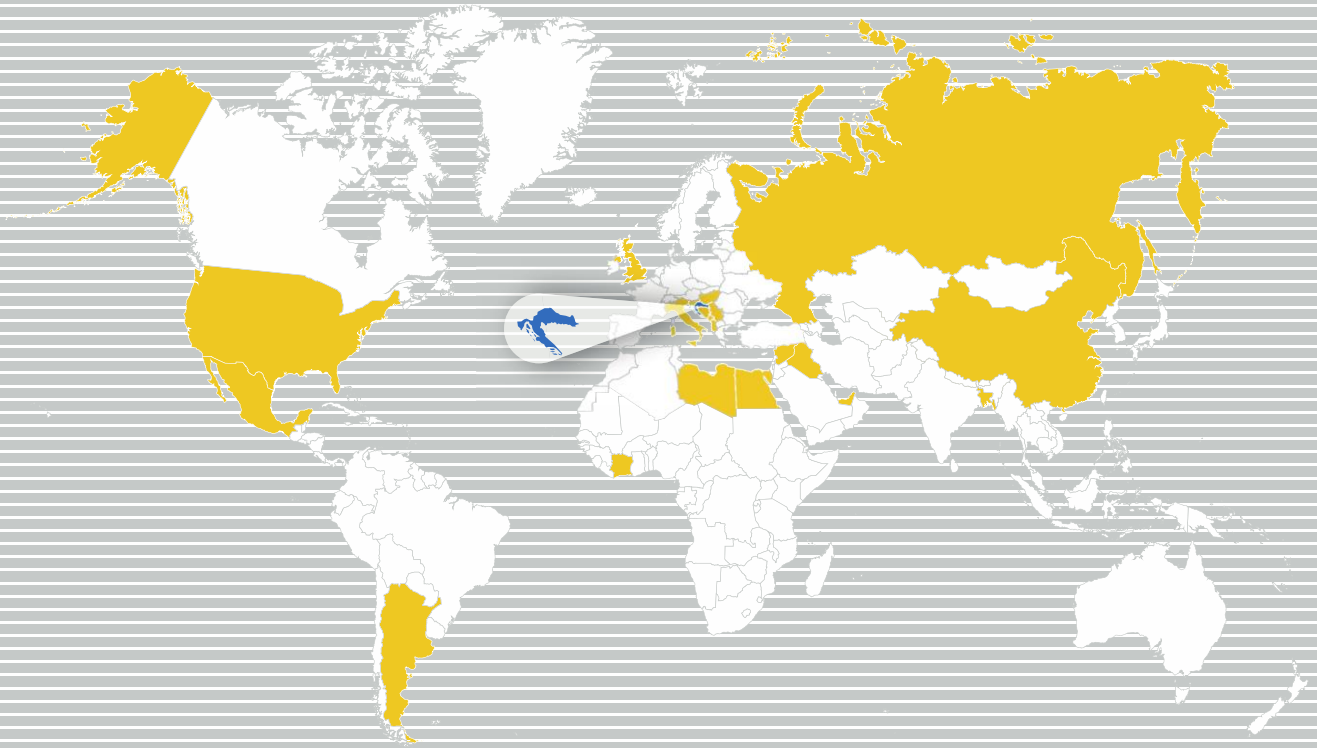


HELB

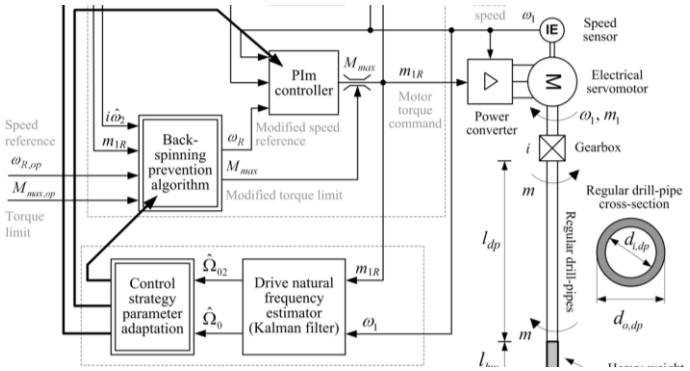
Old rig with new technology
Z – Torque

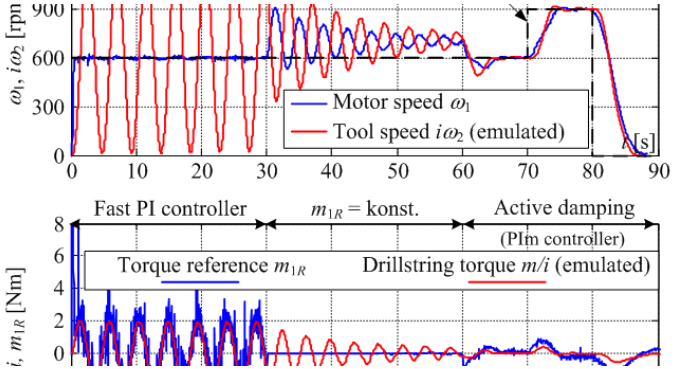
AUTOMATION SYSTEMS – SOFT DRIVE

TORSIONAL VIBRATIONS DAMPING SYSTEM

- Soft drive
  - Research in this field since 2009
  - Based on Shell technology

    (known as: Soft torque, Z-torque)

