Self-Adaptive Technology Approach of Torsional & Lateral Dynamic Dysfunctions Mitigation in PDC Bits to Secure Performance Gain in Deepwater Gulf of Mexico

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Agenda

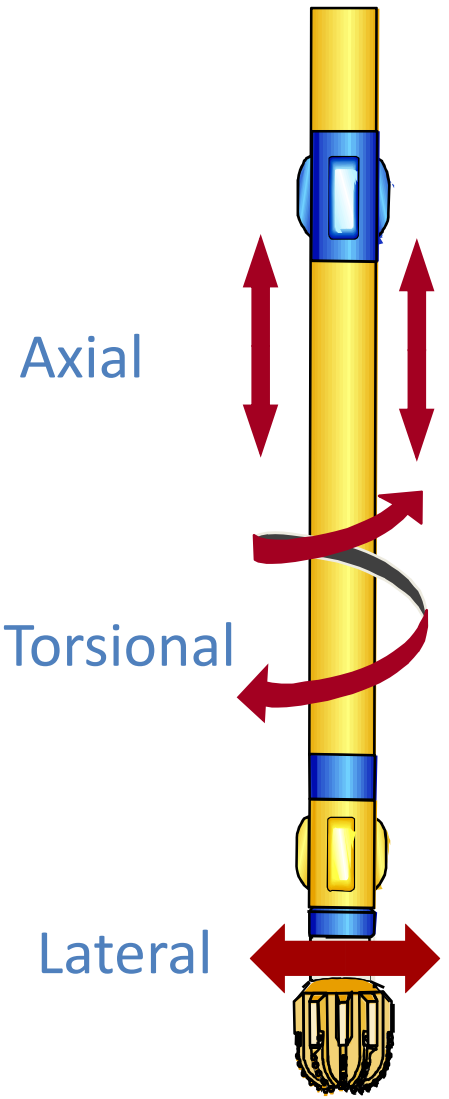
- Torsional Instability
  - Triggers
  - Effects
- Torsional instability - example
- Conventional solution
- Self-adaptive technology
  - Technology
  - Operation
- Case Studies – Gulf of Mexico
- Summary
- Acknowledgement & Questions

Torsional Instability

Triggers

- Torsional elasticity of long drill string
- Aggressive PDC bits
- Drilling interbedded formation
- Reamer application
- Drill string / formation interaction
- Drill string harmonics (coupled vibration)

Torsional dysfunction severely compromises drilling performance may also cause NPT due to tool failure

