

December 5-6, 2018

Norris Conference Centers -
City Centre, Houston, Texas
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Simulation and Mitigation of Mid-String Stick-Slip using Multibody Dynamics

Fred Harvey and Andy Elliott
MSC Software

Agenda

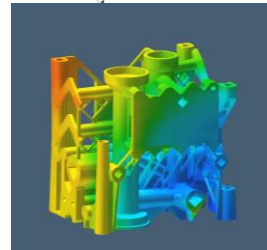
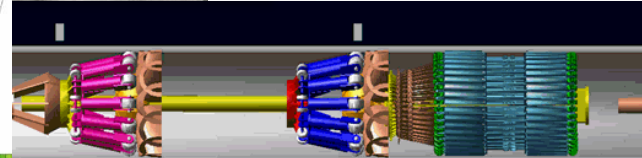
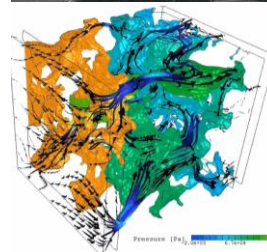
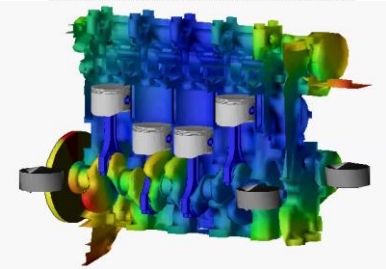
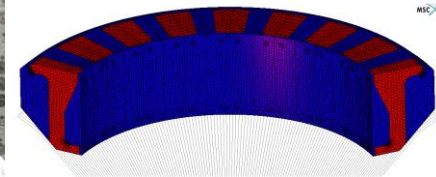
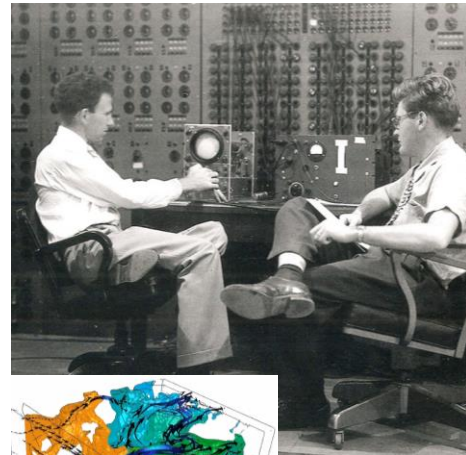
- Introduction
- Stick-Slip Phenomena
- Virtual Drilling Test Rig
- Stick-Slip Mitigation
- Physical Test Results
- Conclusion



**Make Drilling Decisions Based on the
Underlying Physics and Sound
Engineering Judgement**

MSC Software

- Pioneers of the Computer Aided Engineering (CAE) Industry
- Develop best in class simulation software
 - Finite Element Analysis
 - Multibody Dynamics
 - Computational Fluid Dynamics
 - Noise and Acoustics
 - Composite materials
 - Advanced Manufacturing Processes
 - Autonomous Vehicles



Multibody Dynamics

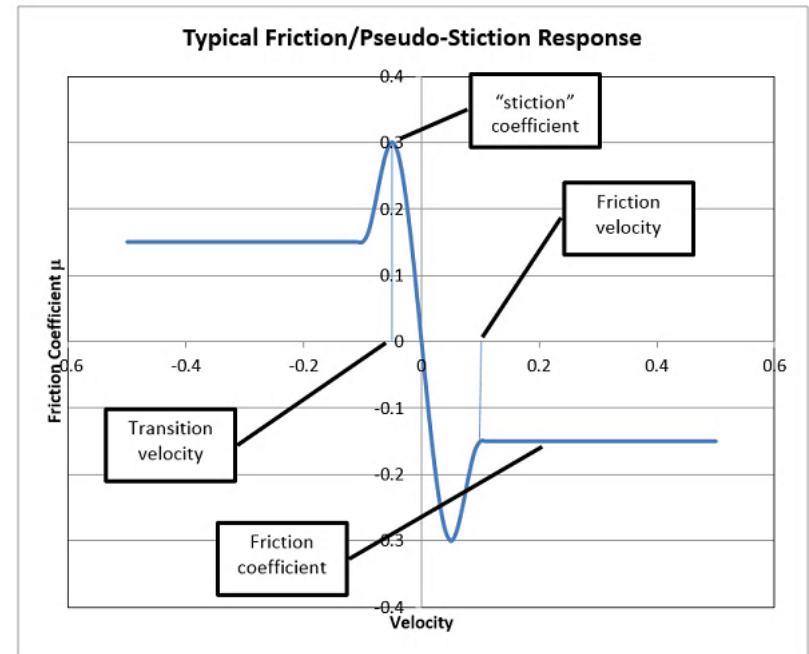
- Dynamic Analysis of Mechanical Systems
- 3D Coupled Physics
- Fully Nonlinear
- Computationally Efficient
- Parametric Modeling
- Designed to explore system response to combination of various subsystems

Simulating Reality,
Delivering Certainty.