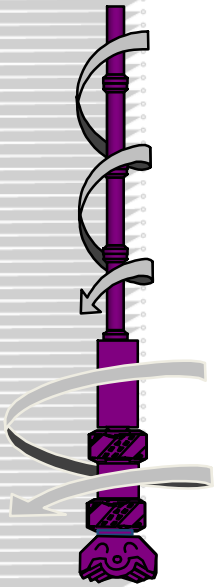




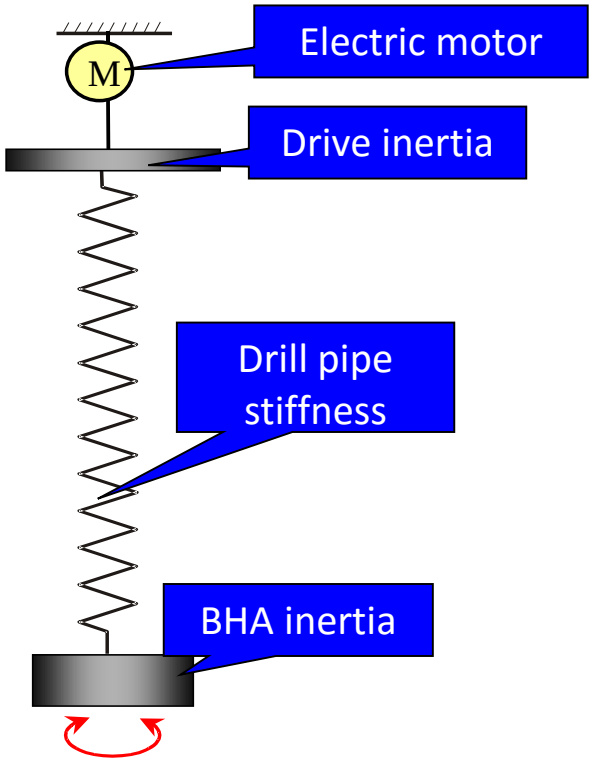
IMPACT OF DRILLSTRING VIBRATIONS

- REDUCED RATE OF PENETRATION (ROP)
- EQUIPMENT FAILURES E.G.
  - Rotary Steerable System (RSS), Downhole motors
  - Measurements while drilling (MWD)
- BROKEN DRILL BIT CUTTERS
- DRILL PIPE FATIGUE FAILURE
- ESTIMATED TO OCCUR 50% OF 'ON BOTTOM' DRILLING TIME

