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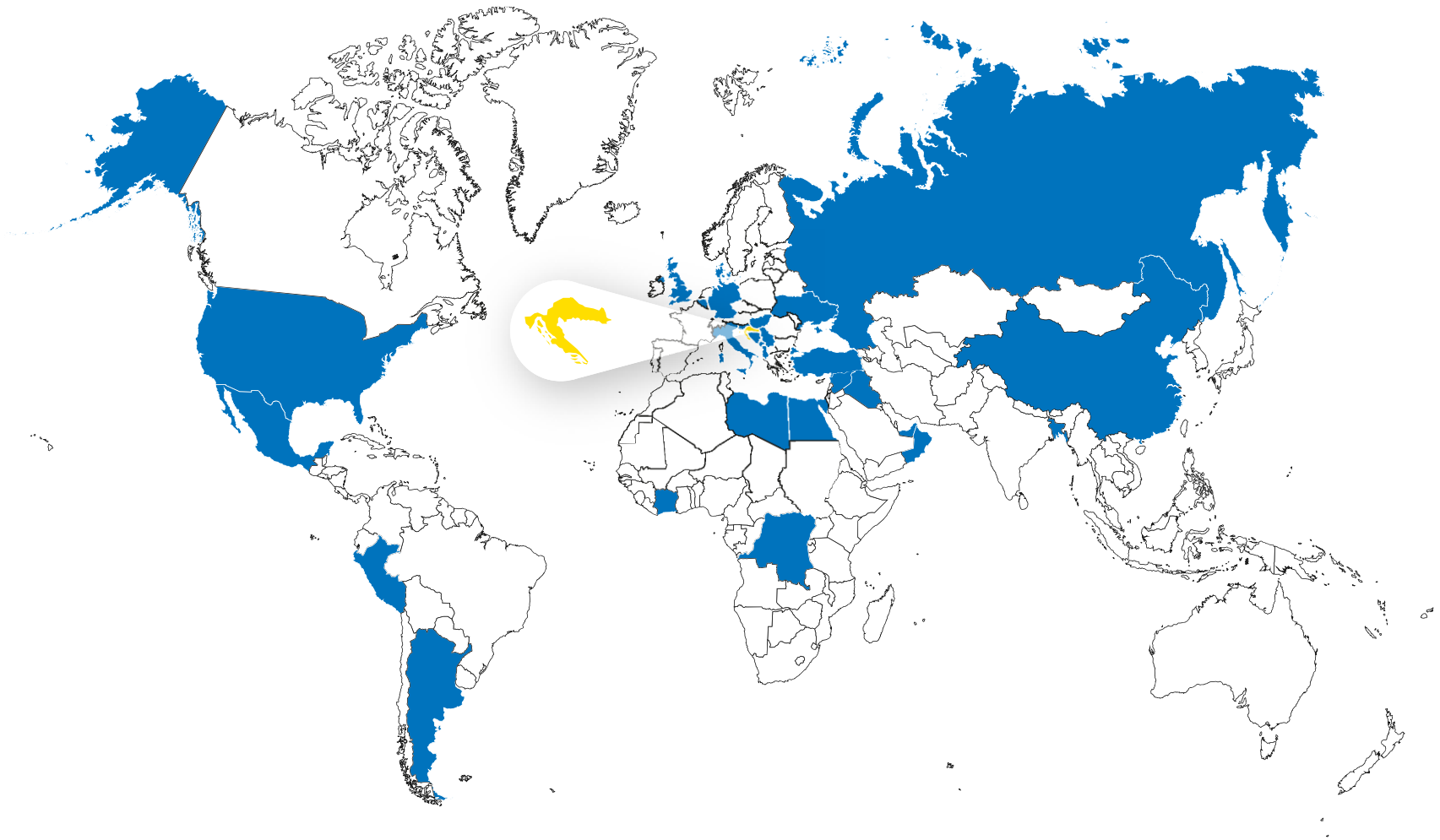

