Impact of high-speed wired telemetry on wellbore surveying, trajectory management and wellbore placement

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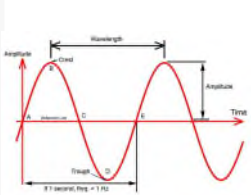
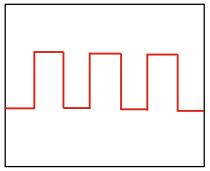
WDP Introduction

Mud Pulse Telemetry

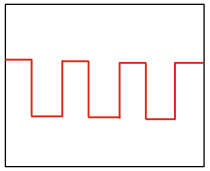
- Downhole flow restriction, change in pressure
- Data rate of 12-256 bps (Data Compression)
- Latency



High Speed Wave
12 – 256 bps



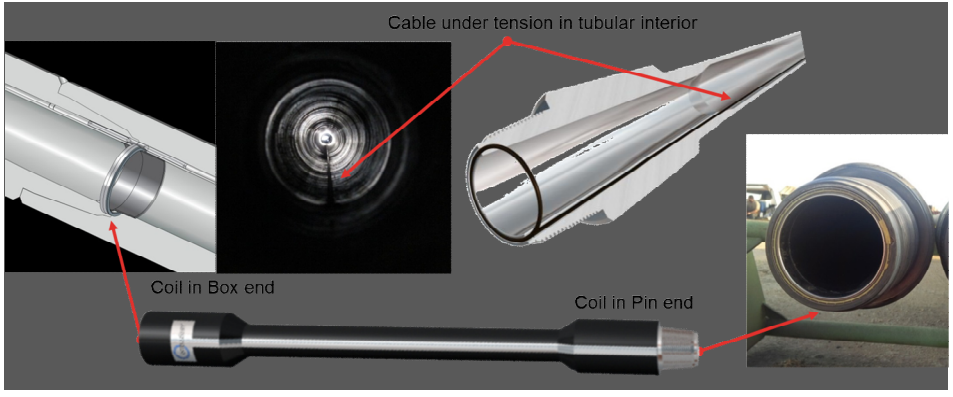
Standard Positive
4 – 20 bps



Negative
12 – 140 bps

WDP Telemetry

- Coils in pin and box, coax cable in between
- Enables data rates up to 57,600 bps
- Instant bi-directional communication