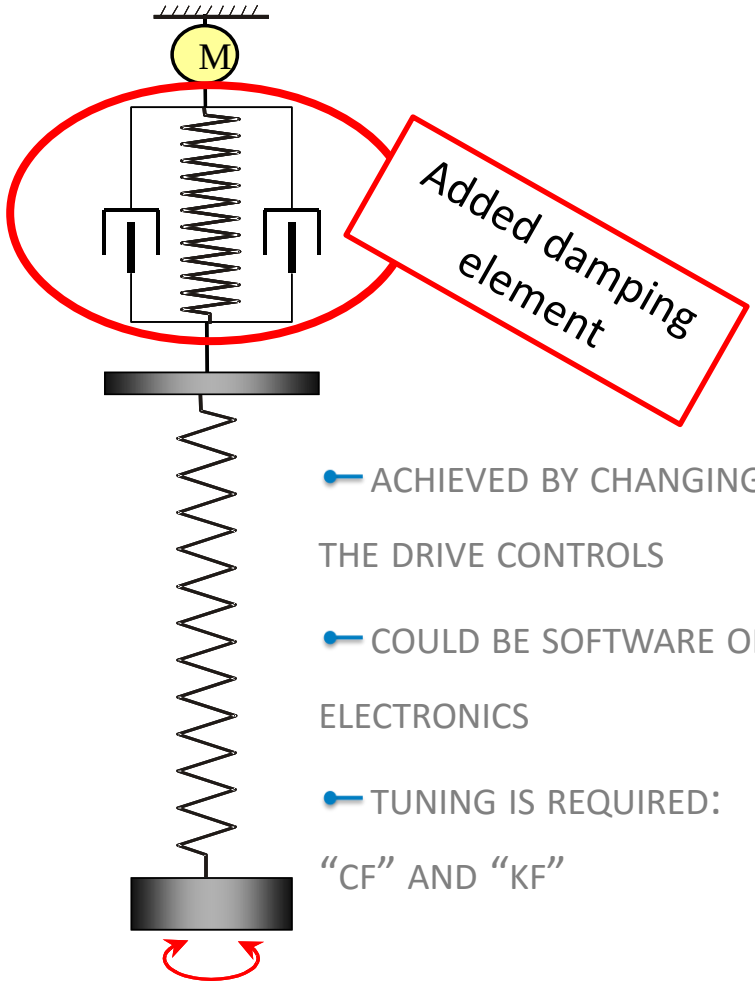
OLD SOFT TORQUE ROTARY SYSTEM (STRS)



NO STRS

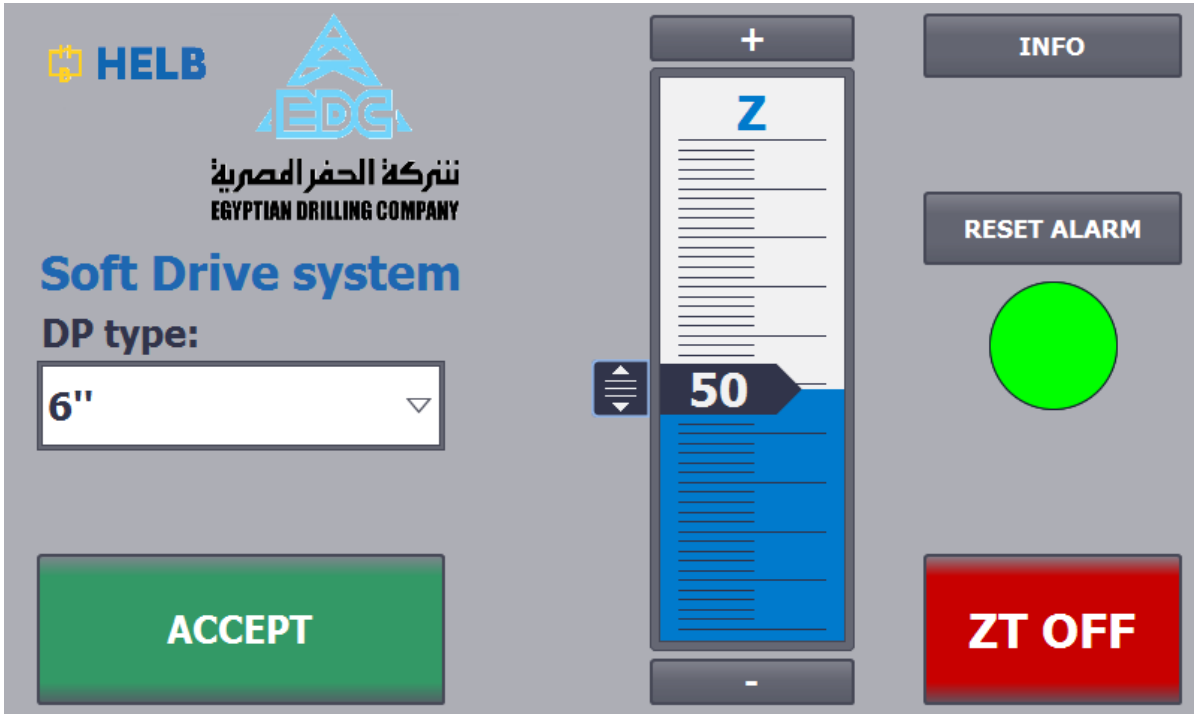


With STRS



- ACHIEVED BY CHANGING THE DRIVE CONTROLS
- COULD BE SOFTWARE OR ELECTRONICS
- TUNING IS REQUIRED: "CF" AND "KF"

