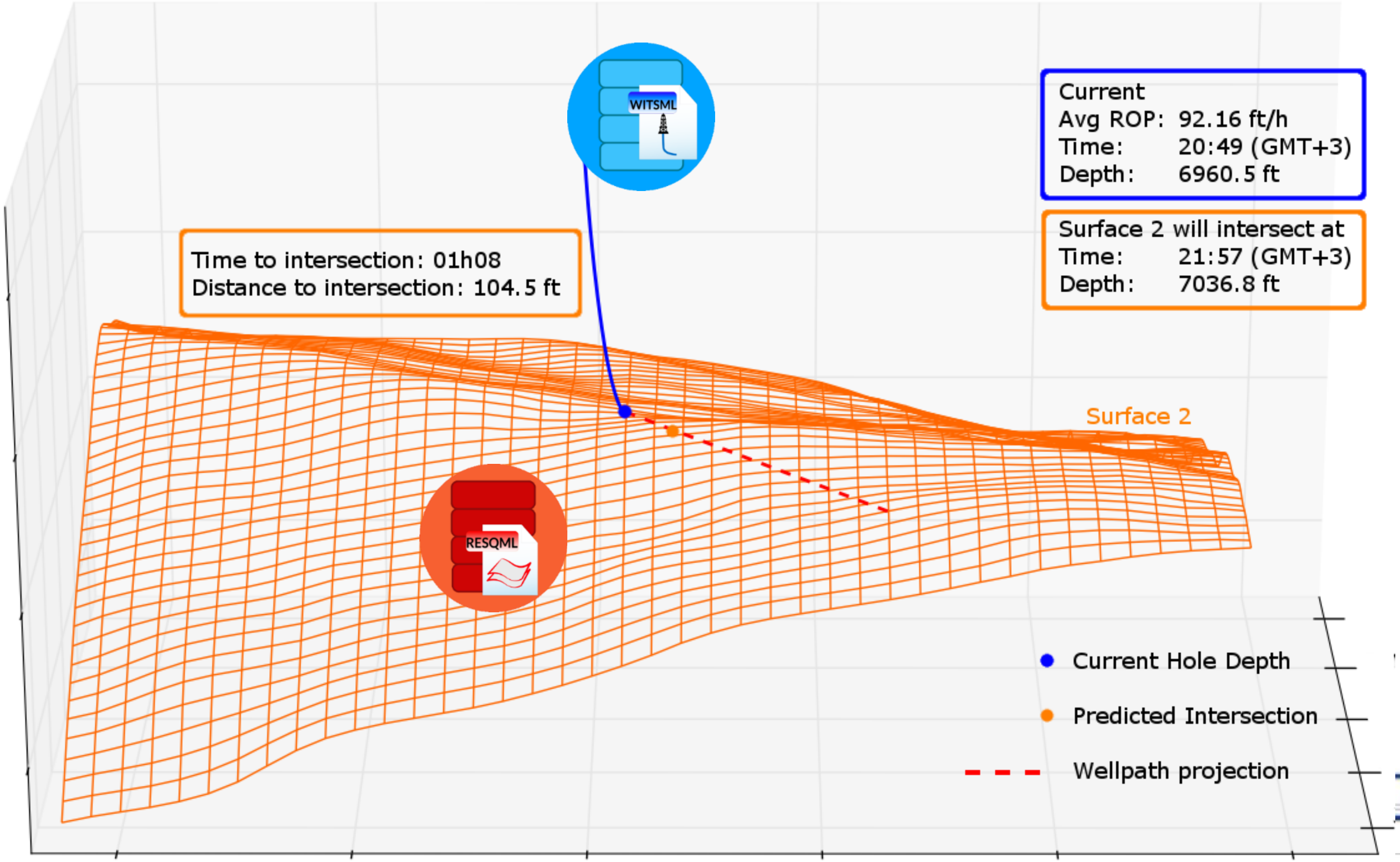