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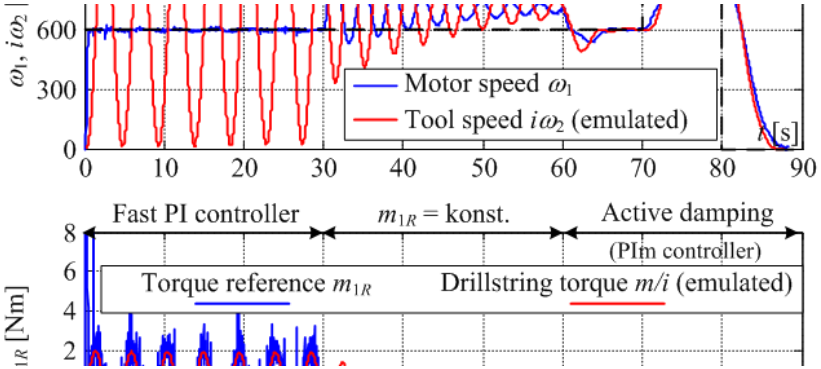
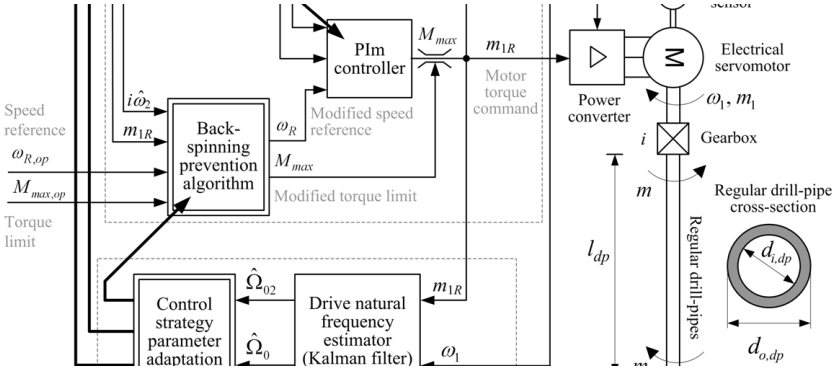
Automation sytems – soft drive

TORSIONAL VIBRATIONS DAMPING SYSTEM

- Soft drive
  - based on our own technology
  - based on technology approved by Shell

    (known as: Soft torque, Z-torque)





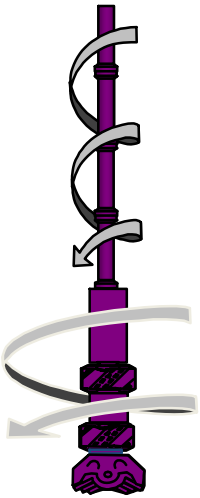
Recap: impact of drillstring vibrations

- 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

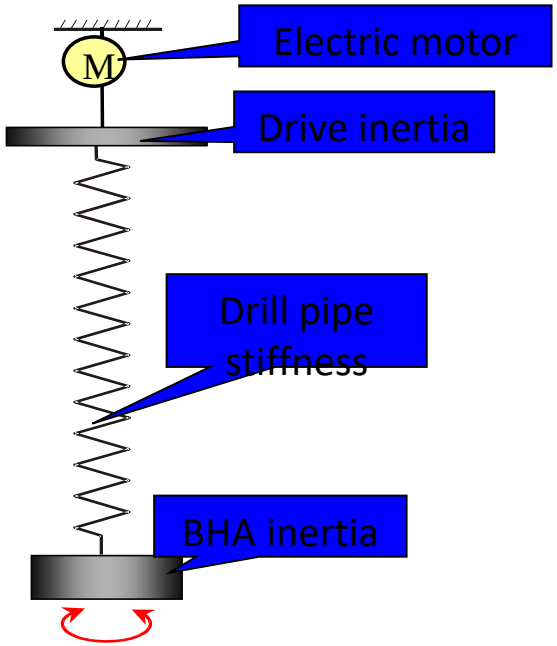
NO STRS

WITH STRS

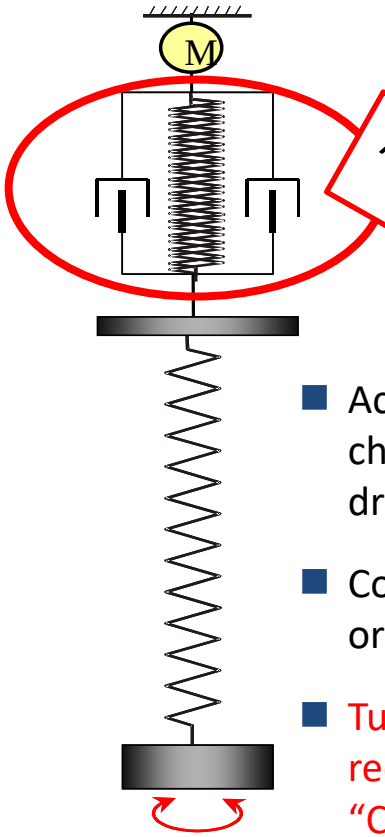
Recap: CLASSIC SHELL SOFT TORQUE ROTARY SYSTEM (STRS)



