



Field Results of Access-Independent Active Magnetic Ranging While Drilling Using Powered Drill Pipe in High Formation Resistivity and Oil-Based Mud Environments

Chad Anton



Clinton Moss



and partners:



ERDOSMILLER



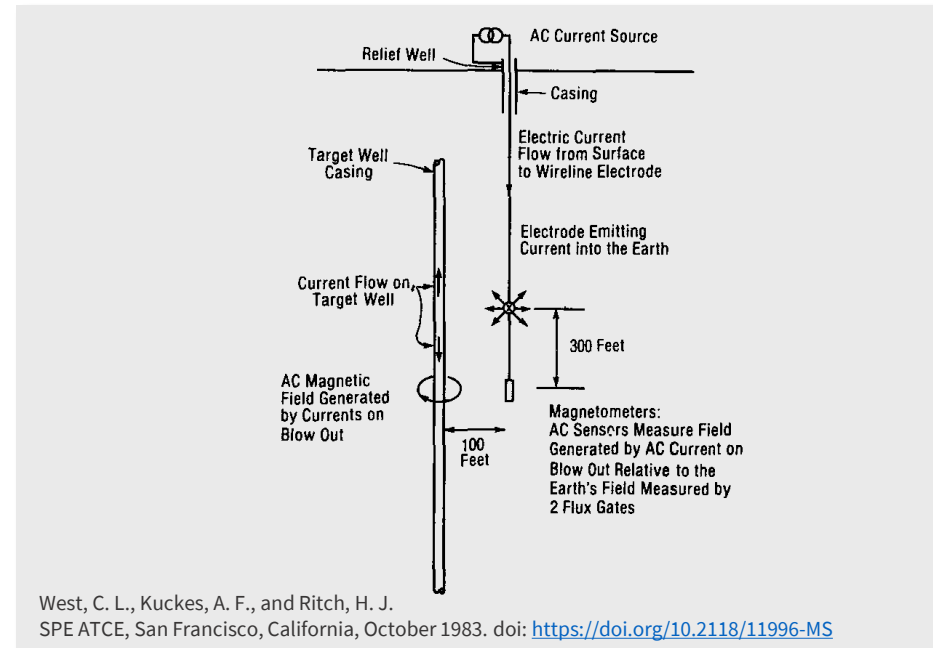


Speakers

- Chad Anton – Senior Drilling Engineer at ExxonMobil
- Clinton Moss – Founder/CEO at Gunnar Energy Services

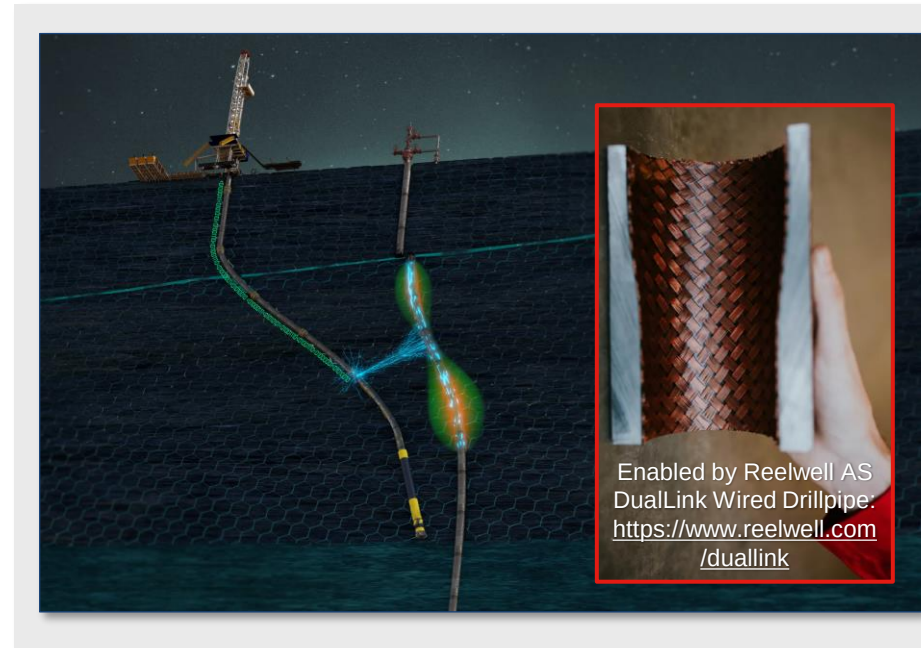
Active Magnetic Ranging – General Theory