System Topology

Broadband Network

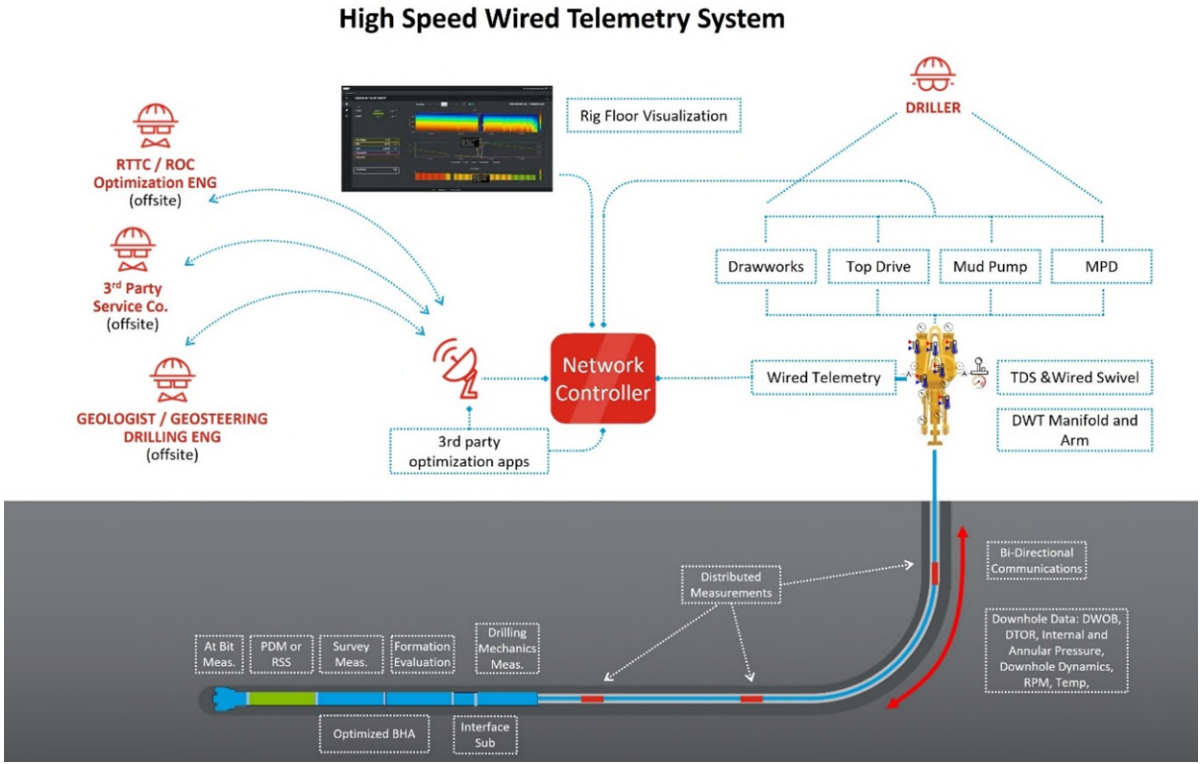
- WDP
- Signal Boosters
- Network Controller
- TD Swivel
- Data While Tripping (DWT)

Tools

- Along String Measurement tools (ASMs)
- Enhanced Measurement System (EMS)
- Advanced LWD – UDR, NMR, RSS etc.
- Wired Interface
- Wired Components

