“How Far Can We Go”, and “How Fast Can We Get There?”

IADD Forum “Motor vs. RSS”
November 11th, 2011
Brandon M. Foster
Outline

• Motor or RSS?
• Where have we been?
• Where are we going?
• What are the limiting factors?
• What is needed to go further?
Motor vs. RSS

• For ERD, there isn’t really any debate
  – RSS is required for drag and buckling reasons
  – This technology will take us a long way

• HOWEVER, RSS isn’t the best choice for everyone
  – For example, ±5,000’ laterals onshore US
  – Haynesville: 5 day curve + lateral w/ motor

• Things to think about before picking up RSS
  – Bit RPM limitations (motors can drill faster)
  – Susceptibility to stick-slip (affects bit selection and WOB)
  – Tolerance for solids (clean mud is more crucial)
  – Dogleg requirements (damn geologist)
ERD: Where Have We Been?
ERD: Where Are We Going?

• All wells feasible with existing technology
  - Many are on hold for economic reasons
  - Some are in the late stages of planning
ERD: Big Numbers In Context
Extended Reach Drilling Record

Annual Oil Price (inflation adjusted)

ERD Record Reach
Potential Limiters

- **Drag / Buckling** – RSS, casing/liner flotation and/or rotation
- **Pump Pressure** – Big drillpipe, big pumps
- **Tension** – Only an issue at deep TVD
- **Telemetry** – Wired DP, Acoustic, better mud pulse
- **Position Uncertainty** – Gyro, IIFR, advanced TVD
- **Torque** – High torque DP, light DP, big top drive
- **ECD** – Big hole, small pipe, thin mud
- **Logistics** – Depends on the location – MOQ ran out of DP!
- **Economics** – Who’s going to pay for all this?
Technology Parallels

Directional Technology
- Single Shot/Stabs
- Motor/MWD
  - HT Drillpipe
  - HP Pumps
  - Flotation
- RSS
  - Huge Top Drives
  - Lightweight Material
  - Wired Telemetry
  - Powered RSS
- Tunneling Machine?

Propulsion Technology
- Steam
- Internal Combustion
  - Tires
  - Aerodynamics
  - Supercharger
- Jet
  - CFD Aerodynamics
  - Wheel Technology
  - Steering
  - Turbofan
- Rocket
Lessons From The Past

Statoil Statfjord C2

• Drilled to ±29,000’ MD (±23,000’ reach) in 1992
  – Entirely with motors, but configured differently than today
    • 0.78° ABH and 0.30° FB, 5% Sliding in the tangent
    • Using 150-180 rpm, with up to 250 hr long runs
  – 2x1600 hp pumps
  – Fit for purpose drillstring design
    • 5½”x6⅝” in the 12¼”
    • 5½”x5” in the 8½”
  – Ester Based Mud
  – Pseudo catenary wellpath
• 12¼” TD was cut short by due to torque (30 k ft-lbs)
• 7” Liner got stuck off bottom
Lessons From The Past

[Graph showing data points and categories such as Low Reach, Medium Reach, Extended Reach, Very Extended Reach, ERD Database well, and Statford C2.]
A Look To The Future

BP Liberty

- 5 Well Development of ±100 Million BOE
- 38,000’ – 48,000’ Well Length
- >$1 Billion Capital Expenditure
- Custom Drillpipe
  - Thin Wall High Strength Steel
  - Aluminum (contingency)
- Massive Rig
- “Designer” Architecture
  - 20”x16”x11 ⅜”x7 ⅜”
  - For ECD Management
  - A consequence of geology
Liberty vs. Record Wells

Unwrapped Length
Liberty vs. Alaska and "Industry" Record ERD

TV Depth (ft)

Distance (ft)

Prudhoe Bay (MD)
Endicott 4-48 K43 (MD)
Northstar NS33A (MD)
Chayvo Z12 (MD)
Wytch Farm M16 (MD)
AI Shaheen BD-04A (MD)
Liberty SDI-01 (MD)
Liberty SDI-05 (MD)
## “Big ERD” Comparison

<table>
<thead>
<tr>
<th>Operator</th>
<th>Well</th>
<th>MD</th>
<th>Reach</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maersk</td>
<td>BD-04A</td>
<td>40,320’</td>
<td>37,956’</td>
<td>10.8</td>
</tr>
<tr>
<td>XOM</td>
<td>Z12</td>
<td>38,310’</td>
<td>34,567’</td>
<td>6.6</td>
</tr>
<tr>
<td>BP</td>
<td>M16</td>
<td>37,001’</td>
<td>35,197’</td>
<td>4.1</td>
</tr>
<tr>
<td>BP</td>
<td>SDI-05</td>
<td>±48,000’</td>
<td>±44,000’</td>
<td>4.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Well</th>
<th>Pumps</th>
<th>Standpipe</th>
<th>TDS</th>
<th>Drillpipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al Shaheen</td>
<td>2x1600 hp</td>
<td>5,000 psi</td>
<td>45 k</td>
<td>5”, 4”</td>
</tr>
<tr>
<td>Chayvo</td>
<td>4x1600 hp</td>
<td>7,500 psi</td>
<td>60 k</td>
<td>5⅞”, 5”</td>
</tr>
<tr>
<td>Wytch Farm</td>
<td>3x1600 hp</td>
<td>5,000 psi</td>
<td>45 k</td>
<td>6⅝”, 5½”, 5”</td>
</tr>
<tr>
<td>Liberty</td>
<td>4x2200 hp</td>
<td>7,500 psi</td>
<td>110 k</td>
<td>6⅝”, 5⅞”, 5”, 4”</td>
</tr>
</tbody>
</table>
Summary

• Where have we been?
  >40,000’

• Where are we going?
  >45,000’ soon, >55,000’ later

• What are the limiting factors?
  Not the DD tool anymore!
  Maybe telemetry or position/geologic uncertainty eventually

• What is needed to go further?
  Lower Torque, Lower ECD, Lower Cost, Less Uncertainty