Accelerate the Learning Curve with Downhole Drilling Dynamics Measurements

Steve Jones – Sanvean Technologies/Scout Downhole
Speaker Bio

- Introduction
  - Steve Jones
  - Sanvean Technologies / Scout Downhole / Turbo Drill Industries
  - 23 years industry experience
  - BSc Mechanical Engineering, MSc Mechanical & Offshore Engineering - The Robert Gordon University Aberdeen, Scotland
  - Specialized in Directional Drilling, Rotary Steerable, Research & Development and Product Management
Company / Affiliation Information

**Turbo Drill Industries (TDI)**
- Parent Company, privately owned founded in 2007
- Focused on the manufacture and sale of downhole drilling motors
- Design and manufacture of drilling tools

**Scout Downhole (SDI)**
- Privately owned, founded in 2009
- Focused on rental and service for innovative downhole technologies
  - Vertical Scout, Steady Scout, Vibe Scout, Turbo Scout, Gear Bine

**Sanvean Technologies**
- Privately owned, founded in 2015
- Electronics, measurements and control systems arm

**Canamera Coring**
- Technology Partnership since 2015
Agenda

- Introduction
- Measurement Landscape
- Embedded “At-Point” Sensors
- Viewer & Analysis Software
- Well Examples
- Conclusion
Introduction

- Dynamics and mechanics?
- Science project?
- Every well?
- Real-time?
- Memory only?
- Data processing time?
- Data analysis time?
- Reliability?
- Sensor placement?
- Cost?

<table>
<thead>
<tr>
<th>Drilling Mechanics</th>
<th>Drilling Dynamics</th>
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<tbody>
<tr>
<td>WOB</td>
<td>Shock</td>
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<tr>
<td>TOB</td>
<td>Vibration</td>
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<tr>
<td>BM</td>
<td>RPM</td>
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<tr>
<td>Pressure</td>
<td>Stick-Slip</td>
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<td>Temperature</td>
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Cost-effective “at-point” Drilling Dynamics measurements for every BHA
Accelerate the Learning Curve

“Smart Accelerated Learning” from CuBIC data post-run

“Hard Learning” from failures and premature wear
## Drilling Dynamics & Mechanics Landscape

<table>
<thead>
<tr>
<th>Learning Curve</th>
<th>Response Verification</th>
<th>Measurements &amp; Placement</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Slow Learning Curve&lt;br&gt;Anecdotal and Opinion Based</td>
<td>Operational Changes&lt;br&gt;Well-by-Well&lt;br&gt;BHA Redesign&lt;br&gt;Verify Changes with Data&lt;br&gt;Root Cause Analysis</td>
<td>MWD</td>
<td>NADA</td>
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<tr>
<td>Fast Learning Curve&lt;br&gt;Actual Data Post-Run</td>
<td>Operational Changes&lt;br&gt;Well-by-Well&lt;br&gt;BHA Redesign&lt;br&gt;Verify Changes with Data&lt;br&gt;Root Cause Analysis</td>
<td>3-Axis&lt;br&gt;WOB-TOB-BOB&lt;br&gt;At-Point &amp; At-Bit&lt;br&gt;Length Constraints</td>
<td>$</td>
</tr>
<tr>
<td>Fast Learning Curve&lt;br&gt;Actual Data Post-Run</td>
<td>Operational Changes&lt;br&gt;On-the-Fly &amp; Well-by-Well&lt;br&gt;Requires Experience&lt;br&gt;Overseeing Operation&lt;br&gt;BHA Redesign&lt;br&gt;Verify Changes with Data&lt;br&gt;Root Cause Analysis</td>
<td>3-Axis&lt;br&gt;MWD or Wired Pipe Placement Limited</td>
<td>$$</td>
</tr>
<tr>
<td>Fast Learning Curve &amp; Real-Time Response to Parameter Changes&lt;br&gt;Actual Data</td>
<td>Operational Changes&lt;br&gt;On-the-Fly &amp; Well-by-Well&lt;br&gt;Requires Experience&lt;br&gt;Overseeing Operation&lt;br&gt;BHA Redesign&lt;br&gt;Verify Changes with Data&lt;br&gt;Root Cause Analysis</td>
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<td>$$$$</td>
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</table>
Small Data versus Big Data

- Big Data – Volume, Velocity & Variety
- Small Data – Accessible, Understandable & Actionable
Drilling Dynamics Measurements

- Bit Bounce
- Lateral Shock
- Stick-Slip
- Whirl
- Delta Temp.