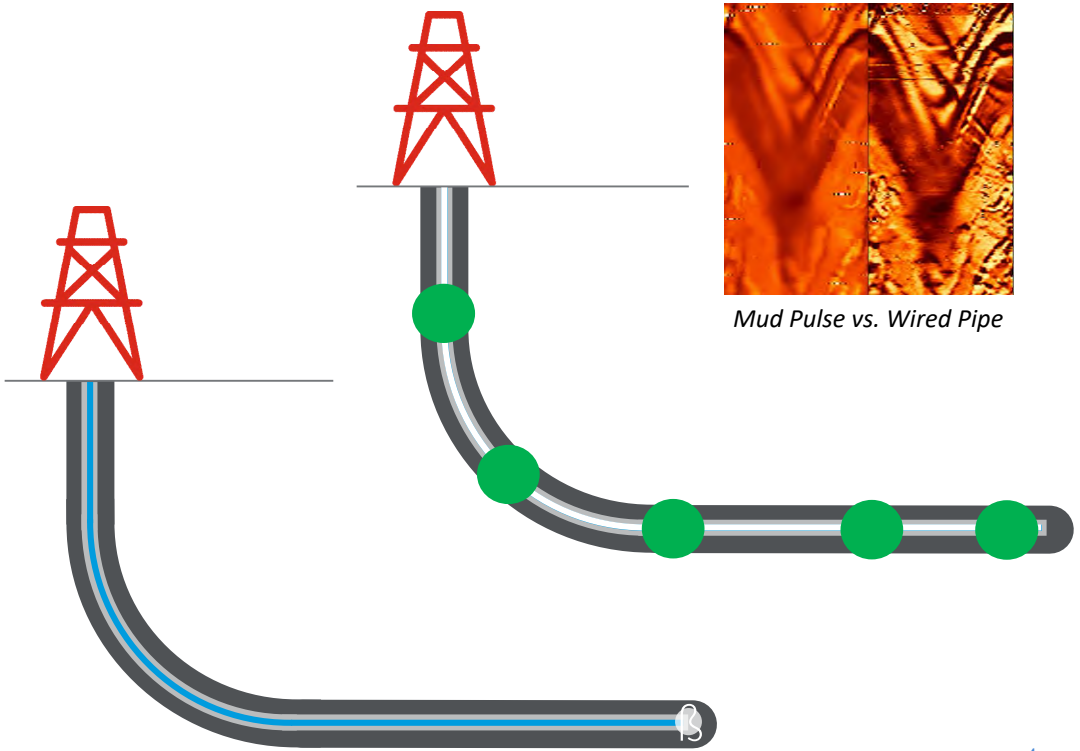
Applications

- Equivalent Fluid Density Viewer
- Remote Drilling Monitoring



Capabilities and Value of High-Speed Wired Telemetry

- High-speed telemetry
  - Memory data quality in real time
  - Instant communication with downhole sensors and tools
- Distributed measurements
  - Along-String Measurements for pressure and dynamics, in addition to BHA
  - Independent of flow rate and flow state
- Time Savings
  - Seconds vs. minutes: downlinks, surveys, etc.
  - No ROP restriction for LWD log quality
  - Optimization of hole cleaning, drilling dynamics
- Wellbore stability risk reduction
  - No more fluctuation in downhole pressure
  - Downhole pressure data independent of flow
- Improvement in Well Placement
  - Optimized well trajectory both geometrically and geologically
  - Improved data choice and availability

