Introduction to Drilling Data Analytics

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RAPID R&D Focus Areas

- Automation Control Systems
- Modeling & Simulation
- **Big Data Analytics**
- Intelligent Mechanization, Robotics
- Undergraduate Programs

ExxonMobil

Sinopec

HESS

Apache

BAKER HUGHES

PIONEER NATURAL RESOURCES

woodside

ConocoPhillips

NOV

ارامكو السعودية
Saudi Aramco

Anadarko Petroleum Corporation

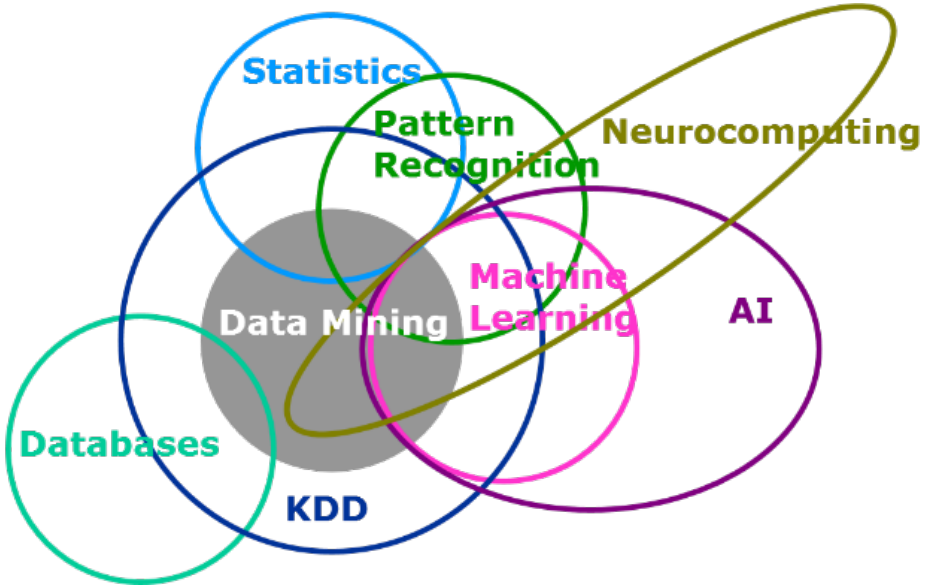
STAGE 3 SEPARATION

Tsinghua University

TERADATA

Big & Messy Data Analytics

- We are at the dawn of using big / messy data analytics in well construction and operation
- Key hurdles associated with data quality, reliability, security, communication, novel sensors, etc. still need to be addressed

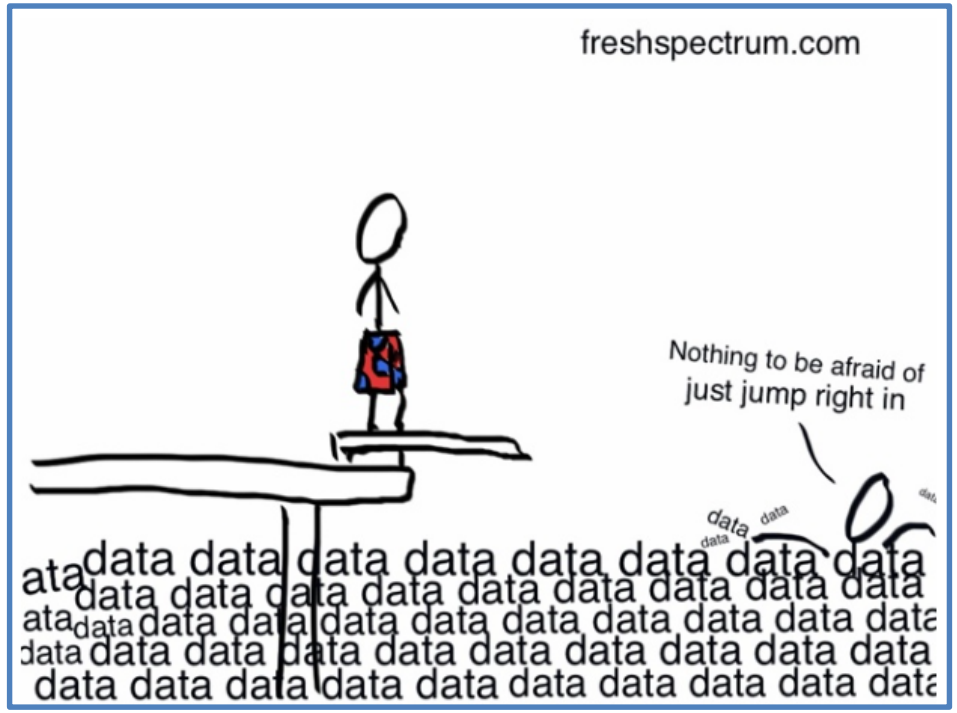


Source: SAS

- Complexity arises because Mother Nature is highly unpredictable, but…….
- There is an incredible amount of value to be obtained from data mining, machine/statistical learning, pattern recognition, AI, etc.
- "**The Future is Data … Resistance is Futile**"

Working with Operators on Value Creation

- Drilling and production improvement from in-depth data analysis
- Using unused/under-utilized datasets by operators
- Messy data-problem: data is structured / unstructured, static/dynamic, low/high frequency etc.
- Data issues:
  - Data quality (requiring cleaning/curation
  - Data security and confidentiality
  - Data storage and organization
  - Data processing, visualization, etc.