- **Purpose of Access-Independent Active Magnetic Ranging:**
 - Detect and locate casing in a nearby target well during intercept operations.
- **General Configuration:**
 - Surface AC generator provides low-frequency current.
 - Current flows down the wireline to an electrode placed 100 – 300 ft sensor.
 - Return current flows through the formations to target casing.
- **Sensor Components:**
 - AC magnetometers measure magnetic field generated by current on target casing.
 - Gyro and accelerometers determine tool orientation relative to Earth's coordinates.
 - Electronics transmits raw signal waveforms to surface.
- **Operating Principle:**
 - In isotropic formation with no offset casing, current distribution is symmetrical → magnetic field cancels at sensor (no signal).
 - Conductive casing breaks symmetry, concentrating current along casing.
 - Current on casing generates detectable magnetic field at injected current frequency (Ampere's law).
- **Output Information:**
 - Direction to target casing determined from active magnetic field vector orientation.
 - Distance estimated from signal amplitude, formation conductivity, and casing resistance, or from active field gradient measured within ranging probe.



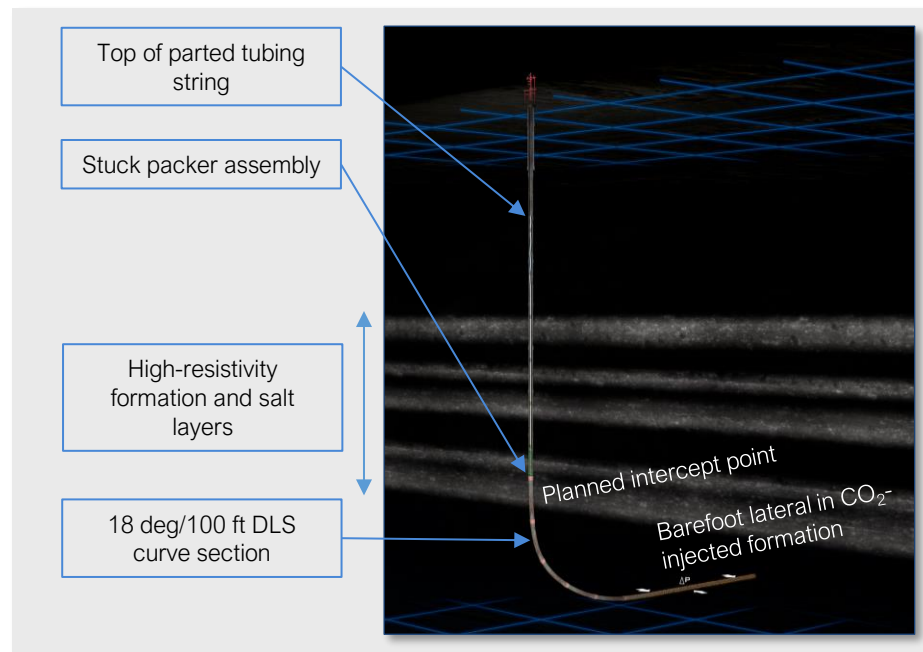
Ranging While Drilling (RWD) Overview

- Depth of investigation/range of wireline AMR systems is limited by power injected into the formation.
- **Powered Drill Pipe offers:**
 - Multiple times higher power delivery.
 - Wireline runs and BHA trips minimized or eliminated.
 - Increased depth of investigation/range.
 - Works in oil-based mud and high-resistivity formations.
- **Ranging-While-Drilling (RWD) offers:**
 - Gyro-While-Drilling (to mitigate magnetic interference).
 - Access-Independent Active Magnetic Ranging While Drilling and Continuous Magnetostatic Interference Monitoring.
 - Downhole ranging data processing and wireless ranging result transmission.
 - Superior alignment with intercept wellbore axis, with surveying and ranging from the same tool for high accuracy results.
 - Two successful deployments in 2025: Australia and USA.