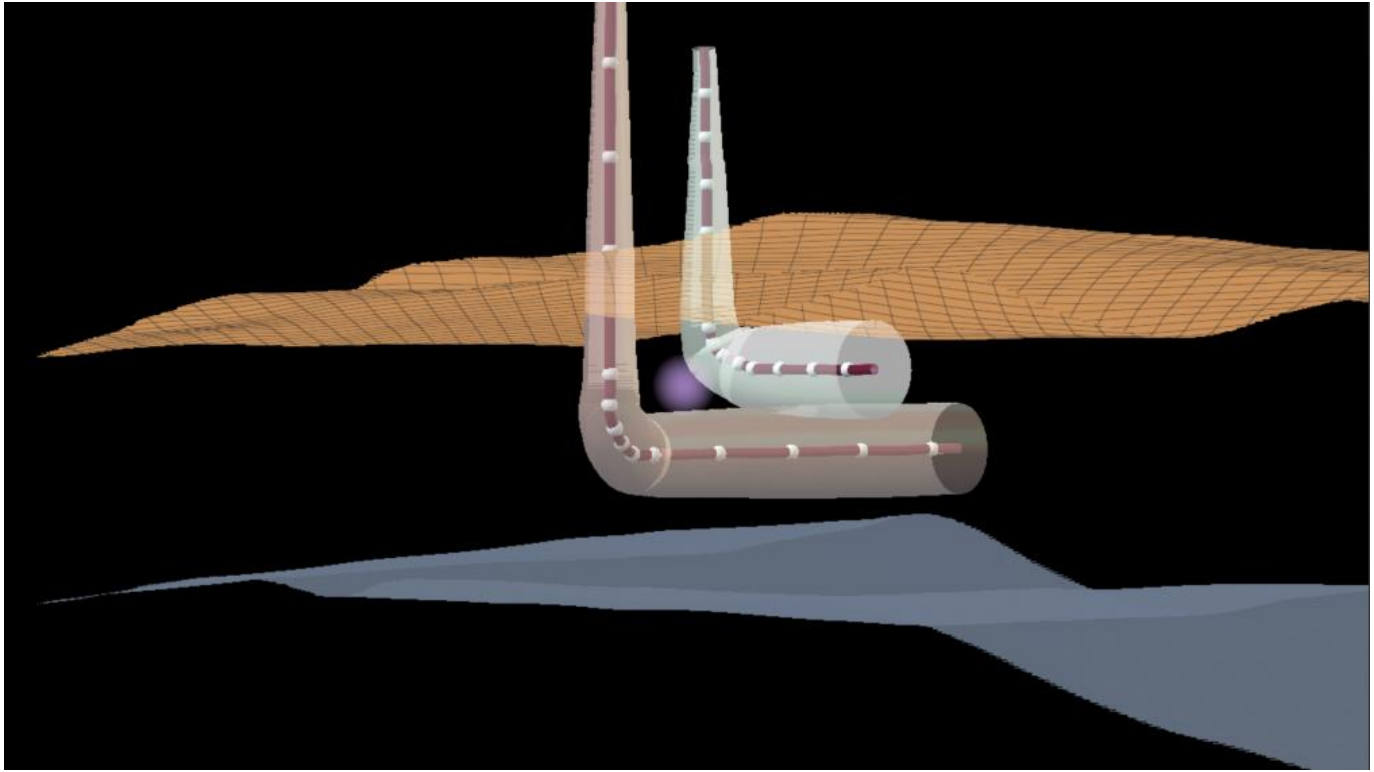