HESS Apache PIONEER NATURAL RESOURCES

ConocoPhillips Anadarko Petroleum Corporation

RAPID RIG AUTOMATION Performance Improvement in Drilling

Why UT-Austin?

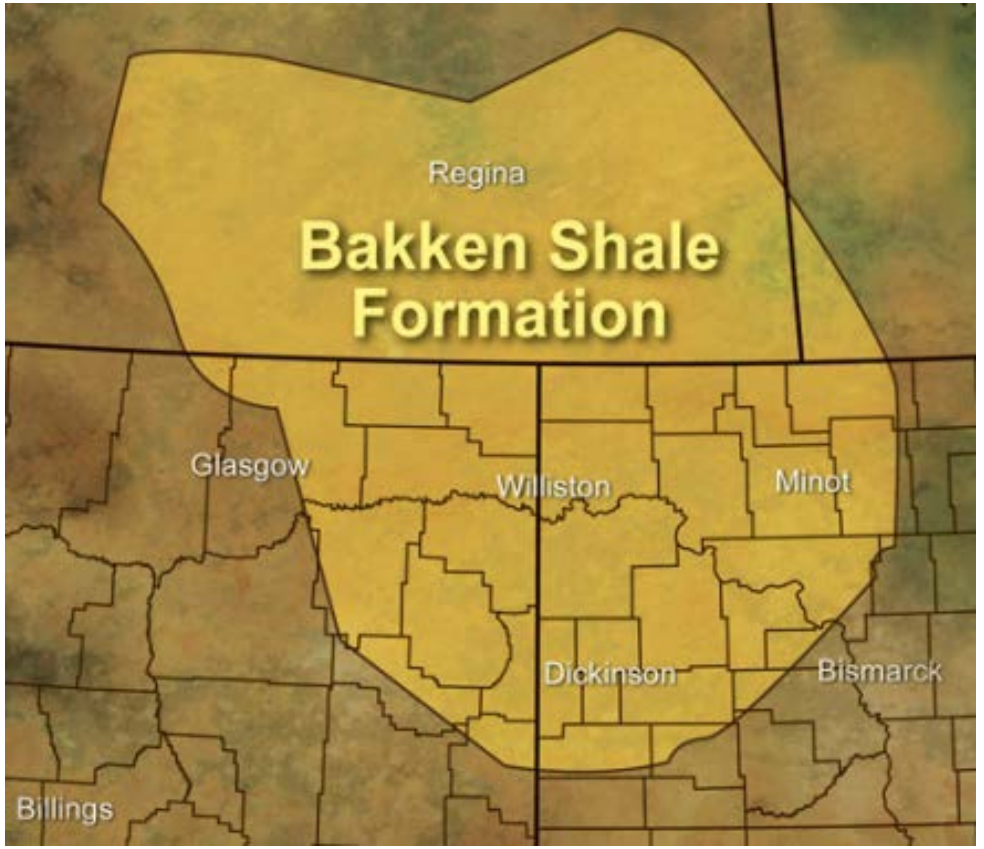
Key enablers:

- Unique infrastructure (Real-Time Remote Collaboration Center, Drilling Simulator)
- High quality gard/undergrad students & senior scientists
- Strong ties to industry with access to field datasets

Really Big Field Data Sources

Wells drilled in the Bakken formation in summer 2015

- Downhole, surface and directional data
- Over 100 GB of sensor data
- Over 20 million rows of data
- 588 listed channels per well
- 6+ GB CSV files
- Daily Morning Reports (DMRs)
- Well plans
- Well surveys
- Formation tops
- Etc.



Typical Example: a 2.5 month data analytics project in the Bakken Shale identified $57.5MM in potential operator savings

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Can Data Analysis Be Accelerated?

Which drilling assembly was the best for the vertical hole section?

Which BHA was the best for the lateral horizontal hole section?

Which rig followed the best connection practice?

How well did the directional driller do?

Which was the best drilled well?

Which drilling crew performed the best?