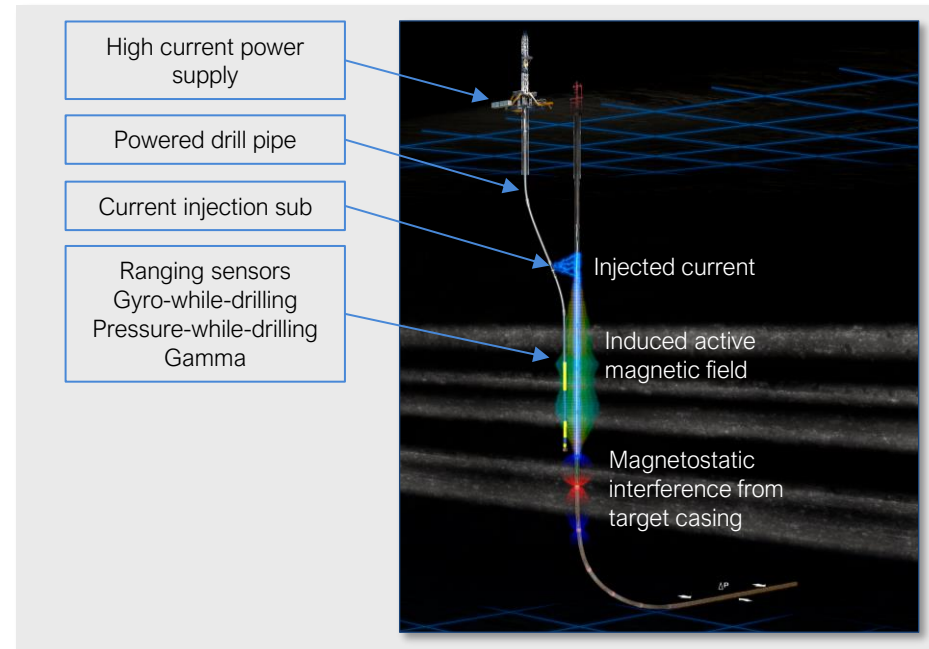
USA Case Study – Target Well Problem Description

- **Conventional P&A Challenges (not feasible):**
 - Packer stuck in 7" casing at 8,580ft TW MD.
 - Tubing cut at 1,180ft TW MD; no access to target wellbore below 1,050 ft.
 - Workover and fishing deemed uneconomical and likely not feasible.
- **Intervention via Well Intercept Challenges (feasible):**
 - Sparse TW surveys (every ~500ft).
 - High-resistivity formations and salt layers weaken AMR signal.
 - Oil-based mud further reduces conventional AMR signal.
 - Unstable formation layers complicate wireline ranging deployment.
 - Narrow TW intercept window (~10 ft) below packer and above kickoff point of 18°/100 ft build section.
 - High CO₂ pressure in lateral section.