NO STRS

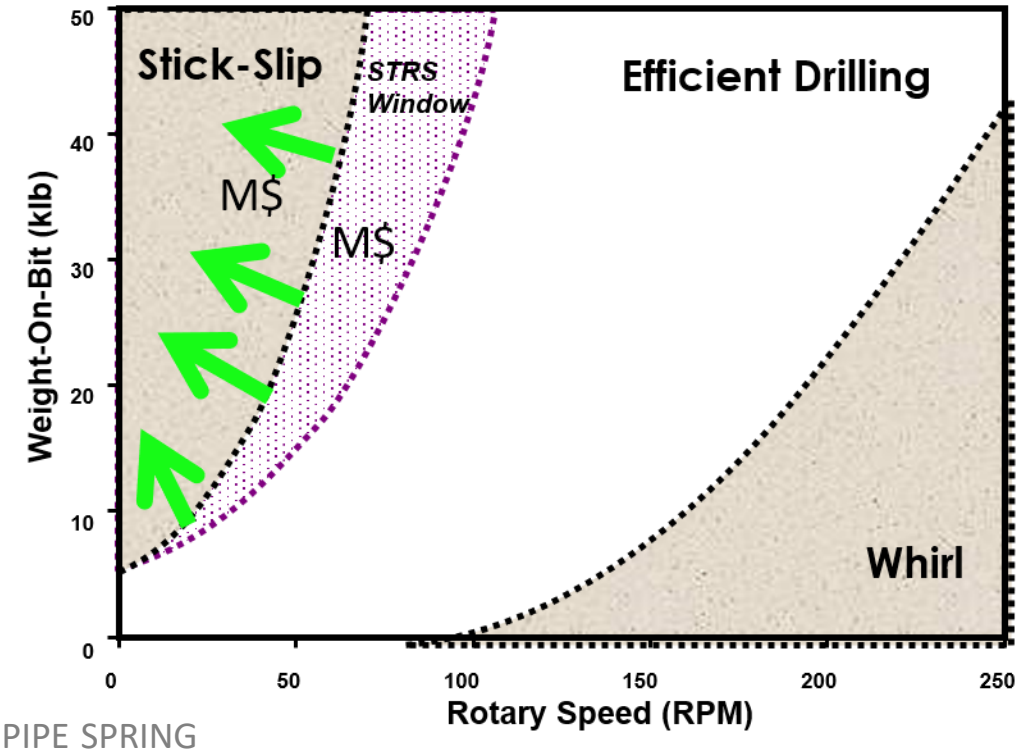


With STRS



- Achieved by changing the drive controls
- Could be software or electronics
- Tuning is required: "Cf" and "Kf"

Why Z-Torque?



'Classic' SoftTorque gaps:

Targets & only tuned to the first 'mode':

- the lowest frequency

Model reduction assumption:

- one lumped BHA mass, and one drill pipe spring

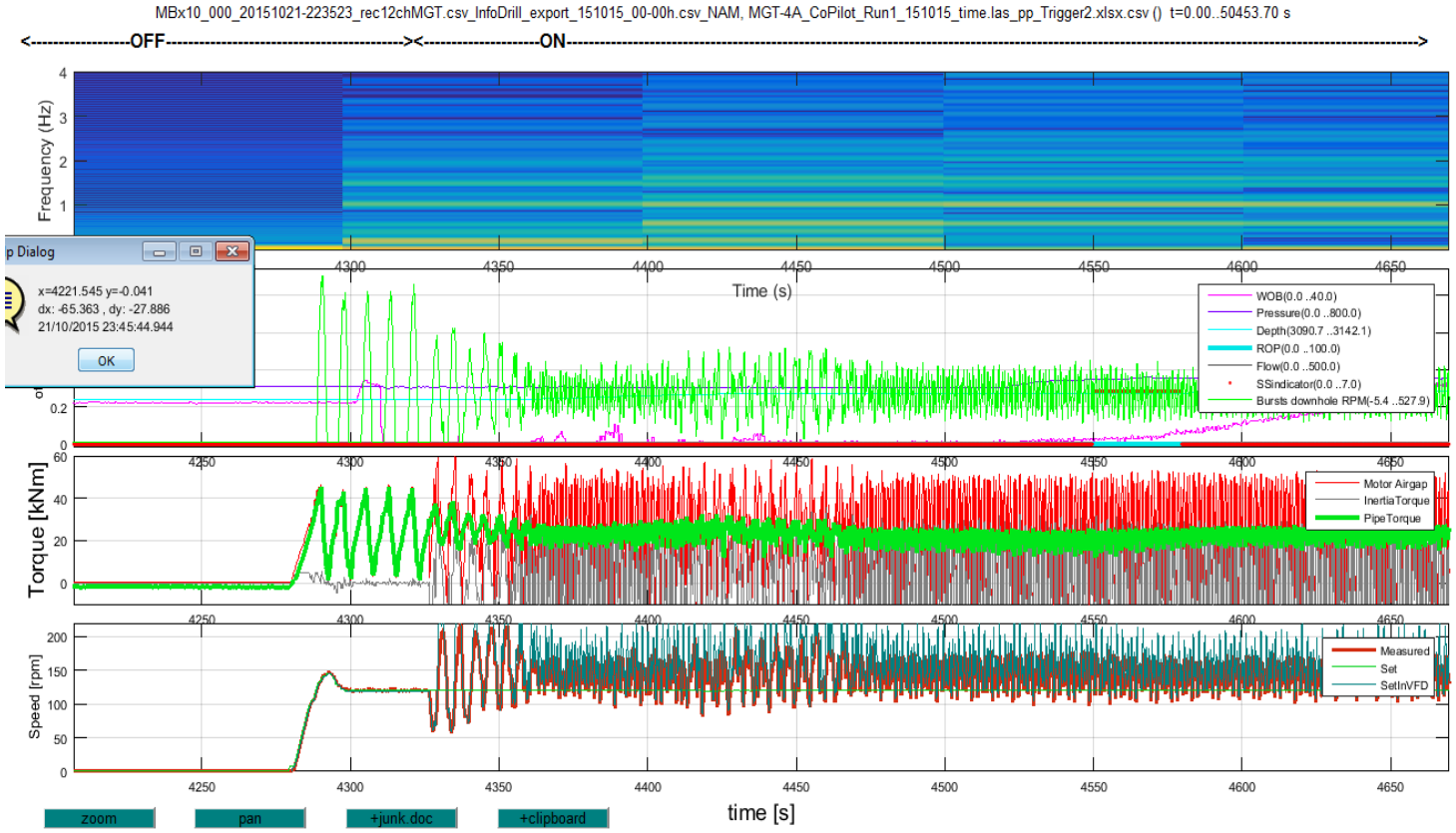
It ignores propagation time delay: a 3 km drill string, 3 km/s…

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

NL Land, Chalk, CoPilot downhole & T-700 surface data



Conclusion

Z-Torque's matched top drive impedance benefits:

- Intrinsic auto-tuning. Forget Kf and Cf sheets. Z-Torque controller only requires Z_pipe and J_topdrive in its brain. These are constants during an entire well section. (Nb: the one remaining 'tuning' parameter, Z_pipe, is easily auto-sensed if a full hassle free system is desired).
- Multi mode challenges solved. Only a matched impedance top drive catches all the waves that travel upwards. For any frequency.
- Stability for proposed implementation is predictable and thus manageable: know the latency in the loop VFD-topdrive-gears-speed_sensor-comms means we know how to optimally low-pass filter the corrective signals.

Conclusion

„RPM can go lower, WOB goes higher. Much higher.

Or we can opt to keep these where they are, but use slimmer drill pipe, or a lower weight BHA.

Either way, we've pushed the limits for economically drilling extreme holes, in ever more challenging places and formations."

- **Sicco Dwars, Shell,** SPE/IADC-SPE-173037-MS -MS,

  „Recent Advances in Soft Torque Rotary Systems".

References

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Egyptian drilling company: z-torque implementation

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

EGYPT: RIG 52, HADS/ST SYSTEM

YEAR: 2015

SCOPE OF WORKS:

- Active Damping System for Rotary Drilling String

Thank you

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