UT's Storyboarding Approach

1. Data Curation

2. Data Visualization

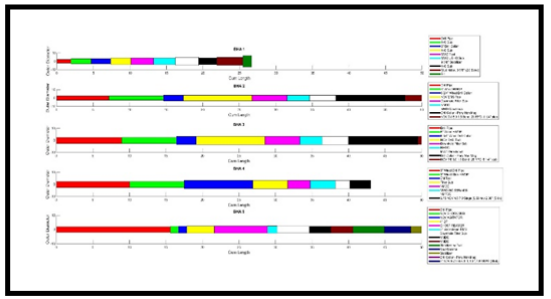
3. Storyboard

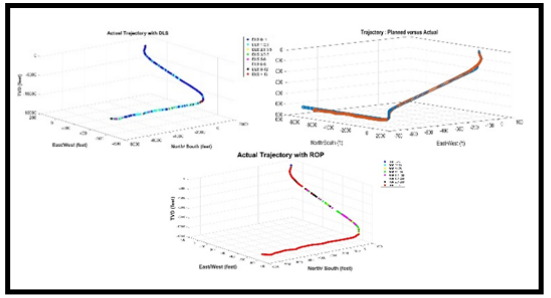
Structured & Unstructured Data Sources

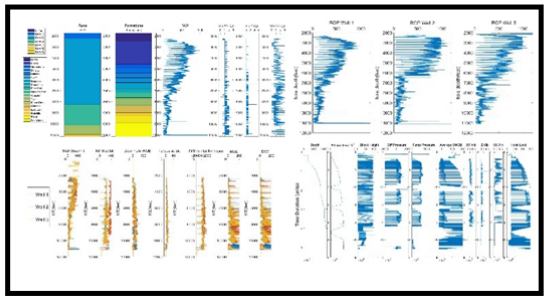
- Well Site Records
- BHA and Run Data
- Survey Data
- Geology Data
- Well Plan

SCRIPTS to import, process and visualize the data

Easy to tweak, control and modify!







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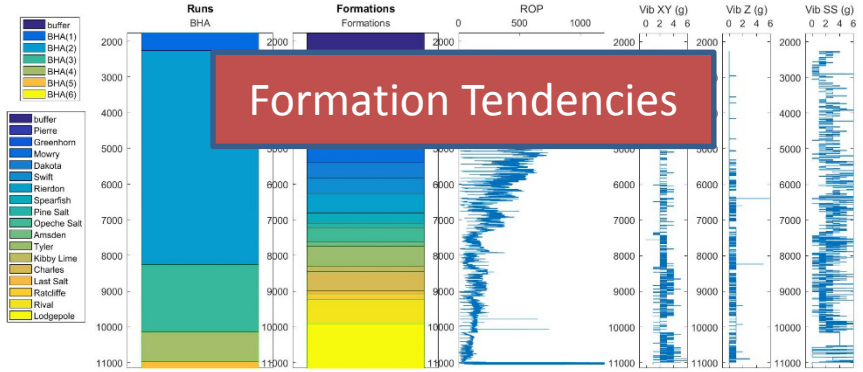
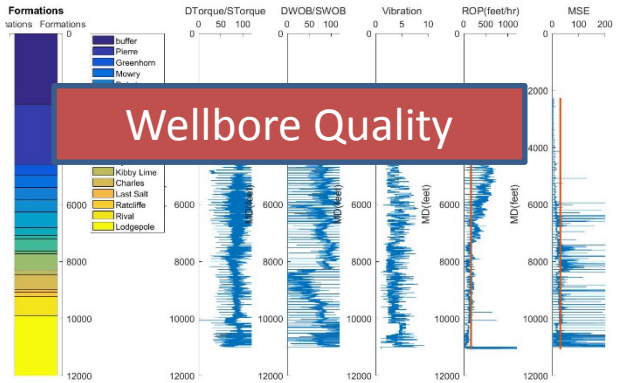
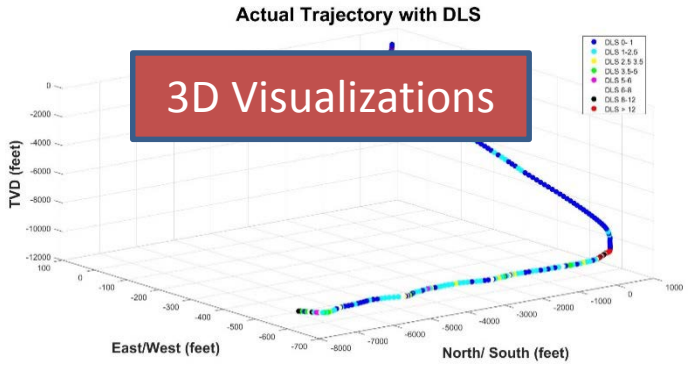
Answering Tough Questions with Visuals