Case Study – Ranging While Drilling (RWD) Solution

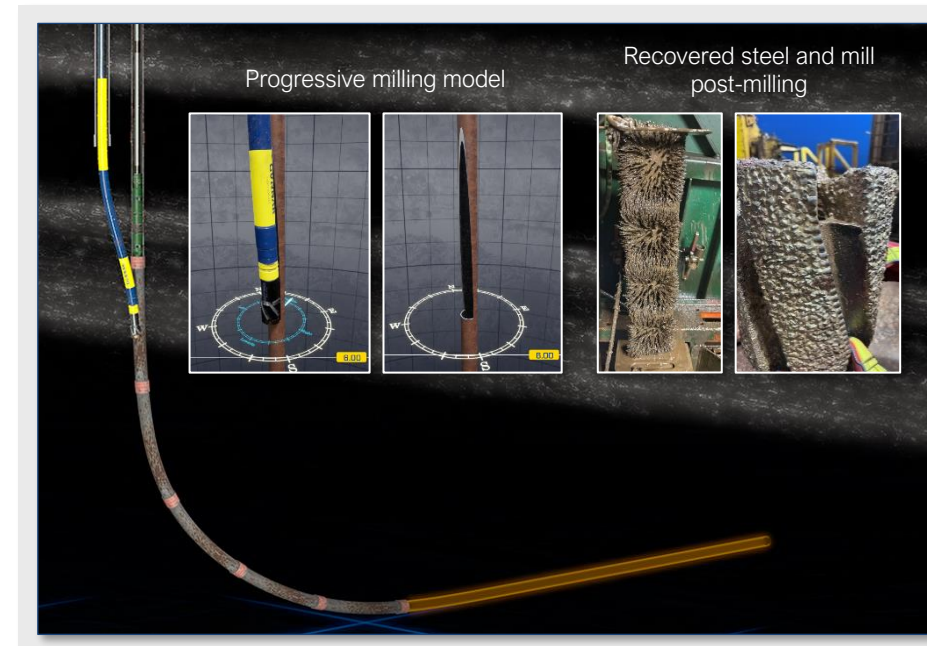
- **Active & Passive Ranging While Drilling system deployed**
- **Enabled by a powered drill pipe:**
 - Delivered 10× higher current injection compared to wireline.
 - Larger electrode surface ensured good formation contact.
- **Overcame conventional AMR limitations:**
 - High-resistivity formations and salt layers.
 - Insulating effects of oil-based mud.
- **Integrated capabilities:**
 - Active & Passive Magnetic Ranging While Drilling.
 - Gyro-While-Drilling.
 - Annular pressure and gamma.
- **Operational advantages:**
 - Continuous real-time active ranging without retrieving BHA.
 - Maintained circulation, rotation, and reciprocation → improved wellbore stability and reduced well control risks.
- **Outcome:**
 - Target well located as planned and followed for 4,684 ft at 5–10 ft separation, despite sparse target well surveys.
 - Continuous magnetostatic interference monitoring acted as external casing collar locator, providing relative depth reference.



-
- Kill string
- Intercept at planned depth
- ΔP
- Upon intercept, 100% mud losses and CO₂ pressure were encountered, followed by a safe and successful well kill