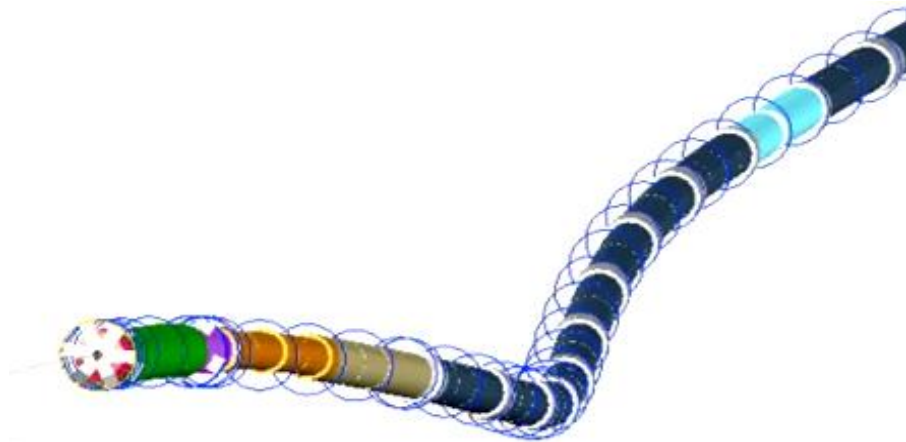
Stick-Slip Phenomena

- Merriam Webster Definition:
Movement of two surfaces relative to each other that proceeds by a series of jerks caused by alternate sticking from friction and sliding when the friction is overcome by an applied force.