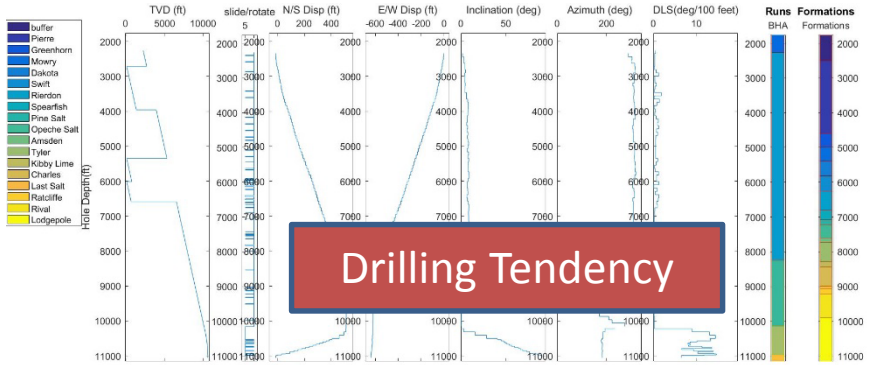
Formation Tendencies



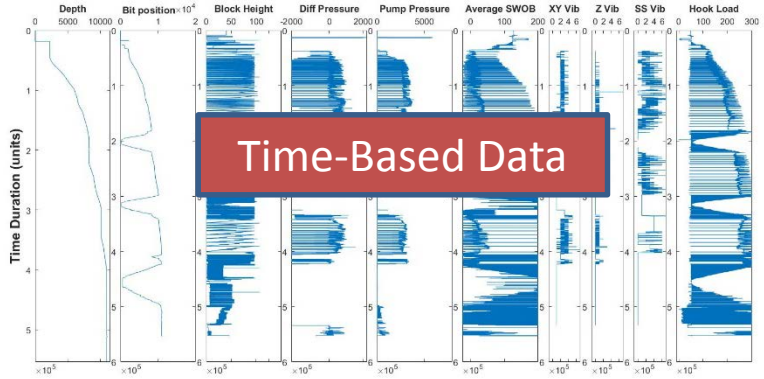
Wellbore Quality



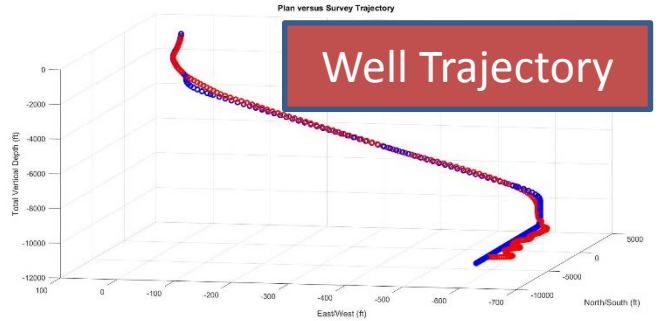
3D Visualizations



Drilling Tendency

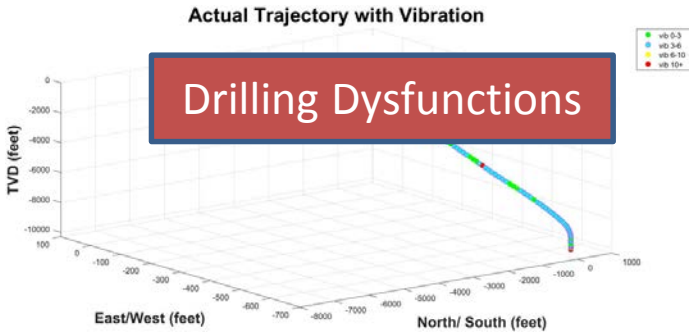


Time-Based Data



Well Trajectory

And many more relevant plots……



Drilling Dysfunctions

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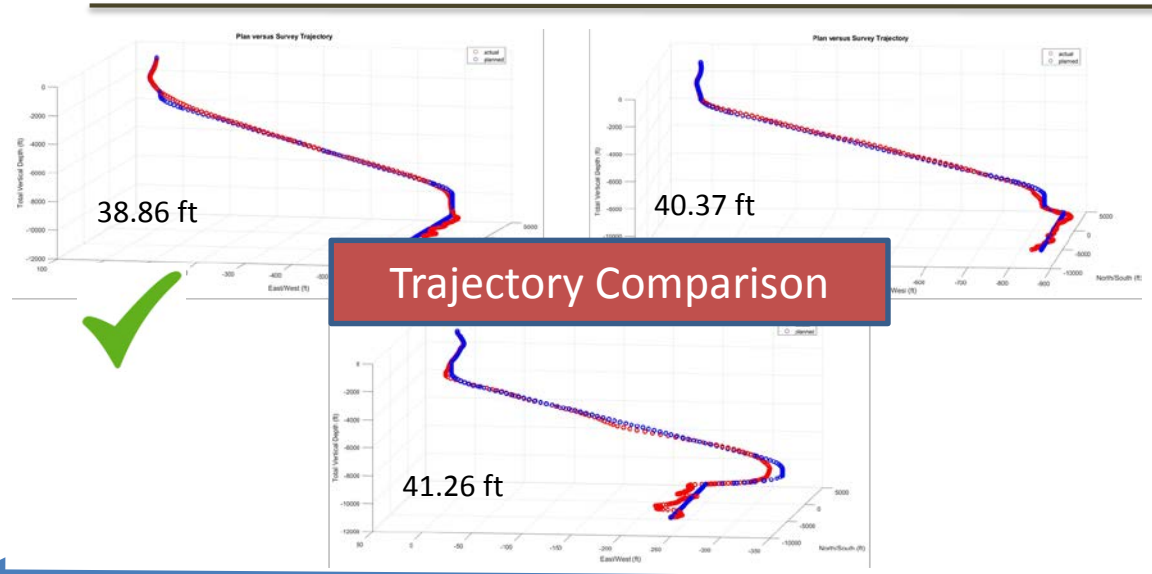
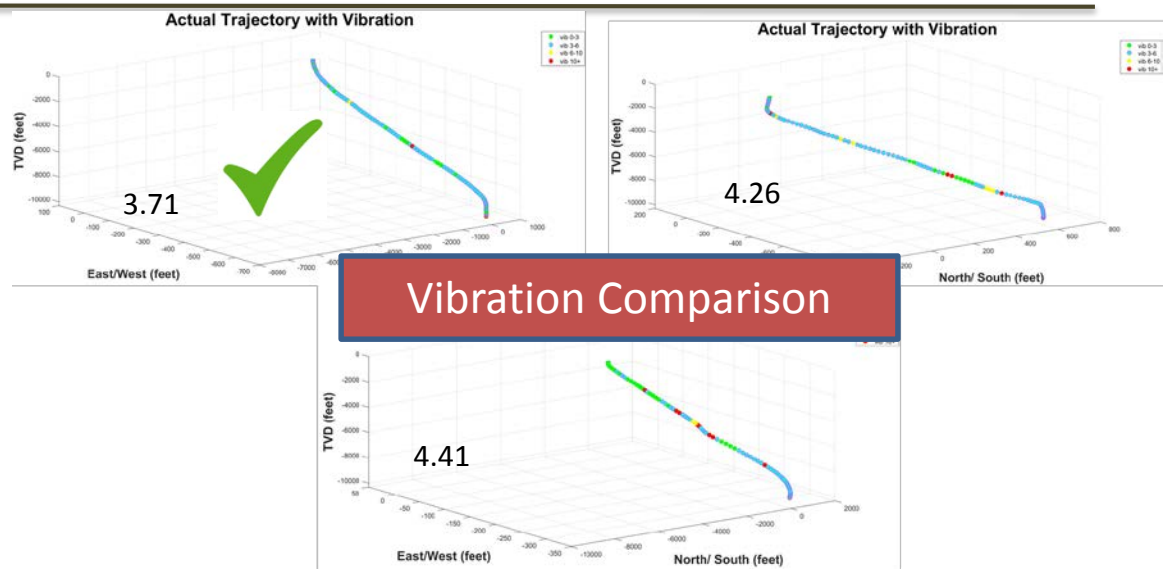
An Example….Finding the Best Well Drilled