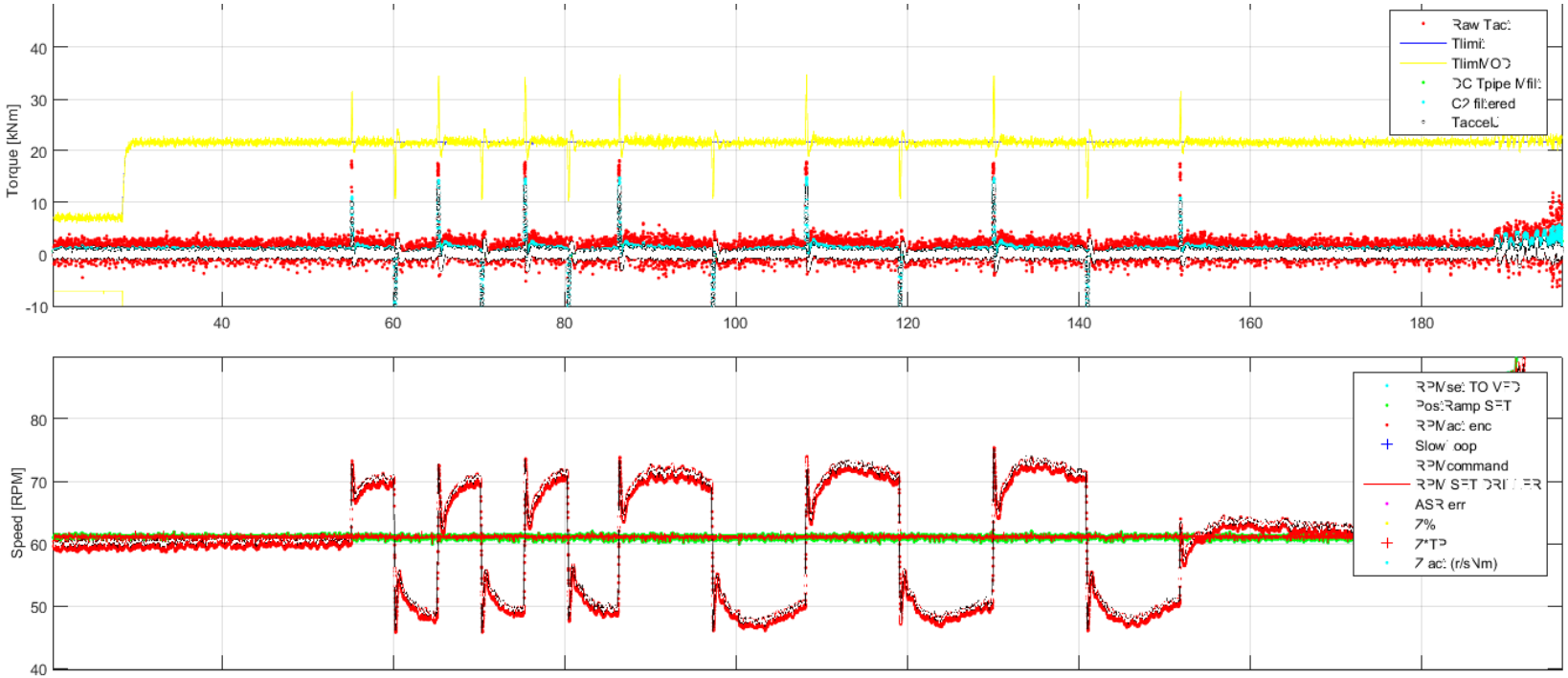
NEW Z-TORQUE TECHNOLOGY - STICK SLIP MITIGATION



- LINE THEORY APPLIED TO DRILLSTRING
- WITH INERTIA COMPENSATION/CORRECTION
- TD CONTROL SYSTEM DESIGNED TO ABSORB 'ALL' TORSIONAL WAVES WHICH 'ARRIVE' AT THE TOP DRIVE
- NO TUNING REQUIRED (FIXED SETTING PER DP SIZE/TYPE)

HOW TO ASSURE THAT Z-TORQUE WORKS?