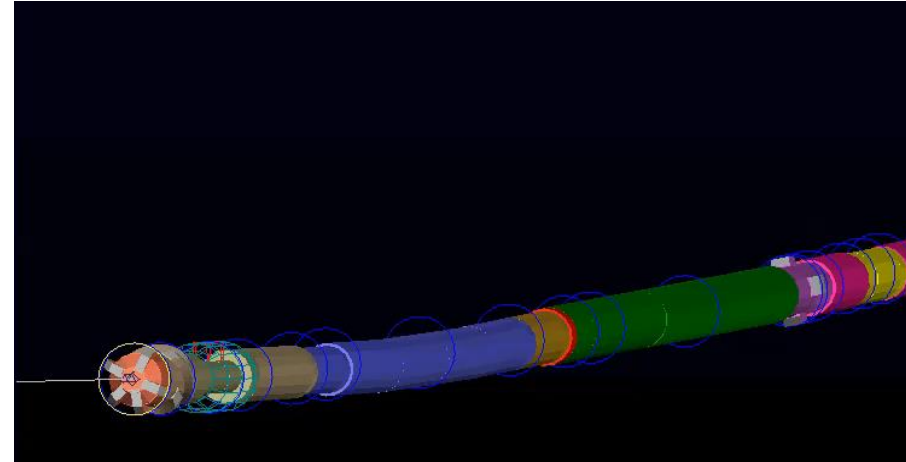


Stick-Slip Phenomena

Cutter Interaction

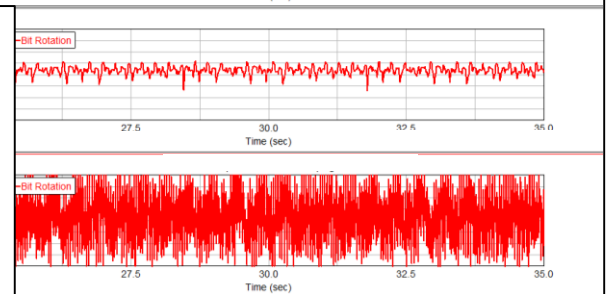
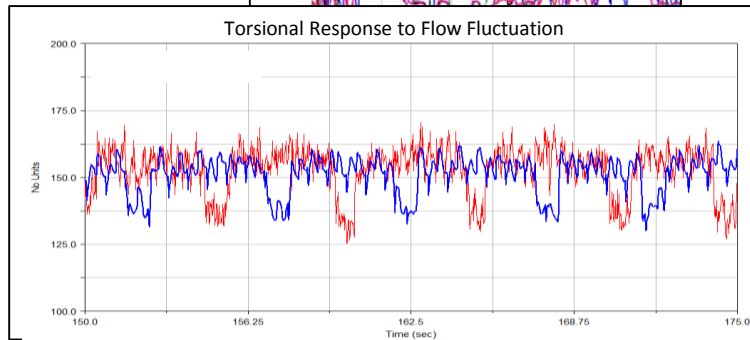
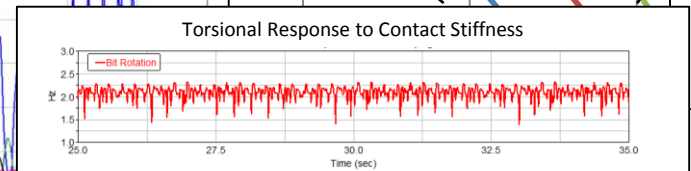
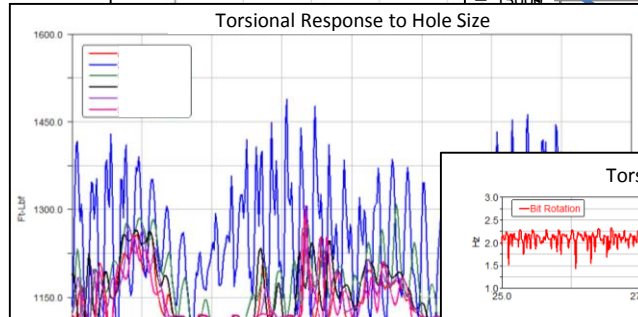
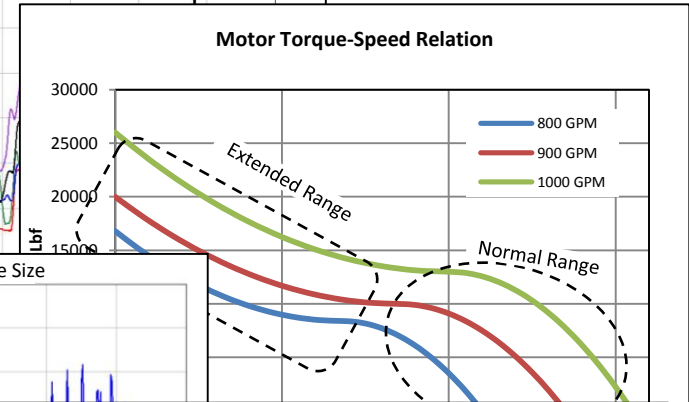
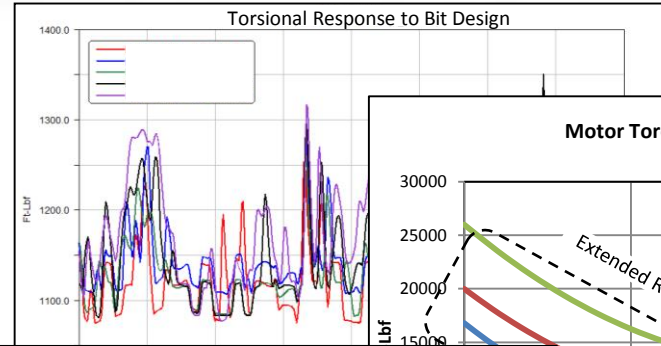