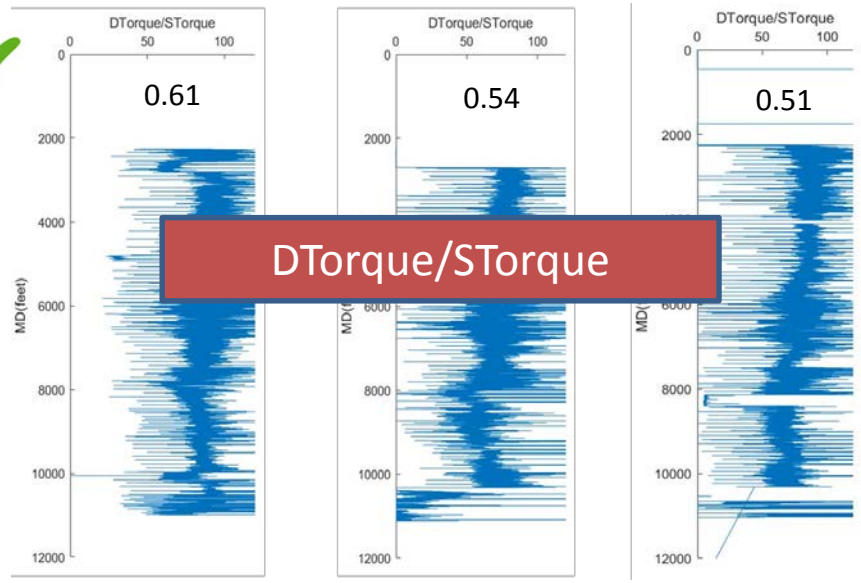


Trajectory Comparison



Vibration Comparison

DWOB/SWOB



DTorque/STorque

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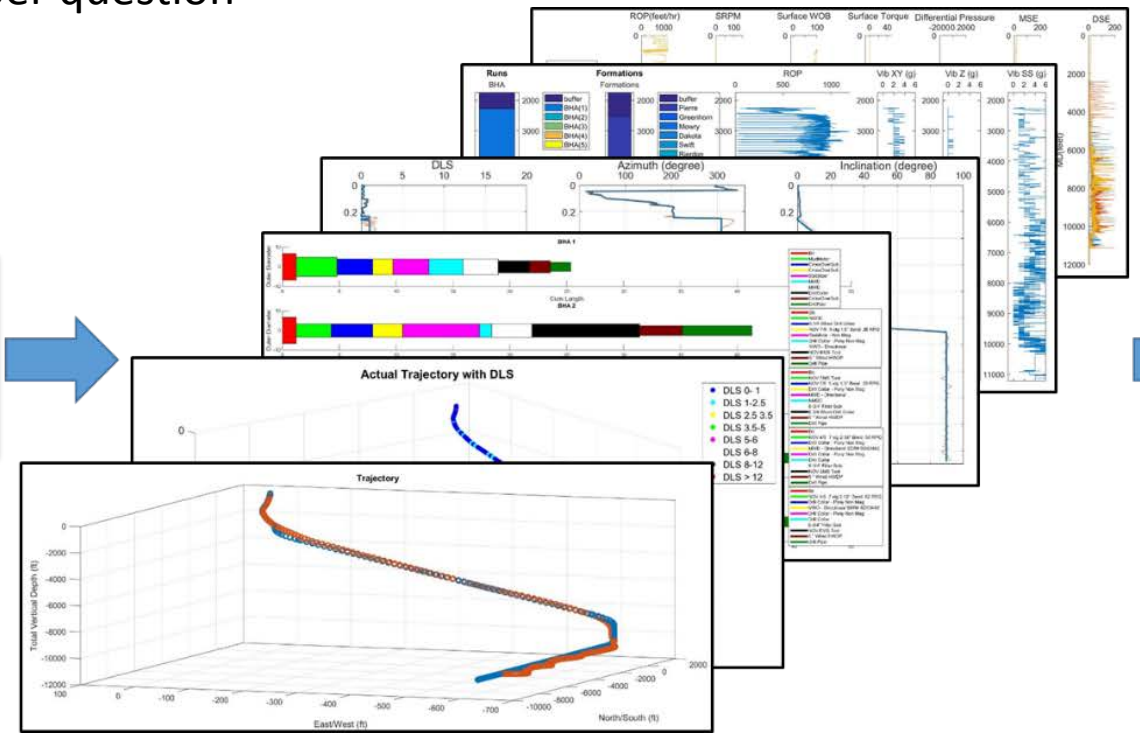
Storyboarding

- Pre-selected visuals to answer commonly asked questions
- Organizing visuals in a sequence to tell a story
- The sequence is decided based on the application