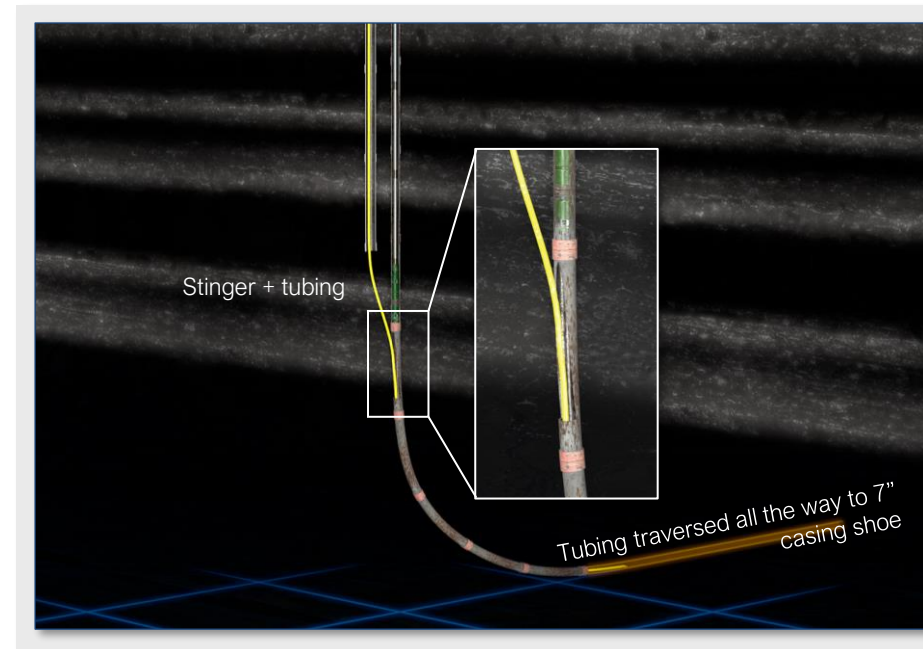
Case Study – Milling

- **Milling Modeling:**
 - Pre-planned model updated with actual survey and ranging data post-intercept.
 - Toolface orientation and milling distance optimized to ensure best window geometry and protect target casing integrity.
- **Custom Mills:**
 - Purpose-built mill designed for first attempt outside-in window milling.
 - Combined with bent mud motor + MWD for precise toolface control.
- **Execution:**
 - Toolface, differential pressure, and MWD vibrations closely monitored to ensure effective casing engagement.
 - Ditch magnets captured steel cuttings, confirming milling progress.
- **Outcome:**
 - Planned milling distance reached successfully.
 - Mill retrieved in excellent shape: expected wear, no balling or excessive damage.
 - Demonstrated strong compatibility of custom mill with application.



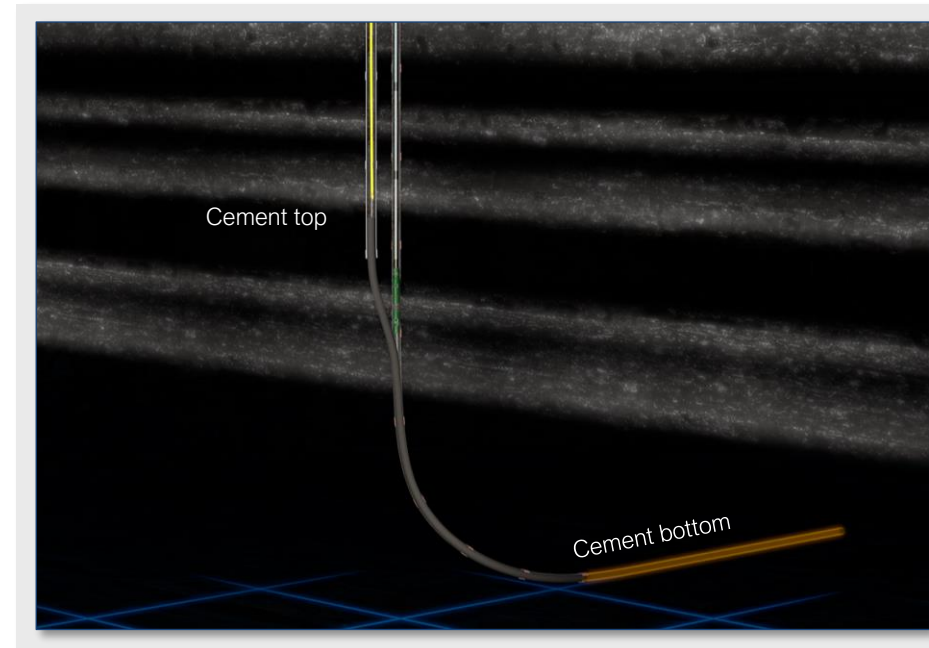
Case Study – Re-Entry

- **Re-Entry String Design:**
 - Dual tapered string: 2-7/8" tubing + 3-1/2" drill pipe.
 - Equipped with specialty re-entry joint (stinger).
- **Execution:**
 - Ran to 8,629 ft and oriented the stinger.
 - Entered top of window at 8,642 ft unimpeded, no pumps assistance required.
 - Circulated as precaution → advanced to 9,203 ft (3 ft outside 7" casing shoe) without rotation.
- **Outcome:**
 - Smooth passage through milled window.
 - No weight hang-up observed.
 - Confirmed high-quality, smooth cut window suitable for further intervention.