Wellbore Interaction

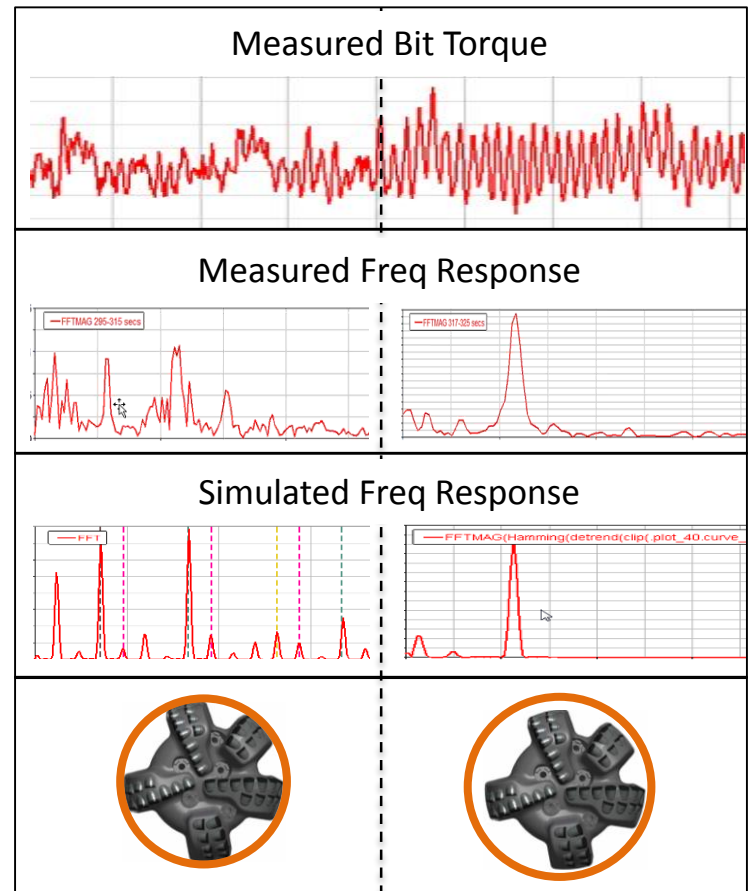
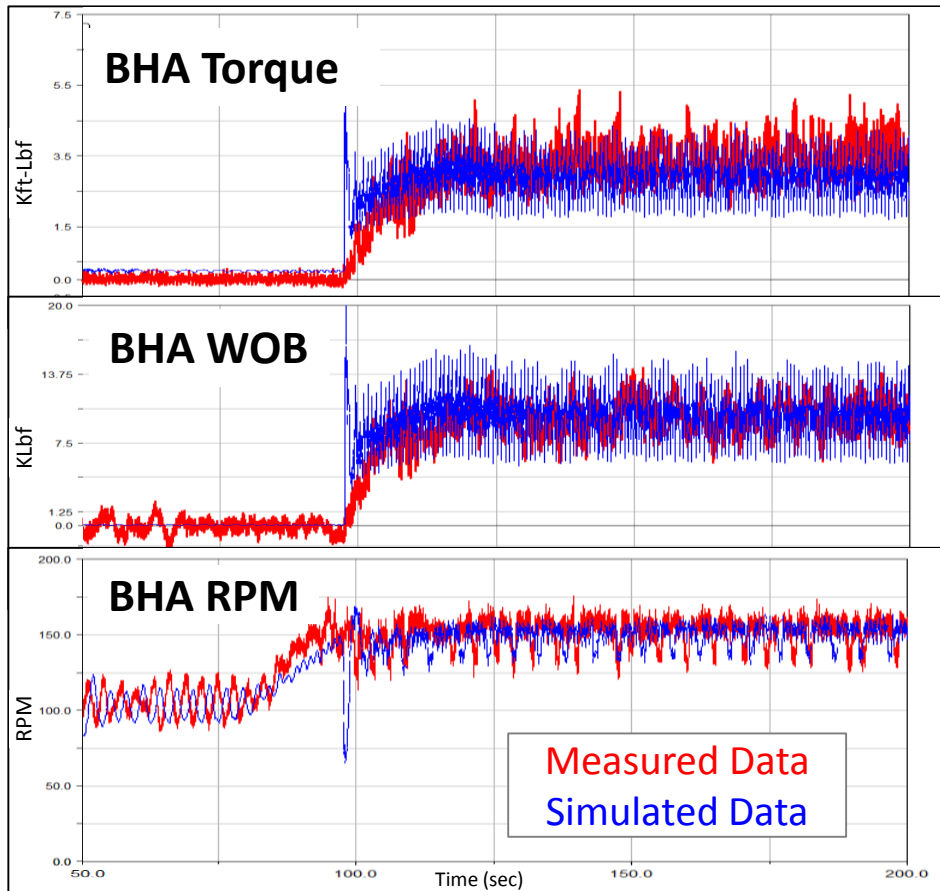