- Around 4 to 10 visuals per question

Performance Questions

- Which BHA was the best in the vertical section of the hole ?
- Which well on the pad had the best lateral?



Performance Decisions & Actions

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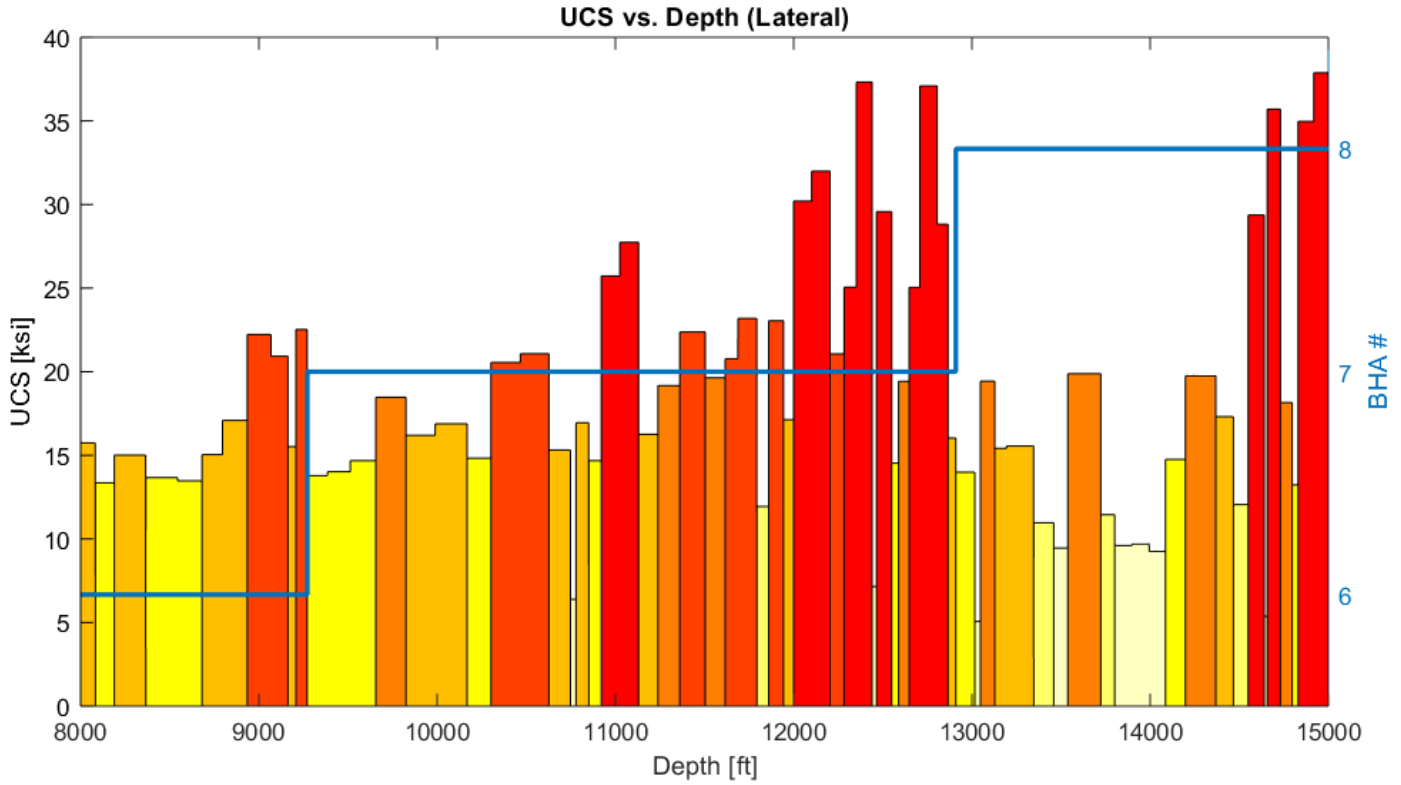
Drilling Data Acquisition for Completion Optimization