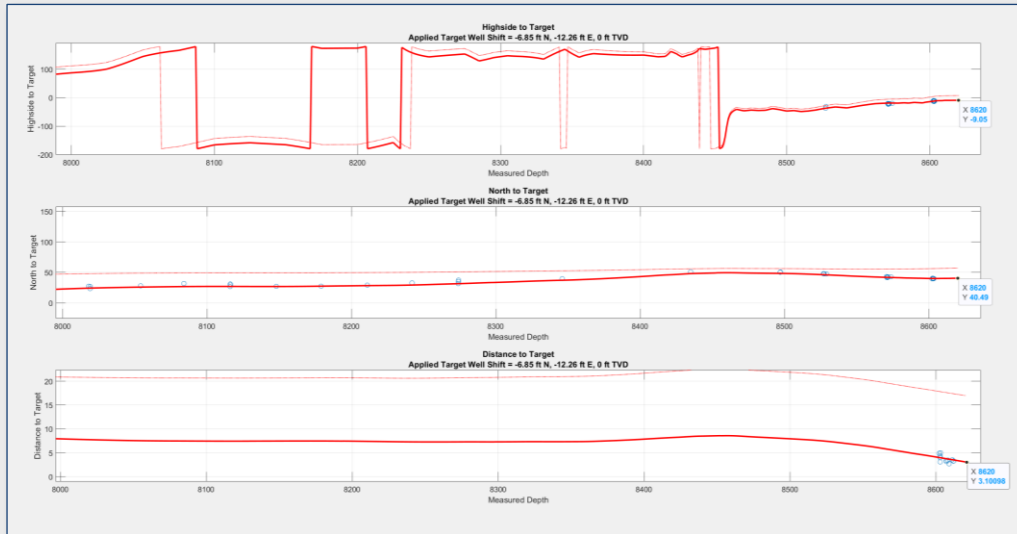
Case Study – Plug & Abandonment

- **Cementing Operation:**
 - Pumped 1,000 ft linear cement plug from bottom of intermediate casing.
 - Cement extended below the intercept, across the milled window into the intervention open hole, and back up inside the kill string.
- **Plug Verification:**
 - Stinger BHA pulled above cement for 18-hour wait-on-cement.
 - Cement tagged at 8,400 ft, within 2 ft of prediction.
- **Regulatory Approval:**
 - Re-entry and plug verification operations witnessed by regulators.
 - Abandonment criteria satisfied for the bottom hole section of the target well