Model Validation

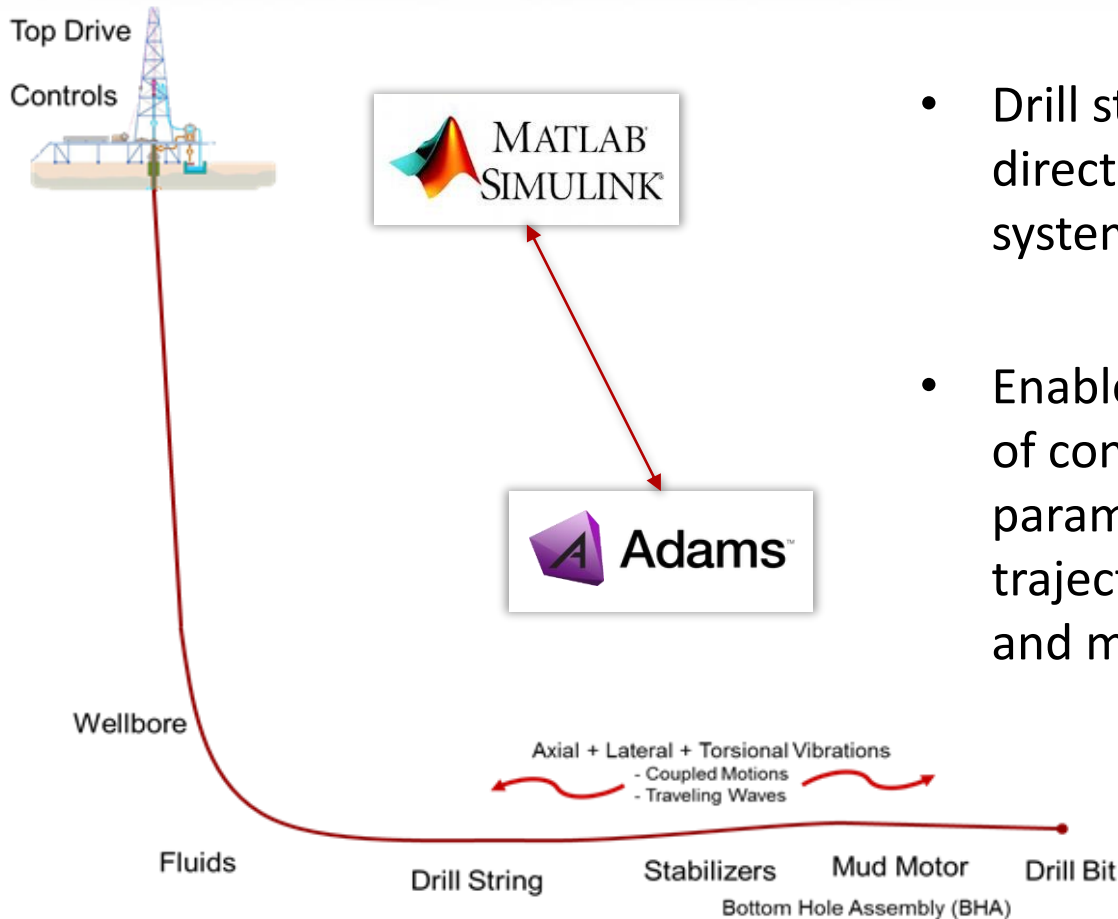
- Parametric Modeling
 - Bit Design
 - Motor Behavior
 - Hole Size
 - Wall Contacts
 - Flow Rates