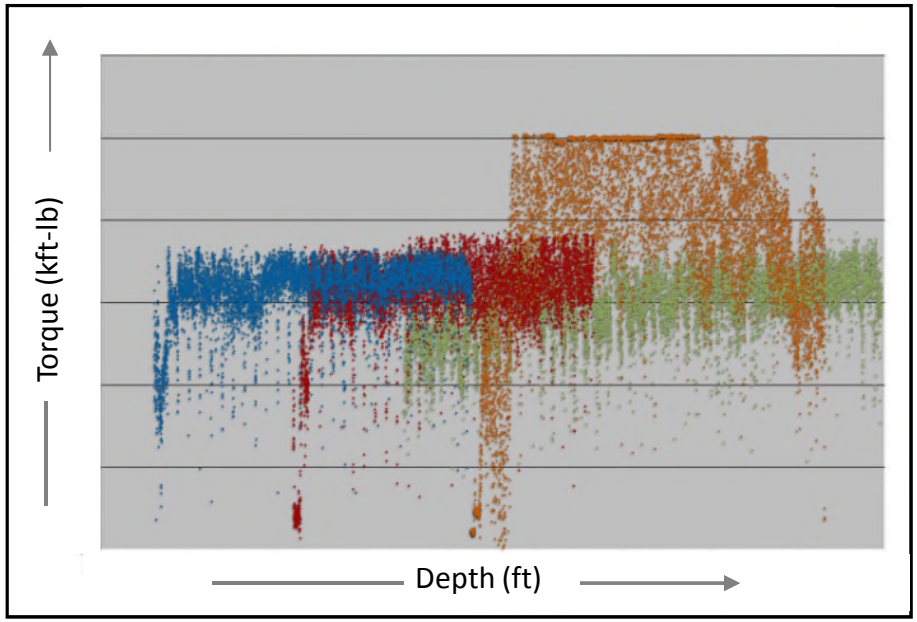


Drill string dynamics modes

Torsional Instability

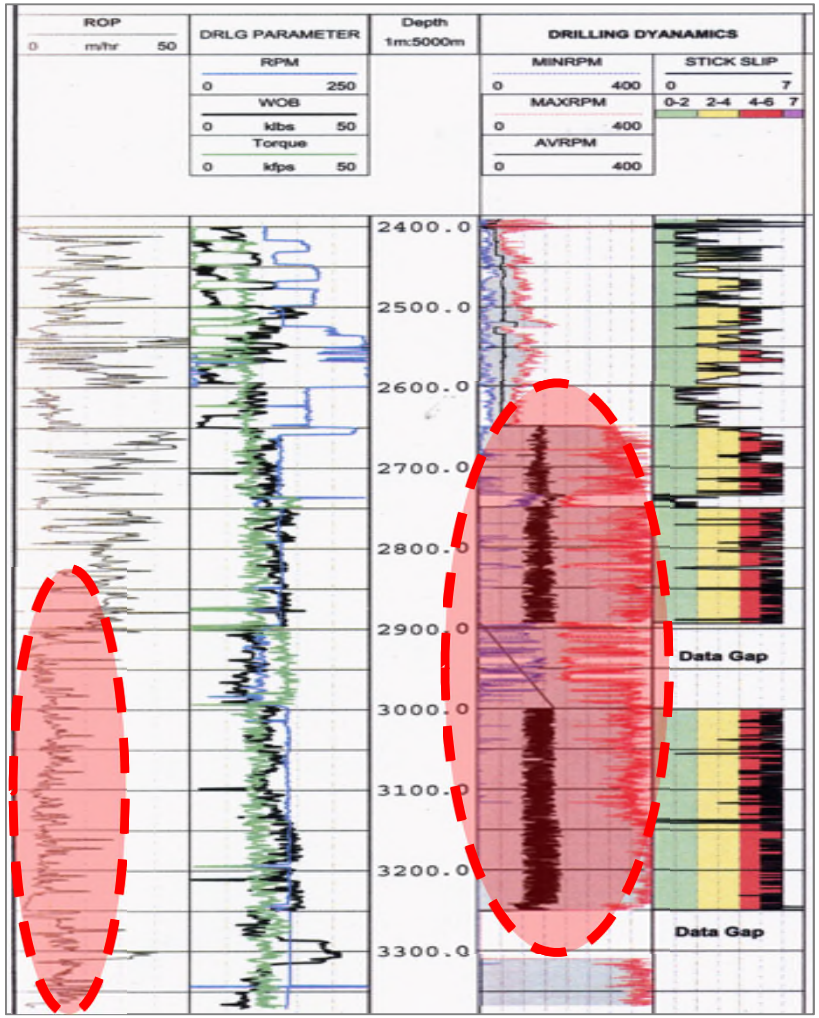
Effects

- Reduced drilling performance
- Downhole equipment failure
- Over torqued connection
- Wellbore tortuosity
- Increased torque & drag
- Inadequate data quality
- Non performing time
- HSE risk during tripping
- Increased cost



Torque variation for different bit types in vertical well

Torsional Instability - Example



Example of Torsional Dysfunction – Stick slip

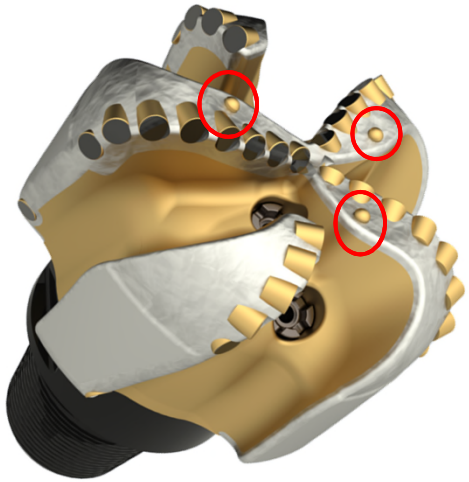
Aggressive 8½-in. PDC bit with RSS BHA

- Bit comes stop and restarts
- Back to back downhole tool failure due to extreme stick-slip
- Several trips due to BHA failure