RESQML – 'Shared Earth Model'



Cone of Uncertainty

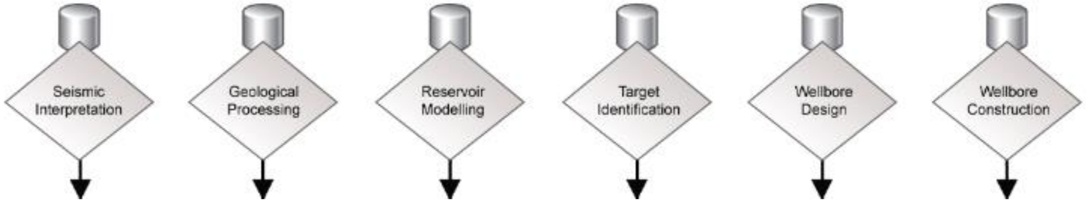


Service Company and Operator Data Sources

Linking these Data Silos ?

Well Planning | Real Time | Earth Model | Service Company A | Service Company B | Service Company C

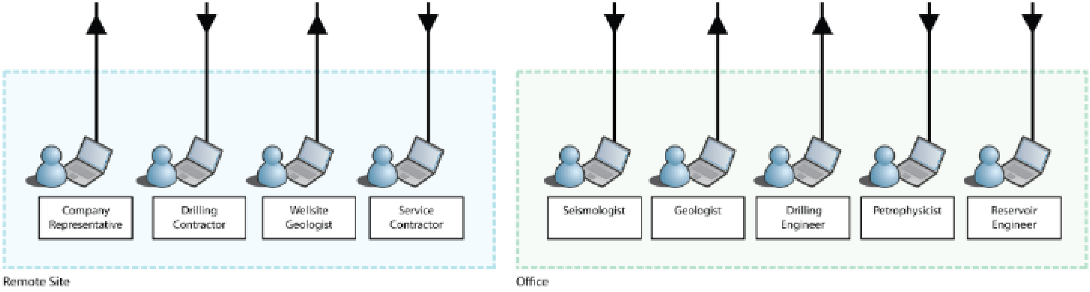
General Oil and Gas ‘Big Data’ Challenge



- Multiple processes involved in well-construction

  Each with:
  - Unique requirements
  - Unique data
  - Different Vendors

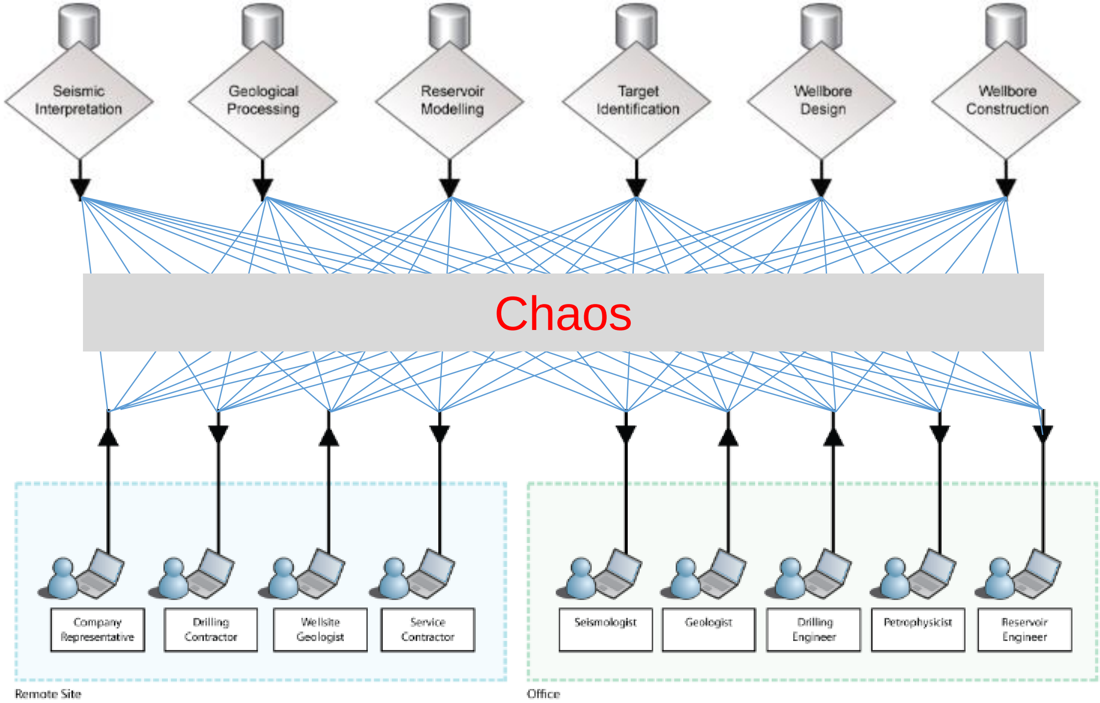
General Oil and Gas 'Big Data' Challenge