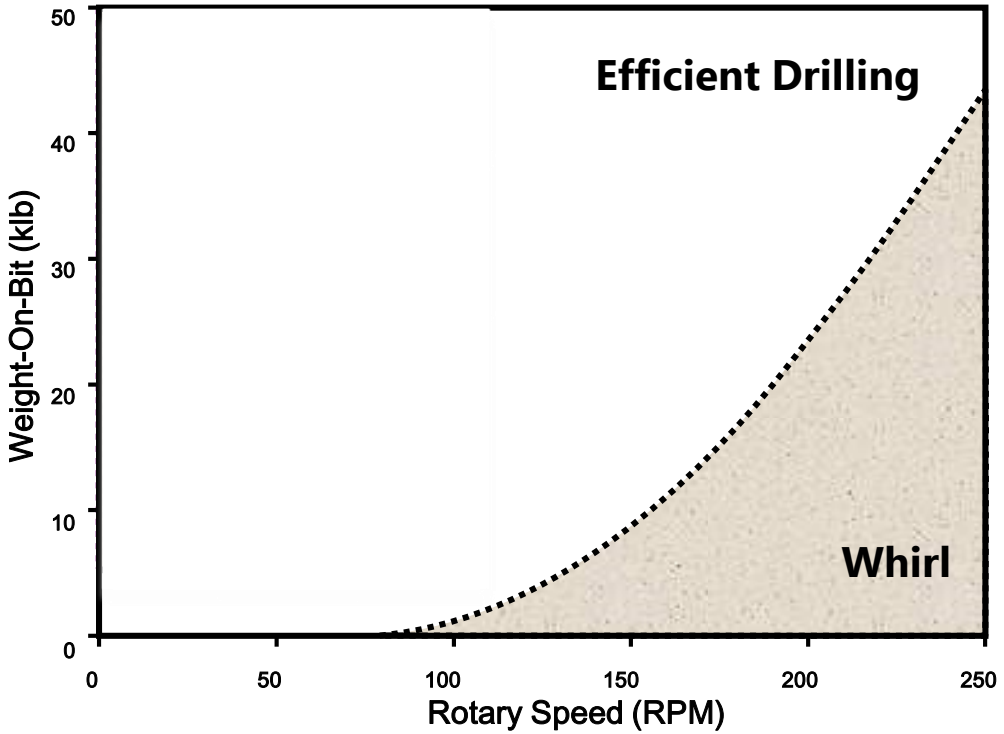
MINIMUM SPEC IS DEFINED IN COMMISSIONING QA/QC PROTOCOL



MINIMUM CRITERIA CONFIRMING SYSTEM FUNCTIONALITY AS WHOLE

- Derived from Unloaded Top Drive testing during commissioning
- Can be confirmed with Drilling data