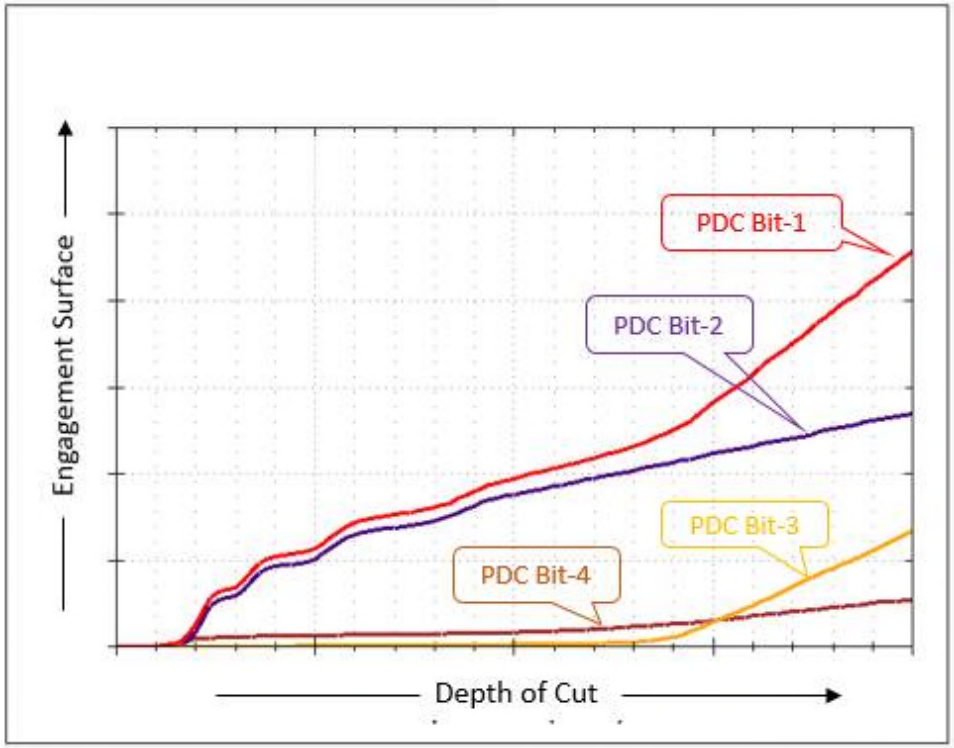
Source: SPE-104388

Conventional solution

Fixed Depth of Cut Control



$$Depth\ of\ Cut = \frac{ROP}{5\ X\ RPM}$$

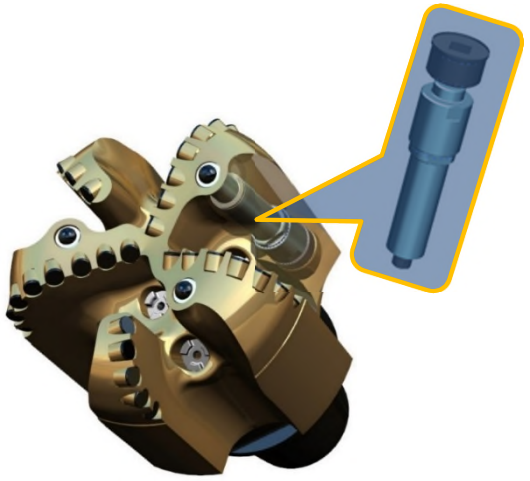


Engagement Surface Variation with Fixed Depth of Cut

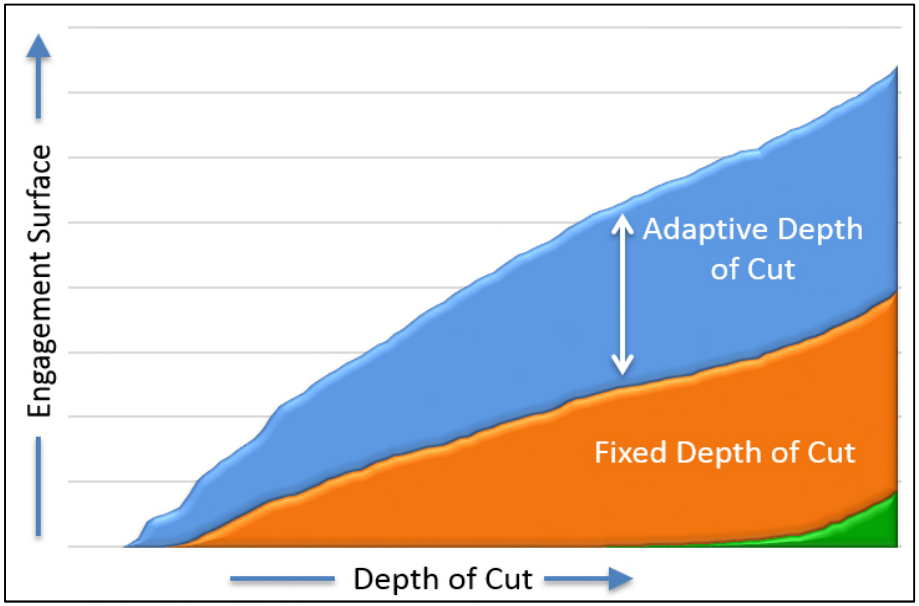
- Under-engagement makes it ineffective
- Over-engagement compromises drilling efficiency

Self-adaptive Depth of Cut Control

Technology



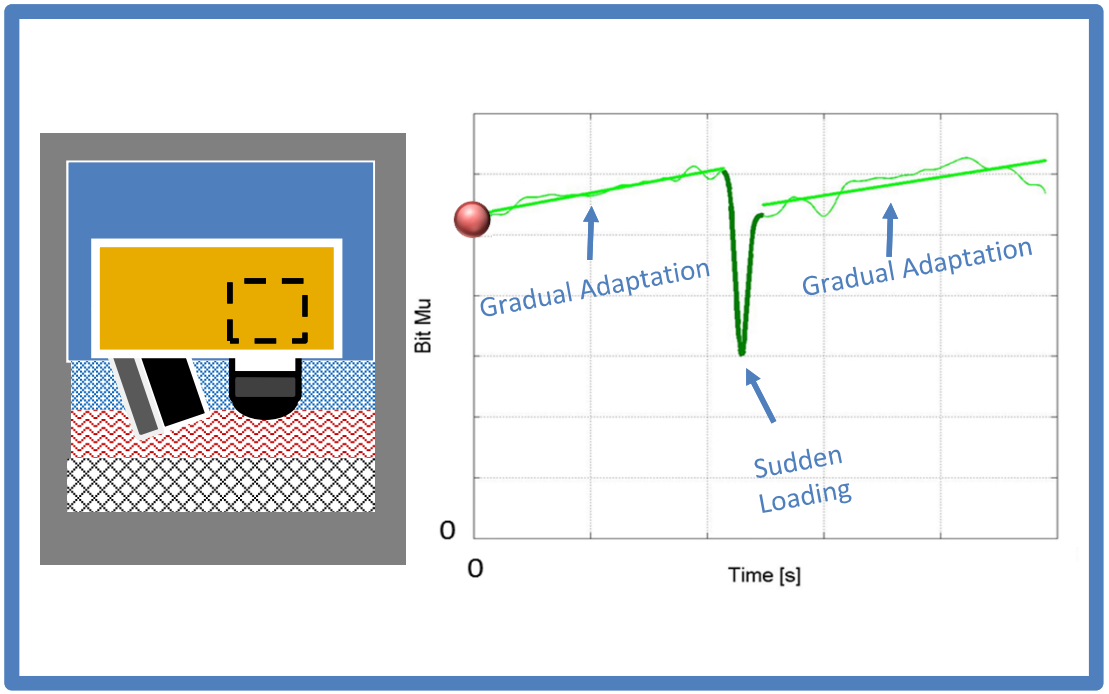
- Three independent hydro-mechanical removable cartridges
- Located in primary blades
- Chambers are pressure compensated
- Diamond encrusted ovoids are connected through a piston



Self-adaptive Depth of Cut Control

Operation

- Ovoids gradually retract under normal drilling condition;
  - Higher aggressiveness
- Ovoids engage limiting cutter engagement while drilling hard formation
  - Lower aggressiveness
  - Mitigates torsional dysfunction
  - Protects overloading cutters