- Deliberate formation evaluation and data-acquisition during drilling for stimulation optimization: “which zones are best to perforate and hydraulically fracture?”
- Drilling parameters (ROP, MSE, mud losses etc.) used to characterize relevant rock/fracture parameters for optimized hydraulic fracturing

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Undergraduates since 2014

Kyle Goncalves
Petroleum
BS Spring 2017

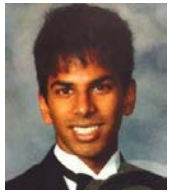
Mitchell Johnson
Mechanical
BS Fall 2017

William Dubois
Petroleum
BS Spring 2017

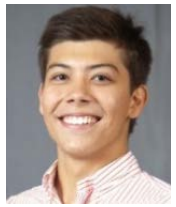
Tiffany Yang
Mechanical
BS Spring 2016

Trip Dickey
Petroleum
BS Spring 2017

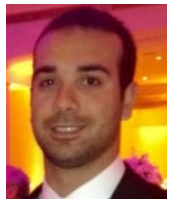
Brandon Hilts
Petroleum
BS Spring 2015



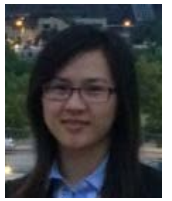
Arjun Chintapalli
Petroleum
BS Spring 2016



Brendan Flores
Petroleum
BS Spring 2015



Arsha Pourghaffar
Petroluem
BS Spring 2015



Yifan Li
Petroleum
BS Spring 2016

Rohan Chittur
Petroleum
BS Fall 2017

Annie Truong
Petroleum
BS Summer 2017

Eric Qian
Petroleum
BS Spring 2017

Cooper Loposer
Petroleum
BS Spring 2017

Jake Celler
Mechanical
BS Summer 2016

Grace Curran
Petroleum
BS Spring 2017

Grace Howley
Petroleum
BS Spring 2017

Valerie Ho
Geosystems
BS Spring 2018

Wesley Chan
Mechanical
BS Spring 2018

Matias Kopinsky
Petroleum
BS Spring 2018

Vee Lee Koh
Petroleum
BS Spring 2020

Angela Luciano
Petroleum
BS Fall 2018

Adam Verma
Petroleum
BS Spring 2018

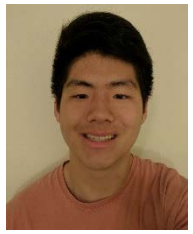
Venkata Ale
Petroleum
BS Fall 2017

Hanna Lee
Petroleum
BS Summer 2019

Melvyn Wang
Petroleum
BS Spring 2019

Grant Tozer
Petroleum
BS Fall 2019

Carson Yang
Mechanical
BS Spring 2019



Charles Wang
Petroleum
BS Spring 2019

Hongxi Li
Accounting
MS Fall 2017

Eric Kim
Petroleum
BS Spring 2019

Trung P Luong
Petroleum
BS Spring 2019

Since the first pilot in the Fall of 2014, more than 30 undergraduate students have graduated from the RAPID data analytics program.