Axial Lateral Torsional Eccentric Heat
Embedded “At-Point” Measurements

- Vertical Drilling & RSS
- Steerable Motors
- Friction Reduction Tools
- Stick-Slip Mitigation Tools
- Gear-Reduced Turbine
Carrier Sub Drilling Dynamics Measurements

Sensor in sub 500ft above FRT
Sensor in sub 300ft below FRT
Sensor in FRT
Sensor in motor top sub
Sensor in bit box

2,500ft
“At-Point” Measurements Versus MWD

MWD Drilling Dynamics Sensors only measure dysfunction at one location in BHA

Drilling Dynamics Sensors measure dysfunction at bit and BHA

Embedded Measurements
Reduced Footprint & Cost

Improved Reliability

MEMS
Micro-Electro-Mechanical System
Cost-Effective Embedded Sensors
# Embedded Sensor Specifications

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
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<tbody>
<tr>
<td>Carrier Sub</td>
<td>✓</td>
</tr>
<tr>
<td>Embedded into Existing Equipment</td>
<td>✓</td>
</tr>
<tr>
<td>Field Replaceable Electronics</td>
<td>✓</td>
</tr>
<tr>
<td>Tool Sizes</td>
<td>4 3/8” to 9 5/8”</td>
</tr>
<tr>
<td>3-Axis Vibration</td>
<td>-16G to +16G (+/- 10mG)</td>
</tr>
<tr>
<td>Vibration Sample Rate</td>
<td>25Hz – 100Hz</td>
</tr>
<tr>
<td>Vibration Record</td>
<td>Sequential</td>
</tr>
<tr>
<td>3-Axis Shock</td>
<td>-200G to +200G (+/- 100mG)</td>
</tr>
<tr>
<td>Shock Sample Rate</td>
<td>800Hz – 3200Hz</td>
</tr>
<tr>
<td>Shock Record</td>
<td>Statistical</td>
</tr>
<tr>
<td>Accelerometer Based RPM</td>
<td>0 to 500RPM (+/- 3RPM)</td>
</tr>
<tr>
<td>Gyro Based RPM</td>
<td>+/- 330 RPM</td>
</tr>
<tr>
<td>Temperature</td>
<td>125°C (257°F) standard</td>
</tr>
<tr>
<td></td>
<td>150°C (302°F) option available</td>
</tr>
<tr>
<td>Pressure Rating</td>
<td>15,000 PSI</td>
</tr>
<tr>
<td>Battery Life</td>
<td>Up to 200 hours</td>
</tr>
<tr>
<td>Memory Storage</td>
<td>33.6 MB</td>
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Viewer/Analysis Software

- Fast and efficient merge of downhole and EDR data
- Data set delivered to DE with viewer software
- Zoom and scale changes for improved data analysis
- Superior data viewing compared to PDF
- Reduces time and effort required by DE to view and evaluate the data
Example 1 – Smooth Lateral Drilling
Example 2 – String Whirl & Bit Lateral Shock
Example 3 – Bit Lateral/Axial Dysfunction & Temp. Rise
Example 4 – Stalling While Sliding
Example 5 – Friction Reduction & Weight Transfer
Example 6a – Stick-Slip Mitigation Tool Offset Comparison
Example 6b – Stick-Slip Mitigation Tool Offset Comparison
Conclusion

- Cost effective sensors designed for utilization in every BHA
- Remove anecdotal and opinion based decisions
- Embedded at-bit and BHA to deliver the full dynamic picture
- MWD measurements do not capture at-bit dysfunction
- Prompt delivery to DE with viewer software
- “Back to Basics” approach to drilling dynamics - make and verify changes with confidence
Thank You