Aggressiveness Change with Adaptation

Self-adaptive Depth of Cut Control

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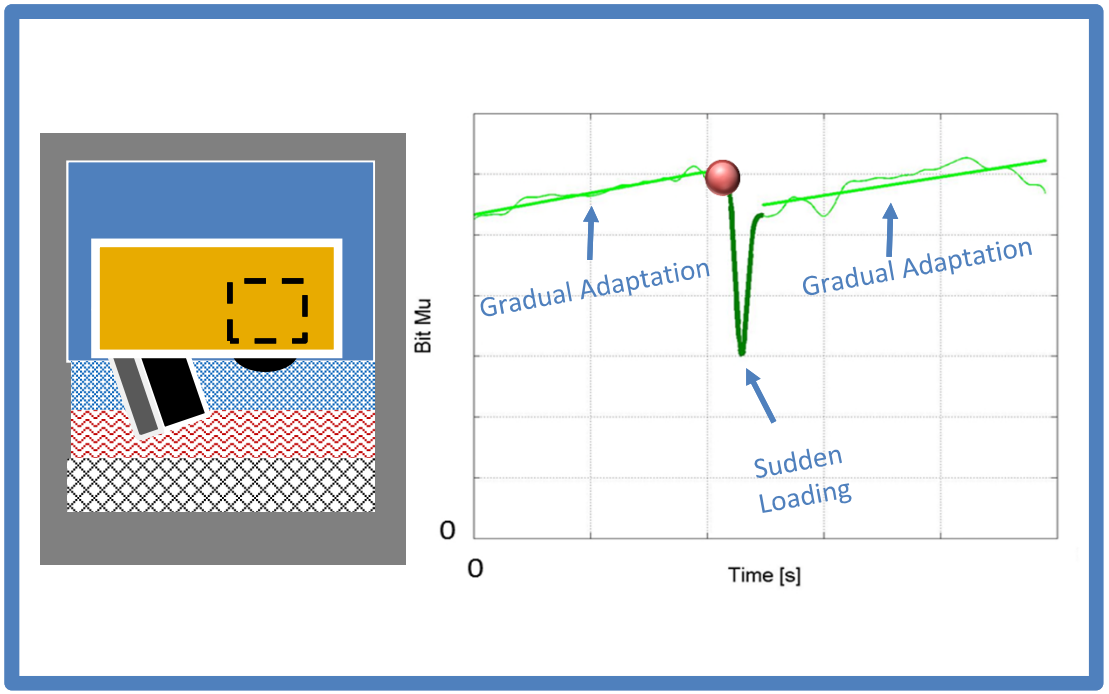

Aggressiveness Change with Adaptation

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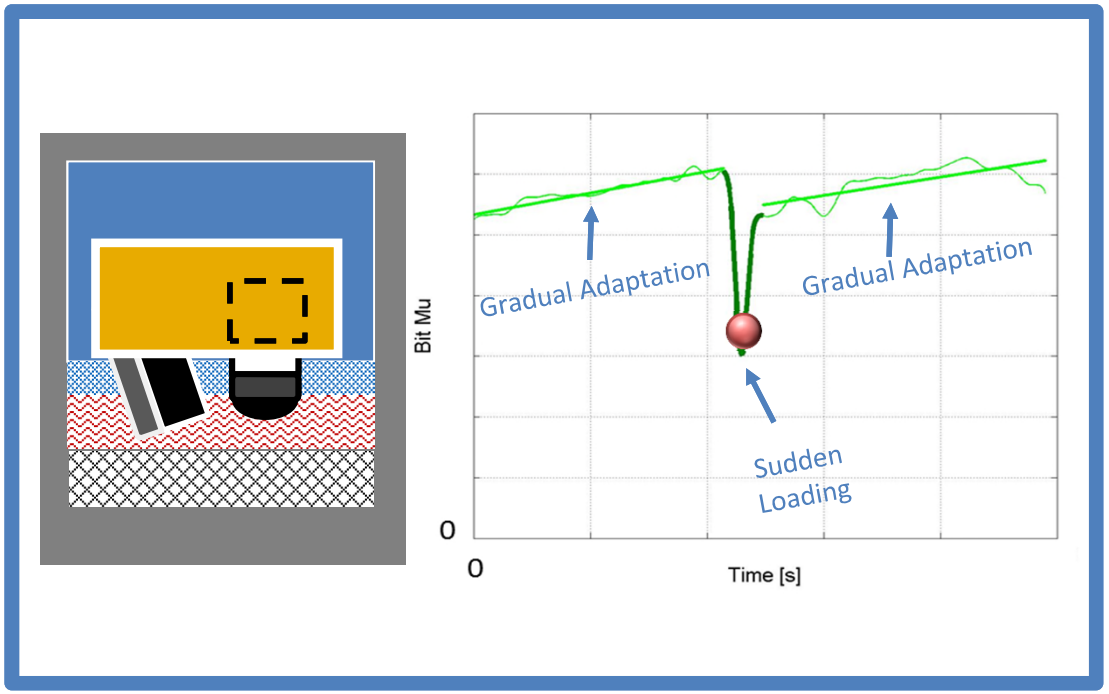