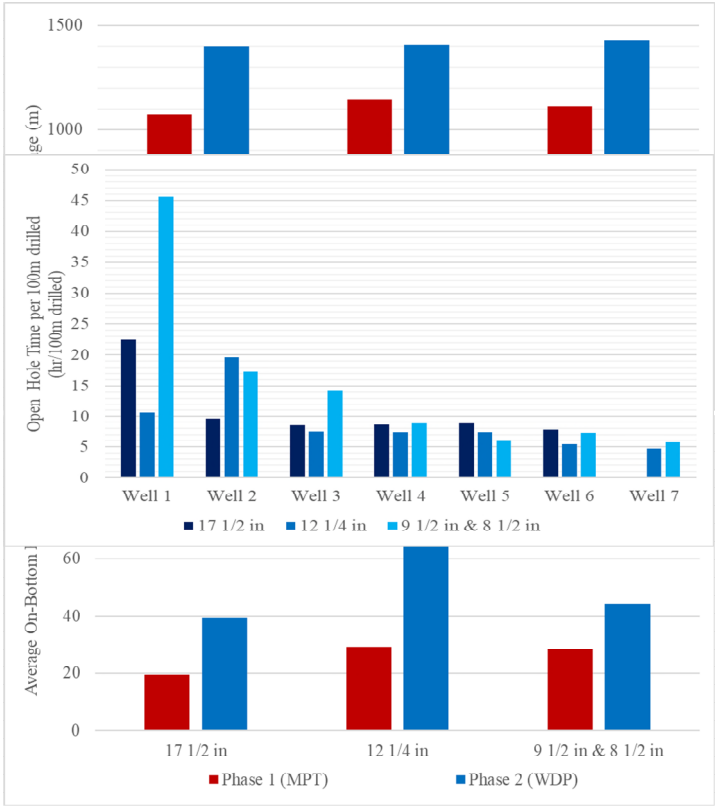


Mud Pulse vs. Wired Pipe

Cost v ROI

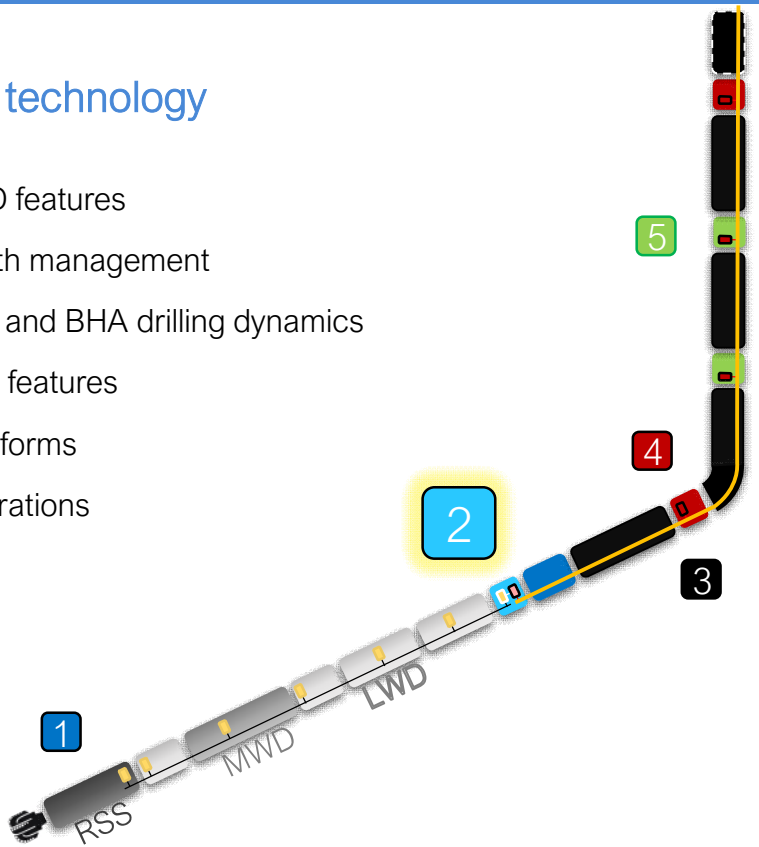
Technology Investment v ROI

- Requires some time to achieve max performance
- Requires often a change in mindset - data v experience
- Performance improvements can be significant
- People are important!



Enhanced WDP Interface technology

- Advanced RSS and M/LWD features
- Adaptive network bandwidth management
- Advanced multi-mode Tool and BHA drilling dynamics
- Downhole tool aggregation features
- Compatible with digital platforms
- Optimized for Remote Operations



1 Downhole tools

2 Interface sub

3 Wired Drill Pipe

4 Datalink (booster subs)

5 ASM (Along String Measurements)

Ultra high-speed enabler for Wired Drill Pipe systems

- Available in all tool sizes
- Integrated with the latest ISV network components **(v2 coil and latest version of the WDP modem)**
- State of the art next-gen tool architecture
- Faster & more efficient communication protocols
- High definition geosteering and Logging While Drilling **(Elevating LWD closer to Wireline experience)**
- Rechargeable batteries and efficient power regulation **(tool is efficient using power and capable of using rechargeable LWD lithium batteries)**
- Optimized for Remote Operations **(no programming on site, just torque it and RIH, programmed while tripping)**
- Advanced multi-mode drilling dynamics | Single tool and BHA level **(New generation S&V sensor)**
- Enabler of closed loop Autonomous directional drilling in Wired Drill Pipe

GWD Survey Workflow with MPT v WDP

GWD survey – MPT (Old Firmware)

1. Downlink to move from WDP to MPT
2. Cycle pumps to set GWD into survey mode
3. Pumps off to take survey
4. Pumps on - survey sent to surface
5. Perform Survey QC
6. Downlink to move from MPT to WDP
7. Drill ahead

Total 12-14 minutes

GWD survey – WDP (New Firmware developed in 2023)

1. Pumps off to take survey
2. Perform Survey QC over WDP during pumps off
3. Pumps on and resume drilling parameters
4. Survey received in acquisition system
5. Drill ahead

Total 3-4 minutes
Time savings in Top Hole 5.95hrs approx. (190K saved)

GWD surveys acquired with **ZERO** waiting time at connection
No change in survey precision or accuracy
Benefits of reduced GWD azimuthal uncertainty (vs MWD) without reducing operational efficiency