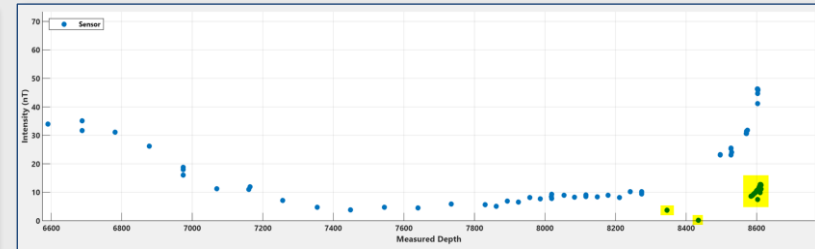


Case Study – Ranging While Drilling Data

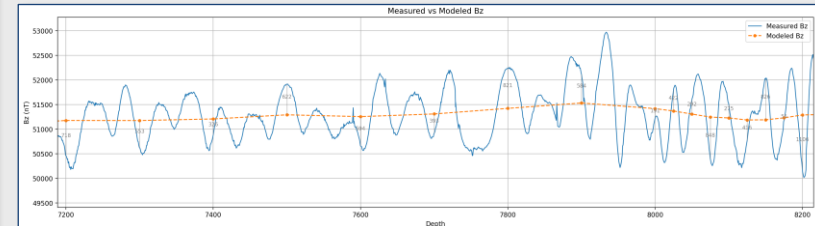
Survey to Active Ranging Data Fit



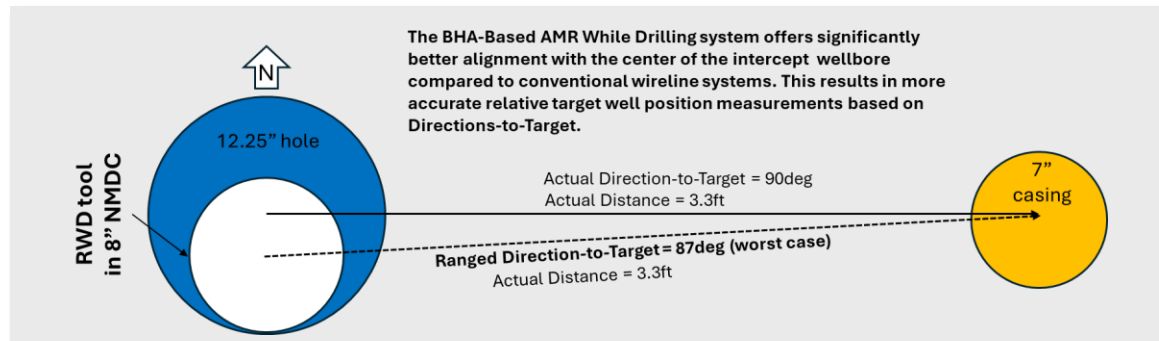
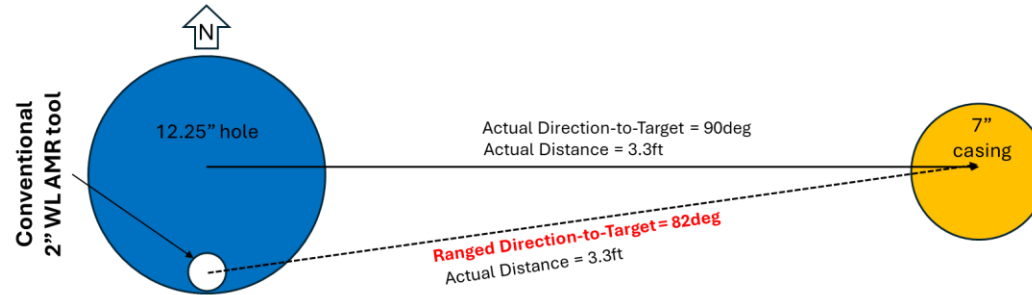
Active RWD signal vs. Wireline AMR (highlighted in yellow)



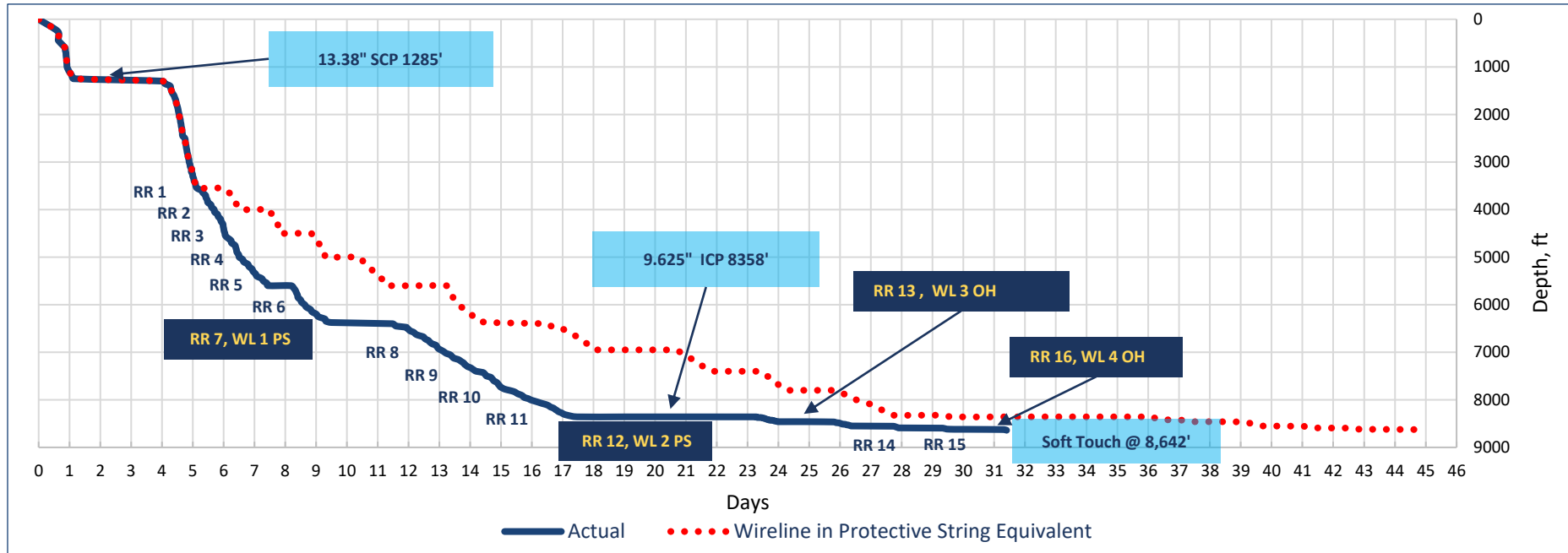
Magnetostatic monitoring of target casing collars