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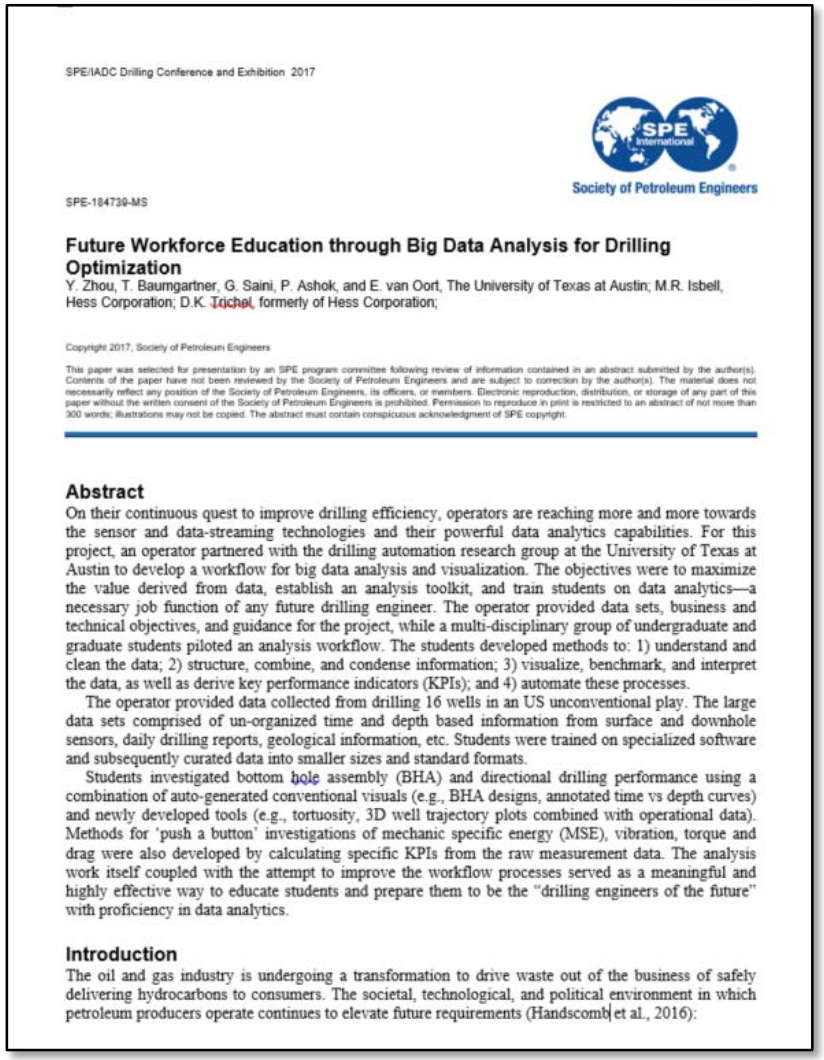
A Plethora of Stakeholder Benefits

- **Industry Operators**
  - Detailed data-analysis of unused/under-utilized data
  - Performance/cost opportunities identified
  - Aiding future workforce development!
- **Students**
  - Better, more active learning on field cases
  - Acquiring relevant data analytics skills
  - Interact with real field data
  - Interact with future employers
- **University**
  - Better teaching
  - Excellent student / workforce development
  - Great applied R&D results, stronger ties to sponsors



SPE/IADC Drilling Conference and Exhibition 2017

Society of Petroleum Engineers

SPE-184739-MS

Future Workforce Education through Big Data Analysis for Drilling Optimization

Y. Zhou, T. Baumgartner, G. Saini, P. Ashok, and E. van Oort, The University of Texas at Austin; M.R. Isbell, Hess Corporation; D.K. Trichel, formerly of Hess Corporation;

Abstract

On their continuous quest to improve drilling efficiency, operators are reaching more and more towards the sensor and data-streaming technologies and their powerful data analytics capabilities. For this project, an operator partnered with the drilling automation research group at the University of Texas at Austin to develop a workflow for big data analysis and visualization. The objectives were to maximize the value derived from data, establish an analysis toolkit, and train students on data analytics—a necessary job function of any future drilling engineer. The operator provided data sets, business and technical objectives, and guidance for the project, while a multi-disciplinary group of undergraduate and graduate students piloted an analysis workflow. The students developed methods to: 1) understand and clean the data; 2) structure, combine, and condense information; 3) visualize, benchmark, and interpret the data, as well as derive key performance indicators (KPIs); and 4) automate these processes.

The operator provided data collected from drilling 16 wells in an US unconventional play. The large data sets comprised of un-organized time and depth based information from surface and downhole sensors, daily drilling reports, geological information, etc. Students were trained on specialized software and subsequently curated data into smaller sizes and standard formats.

Students investigated bottom hole assembly (BHA) and directional drilling performance using a combination of auto-generated conventional visuals (e.g., BHA designs, annotated time vs depth curves) and newly developed tools (e.g., tortuosity, 3D well trajectory plots combined with operational data). Methods for 'push a button' investigations of mechanic specific energy (MSE), vibration, torque and drag were also developed by calculating specific KPIs from the raw measurement data. The analysis work itself coupled with the attempt to improve the workflow processes served as a meaningful and highly effective way to educate students and prepare them to be the "drilling engineers of the future" with proficiency in data analytics.

Introduction

The oil and gas industry is undergoing a transformation to drive waste out of the business of safely delivering hydrocarbons to consumers. The societal, technological, and political environment in which petroleum producers operate continues to elevate future requirements (Handscomb et al., 2016):

Source: SPE 184739