Model Validation



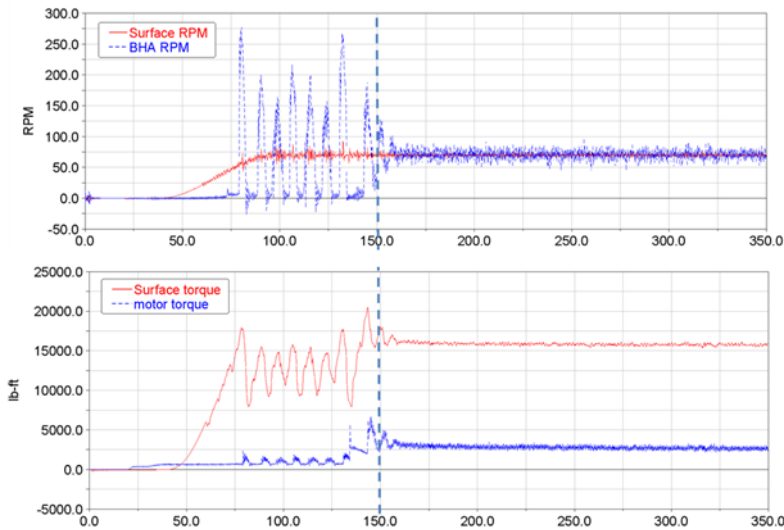
Virtual Drilling Test Rig



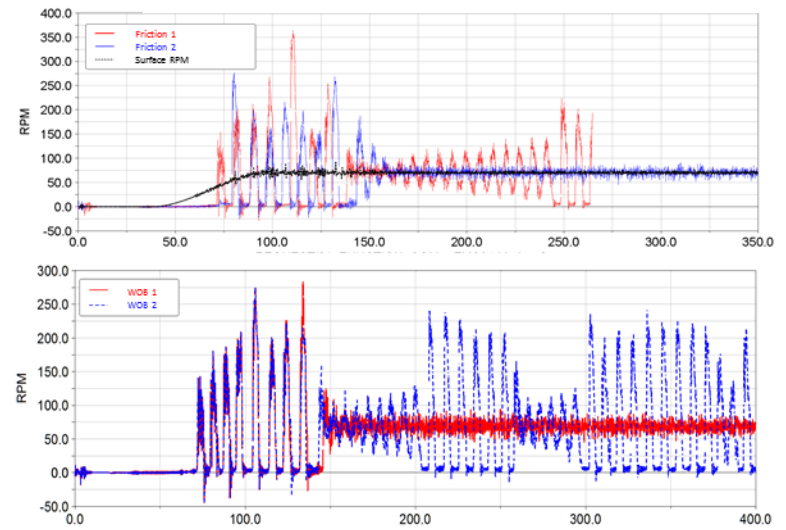
- Drill string model is coupled directly with top drive control system.
- Enables virtual experimentation of control systems, operating parameters, BHA design, wellbore trajectory, environmental factors, and modeling methods.