Steering and surveying Efficiencies – MPT v WDP

Downlinking - MPT

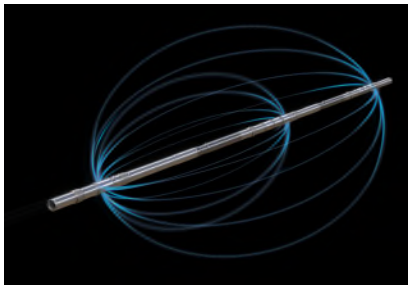
- Flow / RPM variation in pre-defined pattern
- Takes 5+ minutes to send a command
- May require completion off bottom

Downlinking

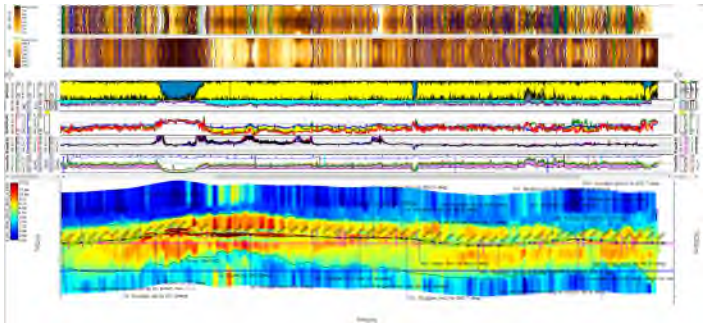
Downlinking - WDP

- Command sent in one click; instant communication to downhole tool via WDP
- Reduced ILT and total time savings
- Geosteering decisions can be executed instantly
- No need to hold back ROP to send command
- Reduces deviation from desired well position
- No change to flow/RPM = no impact on downhole conditions (hole cleaning, dynamic stability)
- Increase in DL frequency – Improved RSS Control

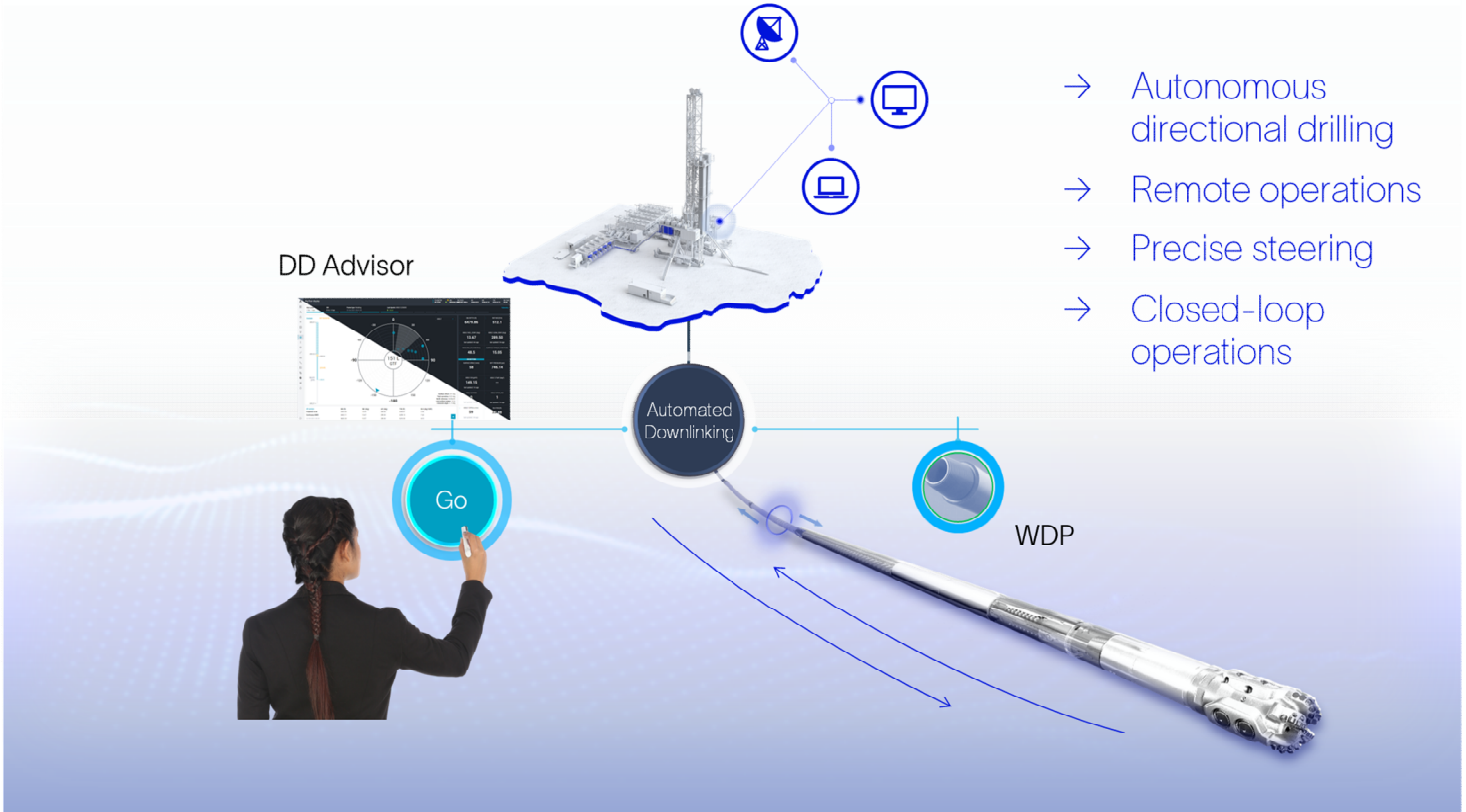
Well Placement Case Study – Geosteering with WDP