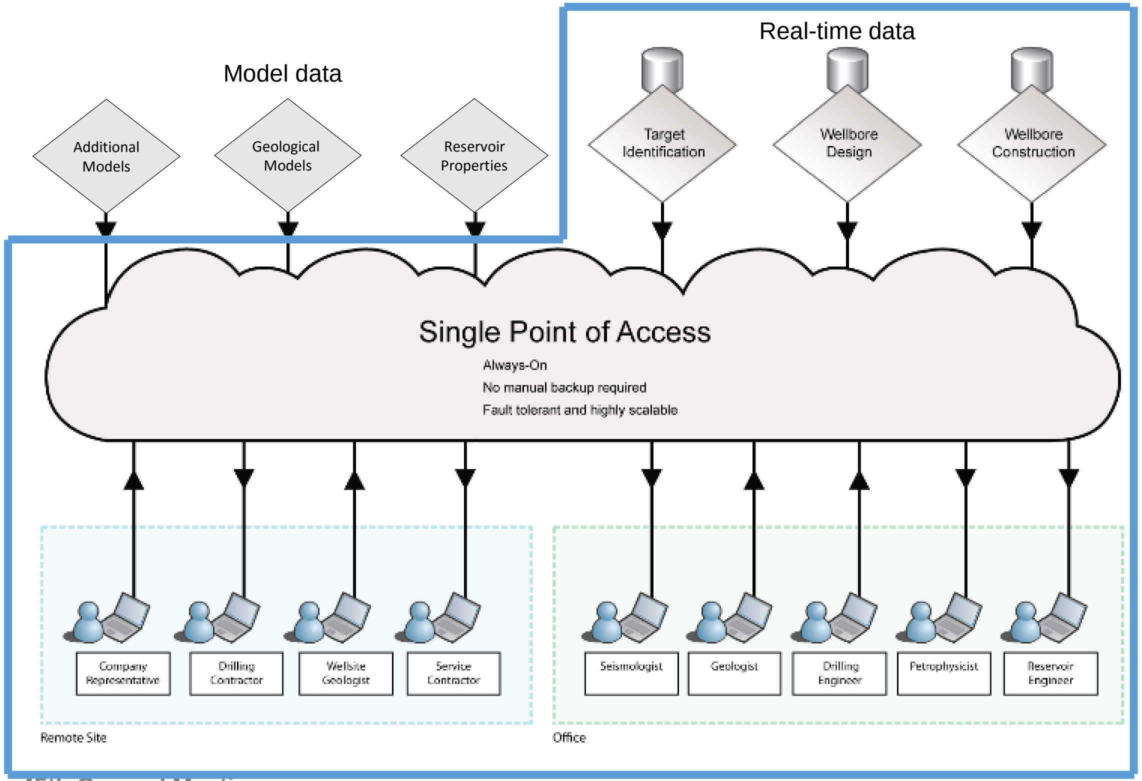
- Multiple services producing aspects of the well-construction

  Each with:
  - Unique requirements
  - Unique technologies
  - Different Vendors

General Oil and Gas 'Big Data' Challenge



Big Data Earth Model – Cloud



- Consistent data – based on Open Standards (WITSML, RESQML)
- Single-Point of access – ensure all relevant data is accessible to all parties needing it
- Built-in redundancy
  Cloud-based technology brought to private systems
- Highly Performant
  Scalable architecture allows growth by users or wells
- Breaks reliance on Vertically Integrated Vendor Solutions
- 'Operator' Earth Model

Big Data Analytics

- Real-time calculations and advanced analytics across all wells, in real-time with sub second response.
- Engineers able to create, test and run their own engineering calculations across the data, real-time and historic.
- Run tens of thousands of calculations simultaneously in a distributed environment
- Allow engineers to focus on engineering, not IT
- 100+ predefined drilling engineering calculations such as MSE, HMSE, Water saturation, Hydraulics ready to use.
- Future support for advanced neural networks and artificial intelligence for predictive drilling and data analysis
- Examples:
  - Calculate ILT, NPT, drilling and rig performance metrics across all wells in real-time.
  - Predict ahead of the bit for time to reach upcoming formations
  - Warn of drilling hazards before they become visible. (Kick detection, fluid loss etc.)
  - Optimize drilling efficiency using ROP Roadmaps

Drilling Ahead of the Bit

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Drilling Ahead of Bit

An Upstream Smart Initiative 2014-2018

Establish an environment to host smart and advanced engineering models to monitor, analyze and interpret drilling data to predict key drilling parameters in real-time and proactively predict and mitigate potential drilling troubles.