Effect of Operating Procedures

Off Bottom Stick-Slip

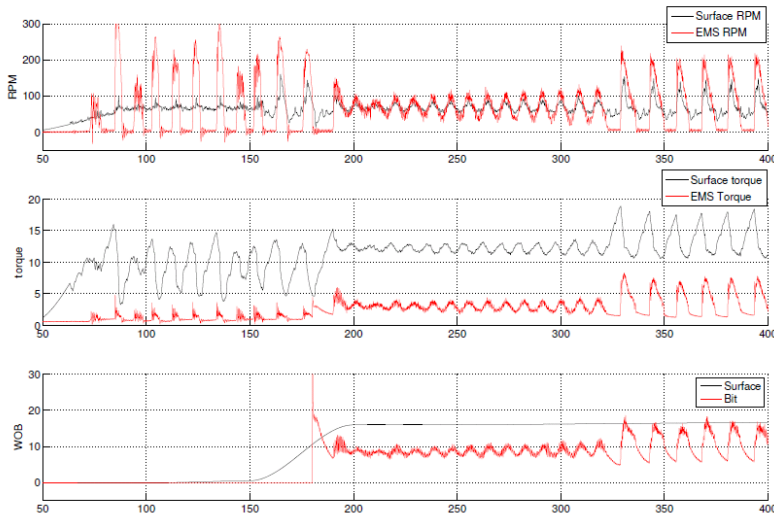


Effect of Friction / WOB

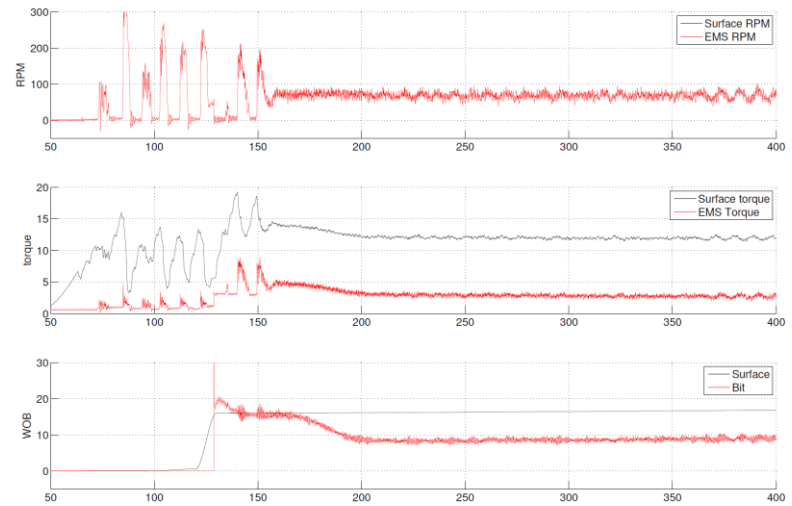


Effect of Operating Procedures

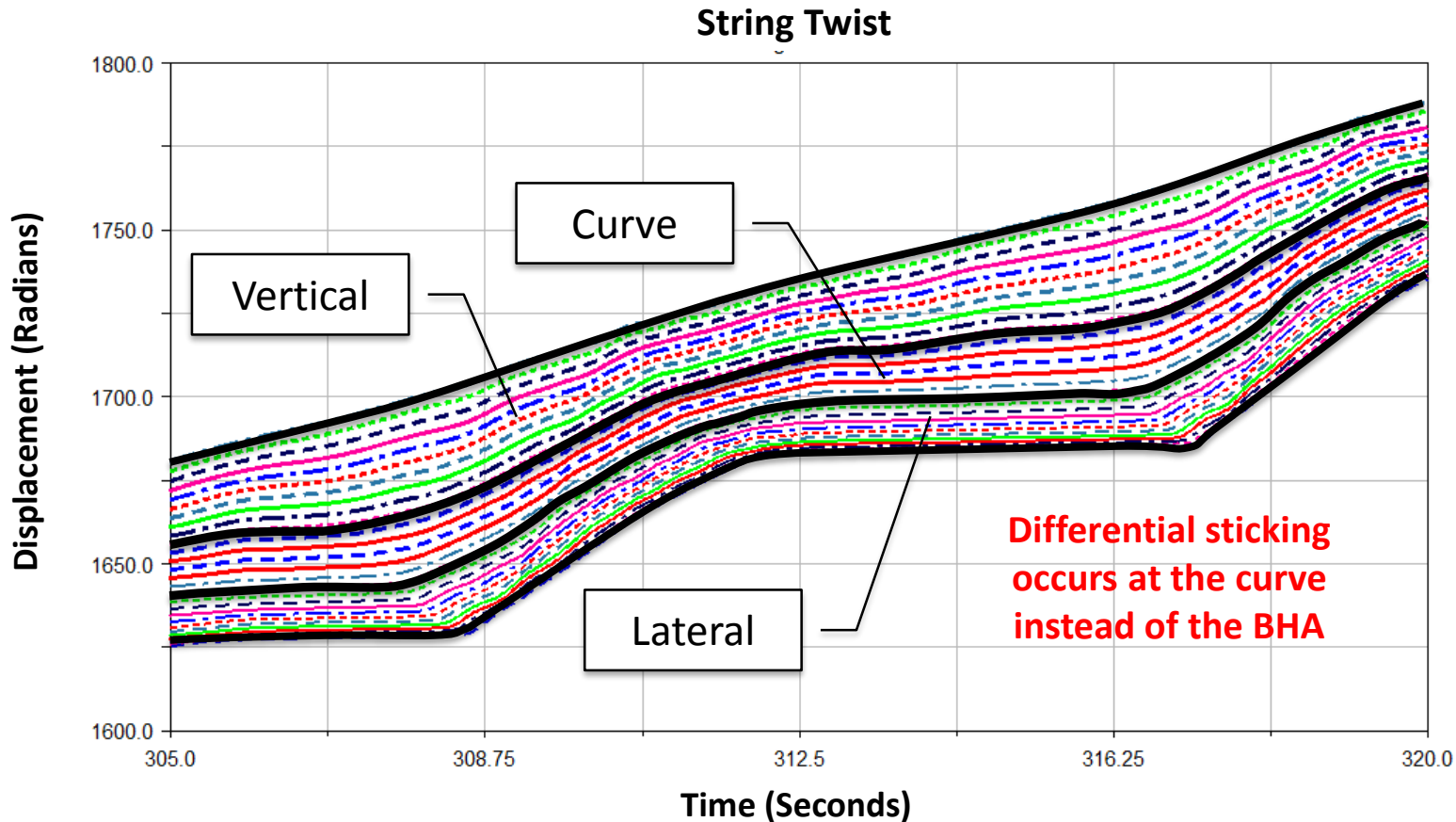
Tag Bottom Slower



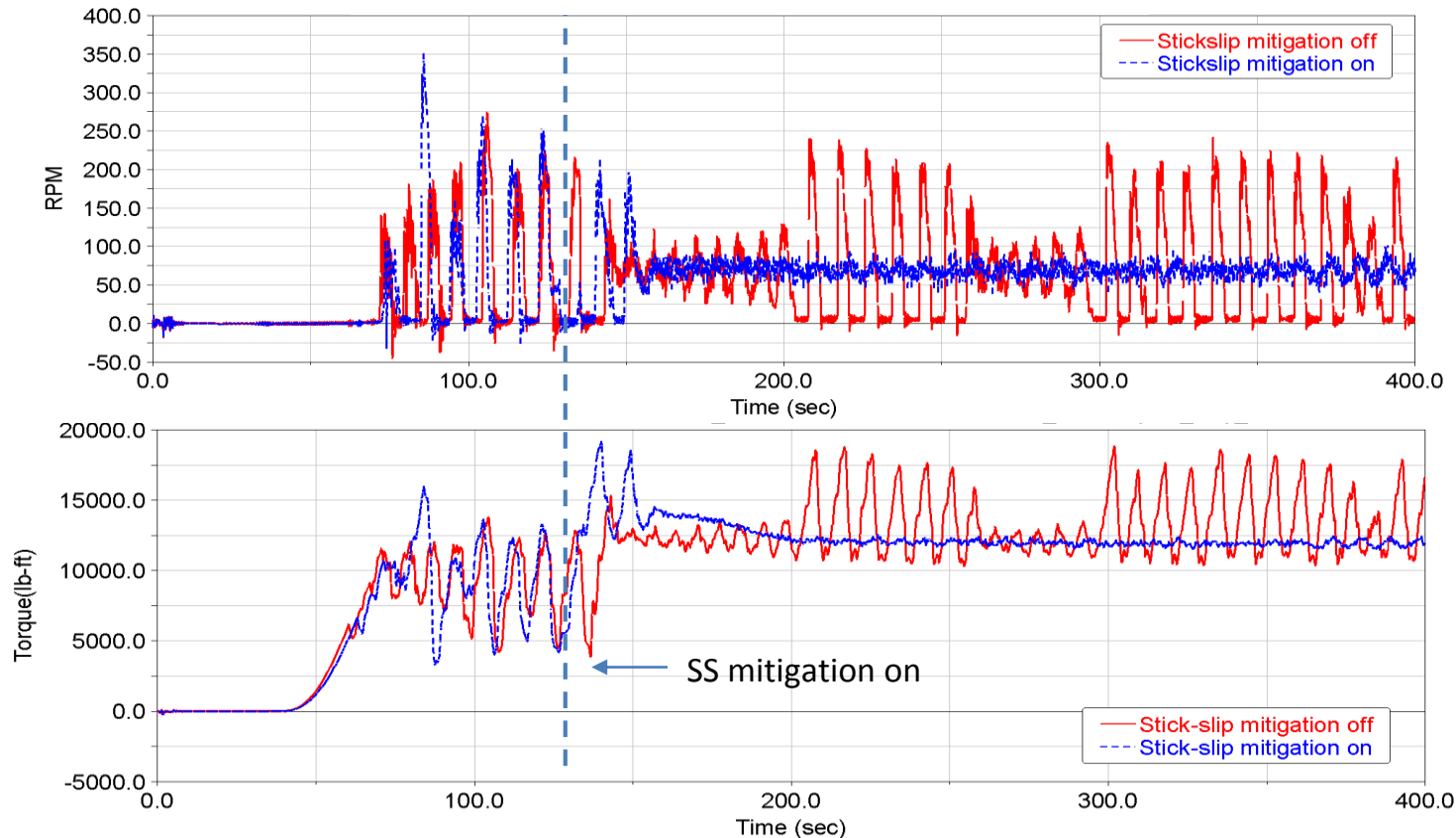
Tag Bottom Faster



Mid String Stick-Slip



Adaptive Stick-Slip Mitigation Virtual Testing in Lateral



Adaptive Stick-Slip Mitigation Field Testing in Lateral

- Adams virtual drill rig enables
 - Deeper understanding of drilling vibration
 - Simulation of different drilling parameter for optimization
 - Testing and evaluation of custom stick-slip mitigation tools
 - Reduced turn-around time during field testing
- Field trial of tool shows similar behavior as Adams simulation

Conclusion

- MSC Adams virtual test rig is an effective way to learn from measured downhole data and gain deeper understanding of drill string behavior
- Enables exploration of drilling parameters, BHA design, operating procedures, and control systems to optimize system behavior.
- Enables decisions throughout the R&D, Planning, and Execution phases to be based on physics and sound engineering judgement

(Simulation + Physical) >> (Simulation) + (Physical)



HEXAGON

MSC Software

Where Drilling Simulation Gets Real

Fred Harvey

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