Case Study – RWD vs. Wireline AMR Alignment

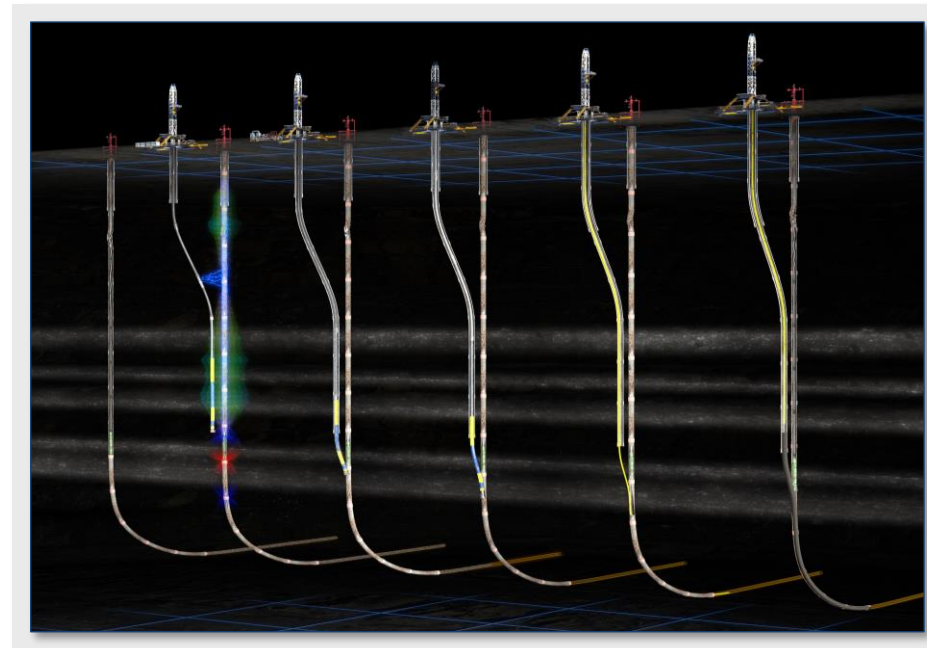


Case Study – Timeline: RWD vs. Wireline AMR Equivalent



Case Study – Summary of Results

- First and successful deployment of Active Magnetic Ranging While Drilling using Powered Drill Pipe:
 - **Avoided 10+ wireline runs: ~2 weeks rig time saved.**
 - Detection range increased by 10× current injection.
 - Excellent performance in oil-based mud compared to weak wireline AMR signal.
 - Superior ranging accuracy achieved through perfect alignment with the wellbore axis, outperforming conventional wireline AMR.
- Located the target well at 3,595 ft and maintained 5–10 ft separation for 4,684 ft while continuously ranging to accurately follow the target well and for anti-collision monitoring.
- Intercept achieved at the exact planned depth of 8,642 ft MD.
- 100% losses confirmed hydraulic comms; well killed via bullhead.
- Milled window outside-in, re-entered with 561 ft of tubing, and placed cement plug with regulatory witness, confirming abandonment criteria for the bottom-hole section of the target well.
- **Ranging While Drilling reduced HSE risk with fewer BHA trips and open-hole wireline runs, while delivering higher accuracy and control compared to legacy methods.**





Questions?

ExxonMobil