Examples of potential drilling troubles:

- Difficult trip, high/low drag
- Borehole instability problems
- Stuck pipe (mechanical, differential)
- Hole Cleaning Issues
- Twist off
- Low ROP

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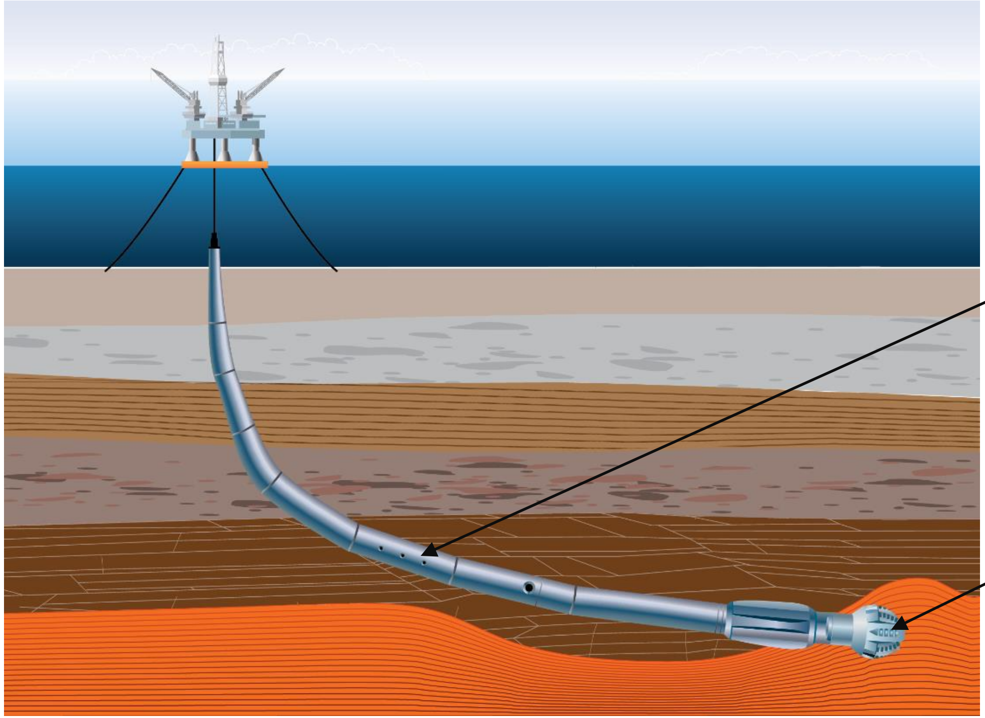
Determination of lithology at the bit by machine learning approach (PoC)



LWD
Tools

Seek
knowledge of
formation
here ?