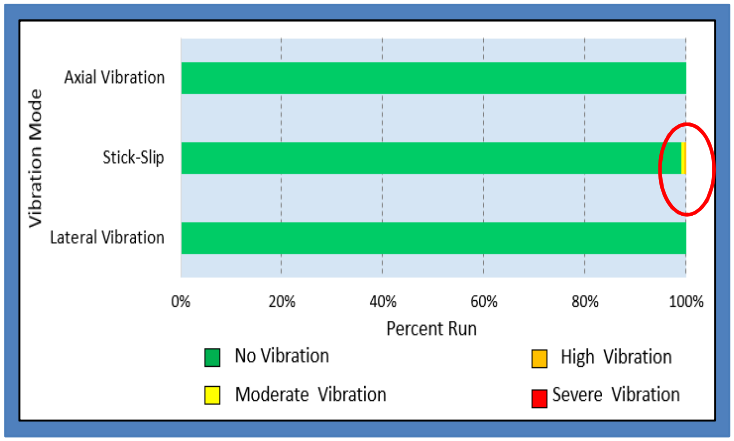
Aggressiveness Change with Adaptation

Field Result - 1

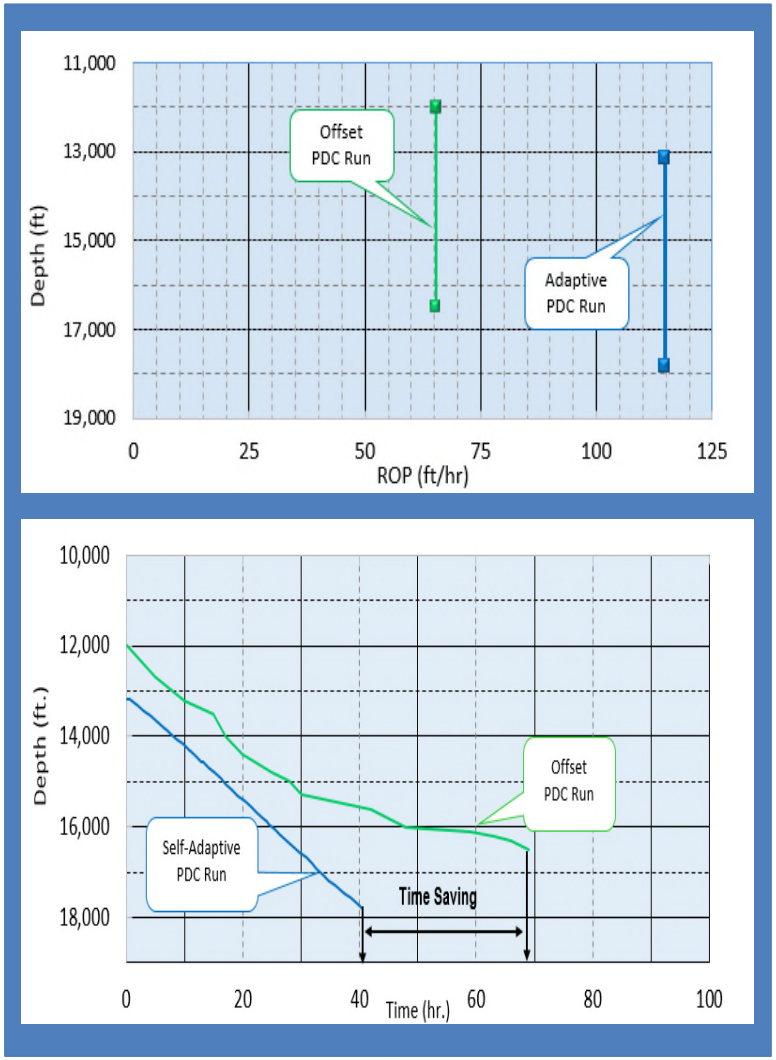
Gulf of Mexico

Application:

- Sand /shale interbedded tangent section, 4,319 ft.
- Drilled with 12¼-in. bit & 14½-in. reamer



Drilling Dynamics Severity Analysis



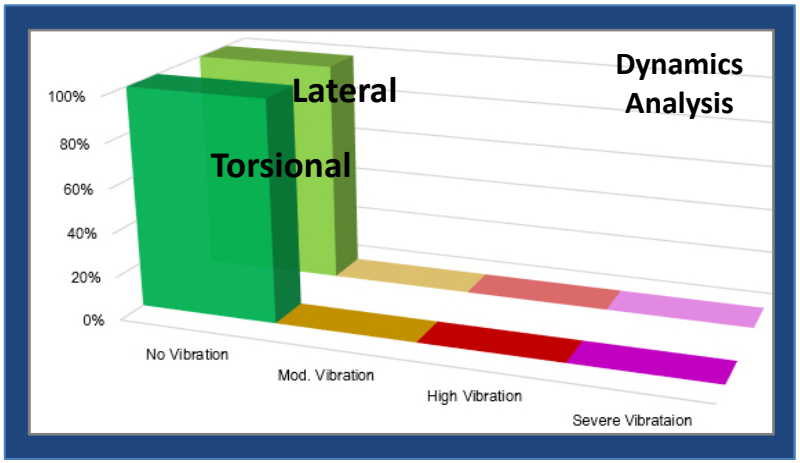
Reduced	Improved	Saved
Vibration to **2%**	ROP by **57%**	Time **28.5hrs**

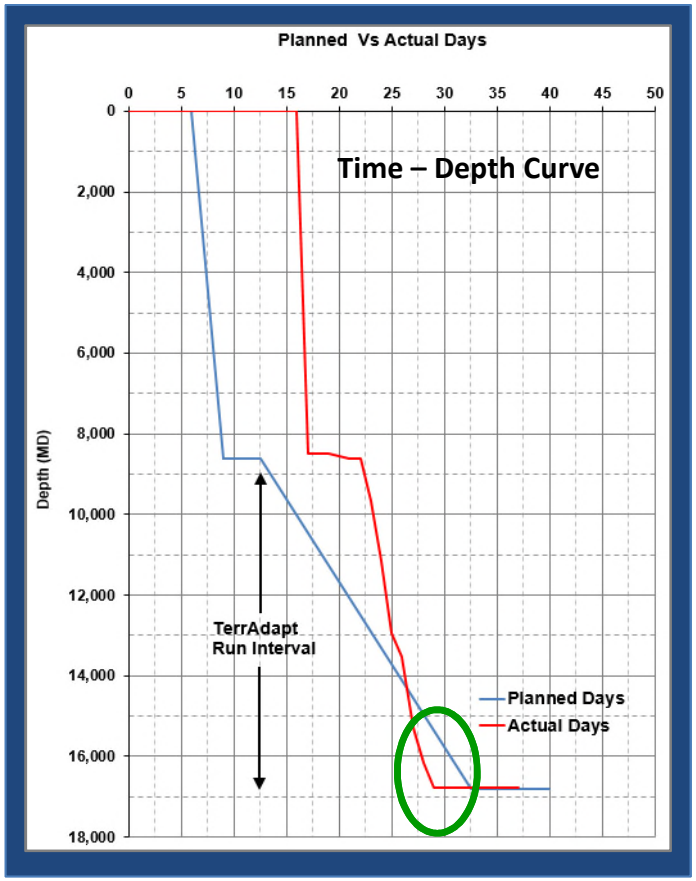
Field Result - 2

Gulf of Mexico

Application

- 8½-in. x 9⅞-in interbedded section
- Three dimensional tangent profile
- Drilled with 8,148 ft. with RSS system