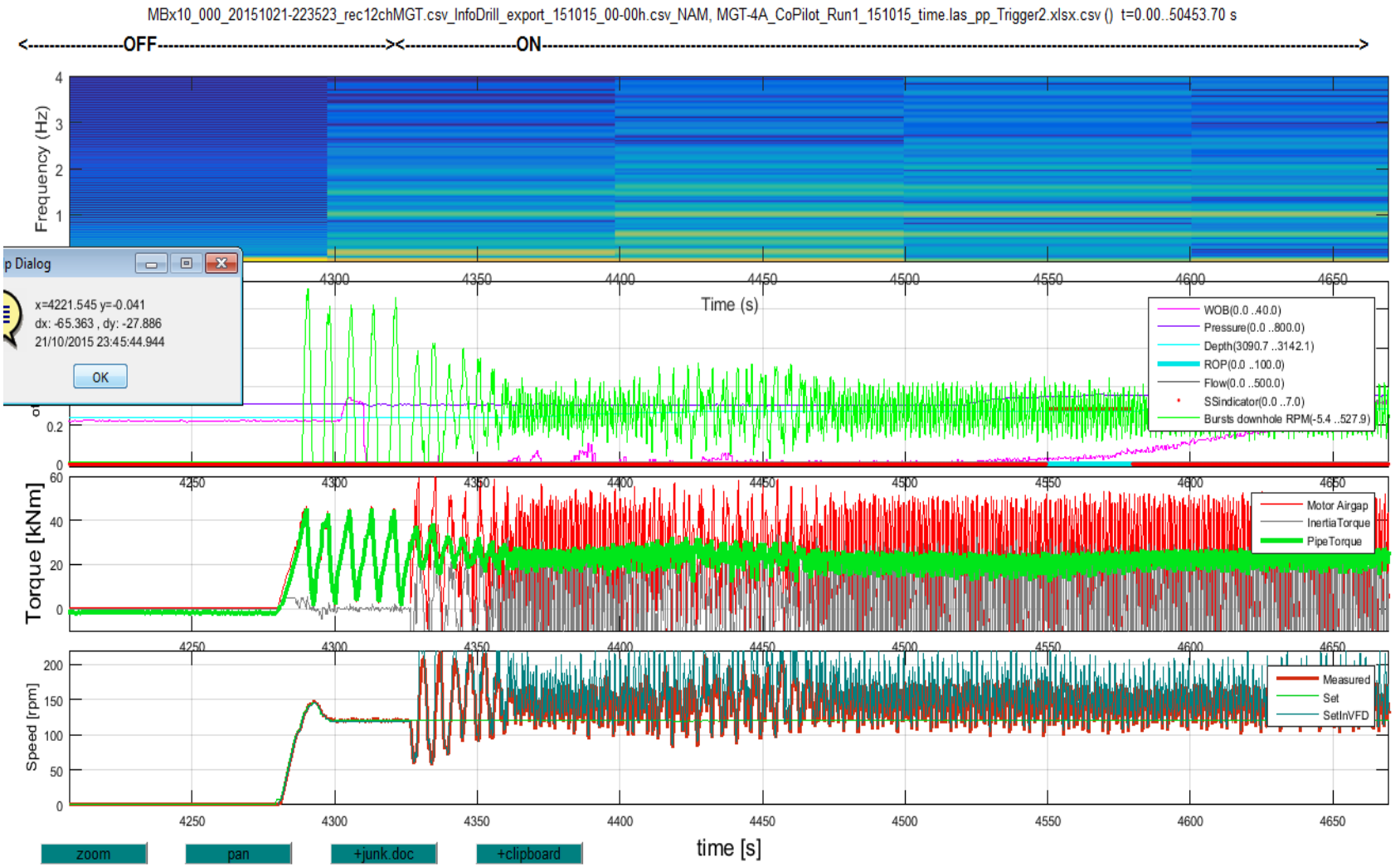
WHY Z-TORQUE?



SOFT TORQUE GAPS:

- TARGETS & ONLY TUNED TO THE FIRST 'MODE': THE LOWEST FREQUENCY
- MODEL REDUCTION ASSUMPTION: ONE LUMPED BHA MASS, AND ONE DRILL PIPE SPRING
- IT IGNORES PROPAGATION TIME DELAY: A 3 KM DRILL STRING, 3 KM/S...
- NEEDS TUNING, AND THAT'S PRONE TO HUMAN ERROR
- OPERATING ENVELOPE CONSTRAINTS: <4" DP AND >6 KM MD ARE A CHALLENGE
- NO GOOD SOLUTION YET FOR HYDRAULIC DRIVES

Z-TORQUE RESULTS



Z TORQUE MAIN IMPROVEMENTS

- HIGHER ROP
- LONGER BIT LIFE
- FEWER TRIPS FOR DOWNHOLE BREAKDOWNS...
- LOWER COSTS

ADDITIONAL Z TORQUE IMPROVEMENTS

- LIGHTER BHA
- SLIMMER DRILL PIPE
- FEWER MUD MOTORS
- LATERAL/WHIRL SOLVED BY ENABLING VERY LOW TD RPM
- DRILL STRING IMAGING
- NEAR SOLID STATE ROTARY STEERABLE: STEER WITH TD

IMPLEMENTATION REFERENCES

HELB

EGYPTIAN DRILLING COMPANY: Z-TORQUE IMPLEMENTATION

CLIENT: COOPERATION AGREEMENT BETWEEN SHELL, BAPETCO, EDC, HELB

EGYPT: RIG 52, HADS/ST SYSTEM

YEAR: 2015 - 2016

SCOPE OF WORKS:

- SOFT DRIVE - Active Damping System for Rotary Drilling String