- Enabled optimal well placement for production (perfect well placement achieved 3-5m TVD below roof)
- Utilized WDP for shale stability monitoring and fast geosteering decisions
- Facilitated optimized real-time data transmission (large volume) from downhole to the surface without compromise on ROP
- Acquired high-definition data in Real-Time
  - With MPT data transmission, misfit of the inversion in relation to the actual measurement is usually high and this is associated noisy or poor data quality. Consequently, the uncertainty in TVD and boundary delineation is generally high.
  - WDP provides high-definition data transmission in real time even with higher ROP, thus enabling high confidence in boundary definition and accuracy in TVD positioning of the wellbore. Enables both 2D and 3D (360 Spatial) inversions.
  - High-definition real-time data is extremely valuable for open hole sidetrack trajectory planning. There is no need to pull out of hole for Recorded Mode data processing.



Closed Loop Automation



- → Autonomous directional drilling
- → Remote operations
- → Precise steering
- → Closed-loop operations

Future Well Positioning Gains and Opportunities

- Availability of HQ continuous Surveying – Ref*: "The Effect of Survey Station Frequency on Wellbore Position Accuracy" -Jerry Codling*
- High Speed Telemetry enables acquisition of both Gyro and HD RT survey data allowing:
  - Improvements in TVD uncertainty
  - Improvements in overall position uncertainty / Anti- Collision Improvements
  - Ability to provide optimized T&D Monitoring
  - RT 3D tortuosity modelling with no impact on formation data quality
- Ruggedized solid-state Gyro while Drilling – definitive surveying with zero operational impact:
  - Improved top hole placement for structure development (Reduce well head congestion)
  - Overall improvements in Geometric Well Placement
- Improvements in autonomous well placement and delivery

Conclusion and Remarks

WDP delivers a holistic improvement of well construction. It is not just ‘faster data’ or ‘higher ROP’ but much

more **...** improving the interaction and operation of redesigned downhole tools, and impacting production through superior well placement geologically and geometrically

UNLOCK
A Superior Downhole Experience

ENABLE
Active Risk Management

ENHANCE
The Autonomous Journey