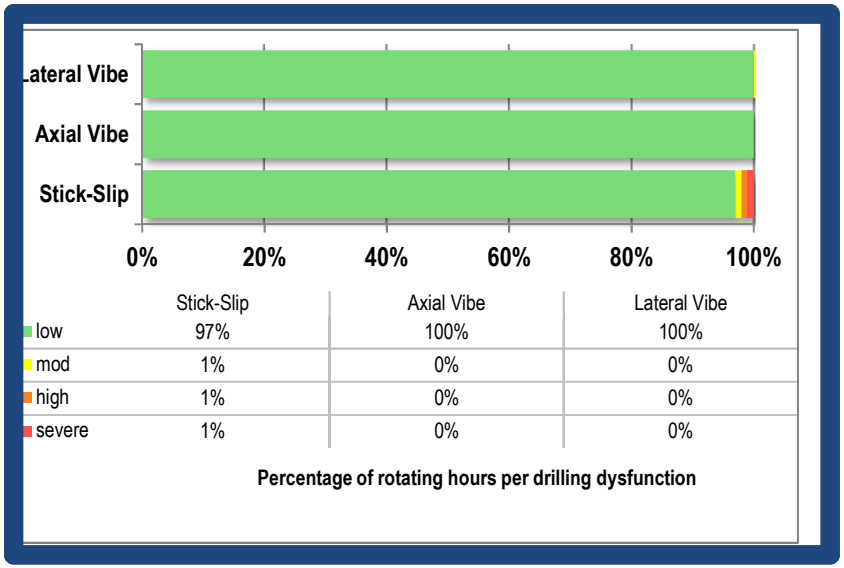
Reduced	Faster	Saved
Vibration to 0.1%	Than All Offsets	4 days

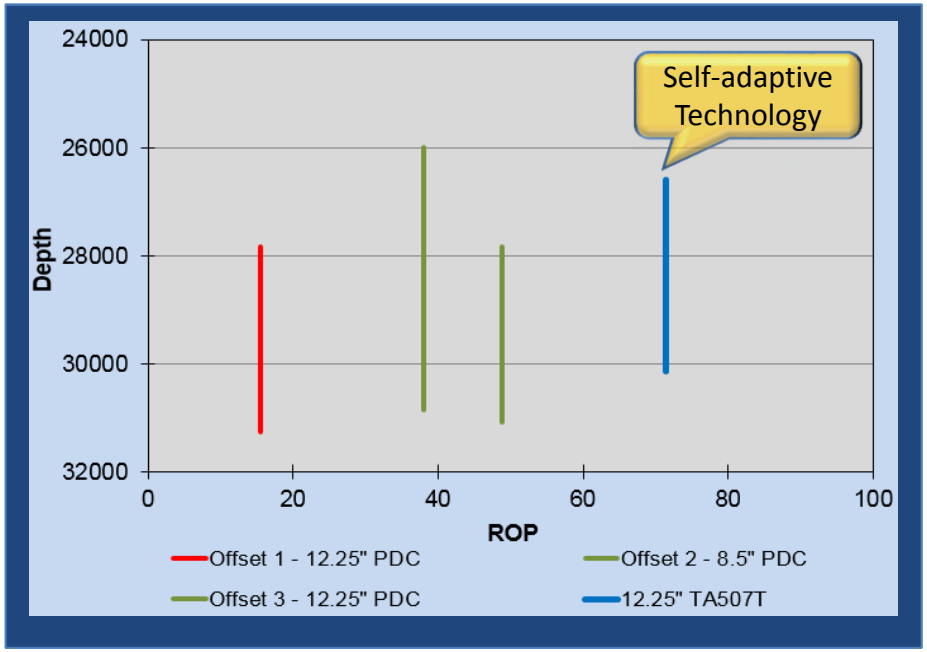
Field Result - 3

Gulf of Mexico

Application

- A 12¼-in. tangent in interbedded formation
- Tangent of 3,535 ft. with turn
- Rotary Steerable BHA





3 % Vibration	46 % Faster	23 hours Saving

Summary

- Self-adaptive depth of cut control improves torsional stability
- Improving torsional stability of drill bit helps to improve drilling performance
- Adaptive technology provides sustained drilling performance improvement
- Adaptive technology helps in bit - reamer synchronization
- Helps to drill interbedded formation efficiently

Acknowledgement & Questions

- Baker Hughes, a GE Company for supporting the work
- World Oil for accepting the abstract for presentation
- My colleagues in Baker Hughes who provided valuable inputs