Drivers

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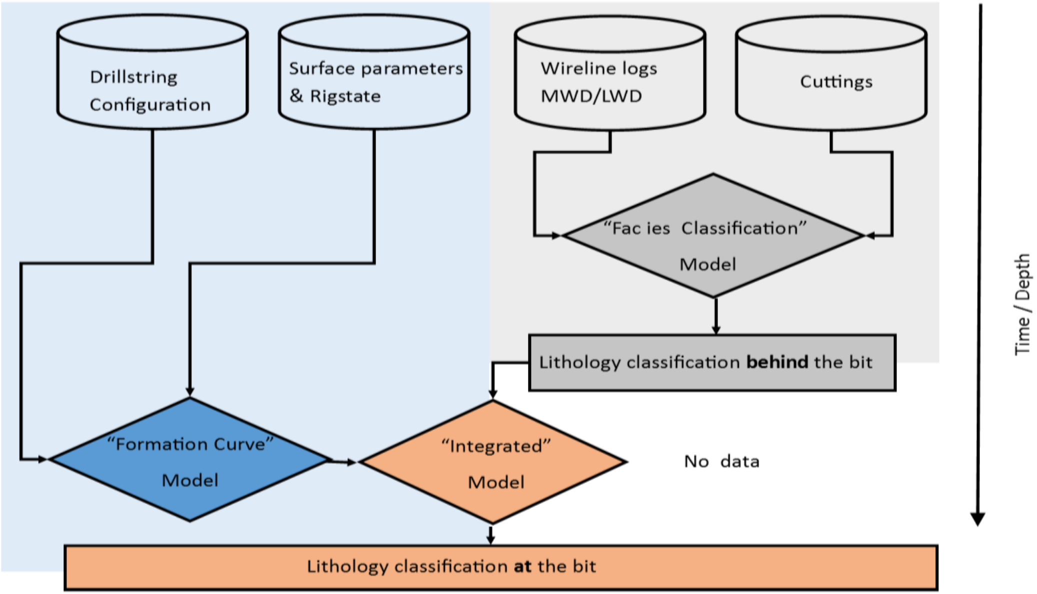
- Knowledge of work flow by machine learning approach in facies classification project (SEG Contest)
- Availability of multiple wells in the same region (UK)
- Availability of good quality data from LWD, Surface, trajectory logs, static data (Bit information) in these wells
- Availability of empirical drilling models
- BHA consistency
- Drill bit information

Two models running together

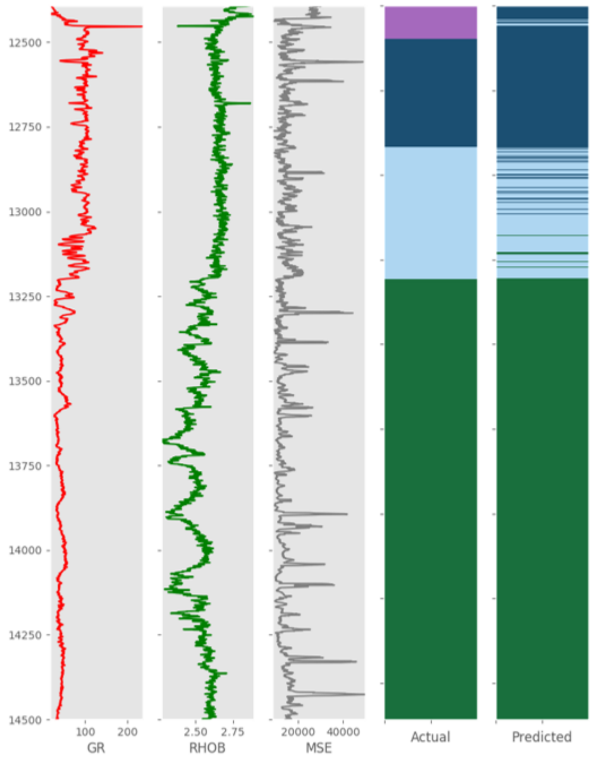
- One model predicts the type of lithology from the LWD logs behind the bit
- One model predicts the type of lithology form the surface parameters. The prediction from the LWD logs feeds with the model and enables the prediction at the bit.



Feature Engineering Techniques Incorporated

- Outlier removal – Data quality technique
- Feature Augmentation
- Use of mean specific energy (MSE) also to represent surface parameters
- Bit design features incorporated. Bit Wear is assumed to be proportional to its depth
- K – drillability models
  - Parameters of drillability models established by least squares moving window method

Prediction of Lithology Type



Accuracy 90 %

Comments

- Model could be improved with hyper parameter tuning.
- Cuttings lithology classification is prone to error as it was a manual digitization of a pdf document

SEG Competition:

- https://agilescientific.com/blog/2017/2/2/no-secret-codes
- In this PoC, a machine learning approach was implemented to estimate the type of lithology at the bit.
- Classification models were employed with an integrated workflow obtained from facies classification project and formation curve project
- Feature engineering techniques improved prediction accuracy.
- Future
  - Validating with more data. More variety of lithology type. Currently, we investigated only 4 types.
  - Incorporate ROP models in feature engineering
  - Estimate the recommended ROP for a predicted formation type to ensure drilling accuracy


Thank You
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