

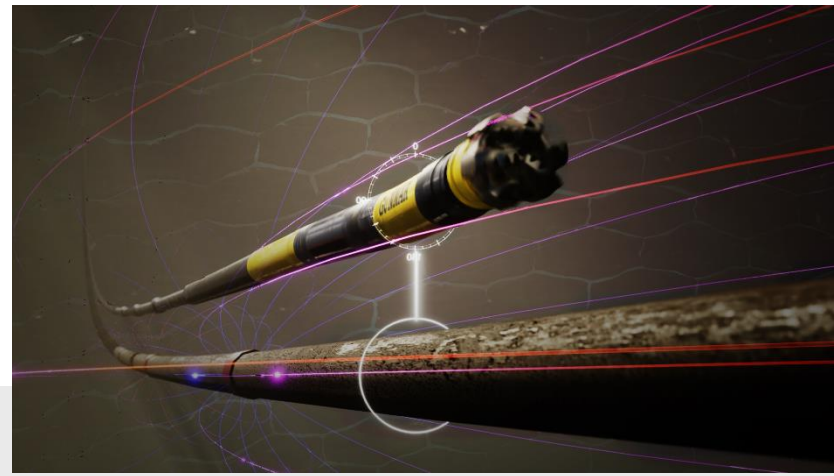


**Precision in Practice: Field-tested magnetic ranging and directional drilling techniques for target well intersect, milling, re-entry, and P&A in urban California gas storage operations**

**Georgy Rassadkin**  
Product Champion / Ranging Specialist

 | [GunnarEnergyServices.com](https://www.GunnarEnergyServices.com)

# Introduction

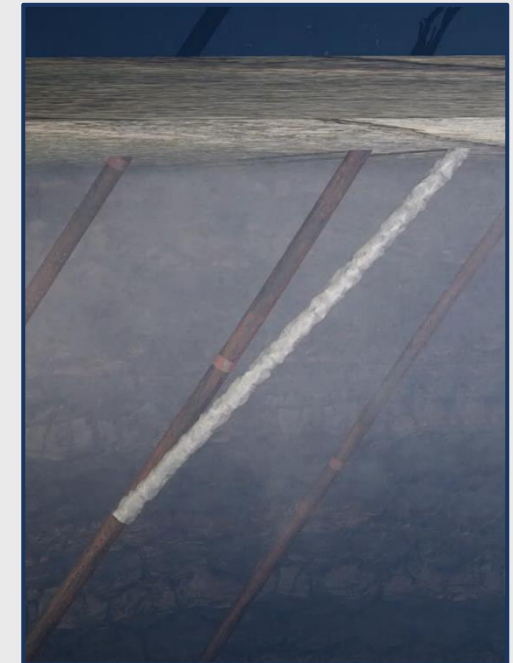


Gunnar Energy Services provides highly specialized technology, expertise and services in the field of precise wellbore placement, magnetic ranging and well intersections

## What is Ranging?

- Addresses conventional wellbore surveying uncertainty
- Identifies location of an offset wellbore relative to a reference wellbore
- Used to avoid unintentional collisions or purposefully twin and intersect wellbores

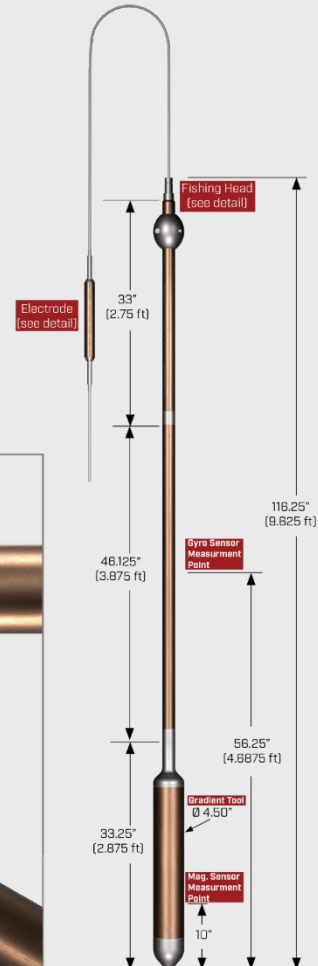
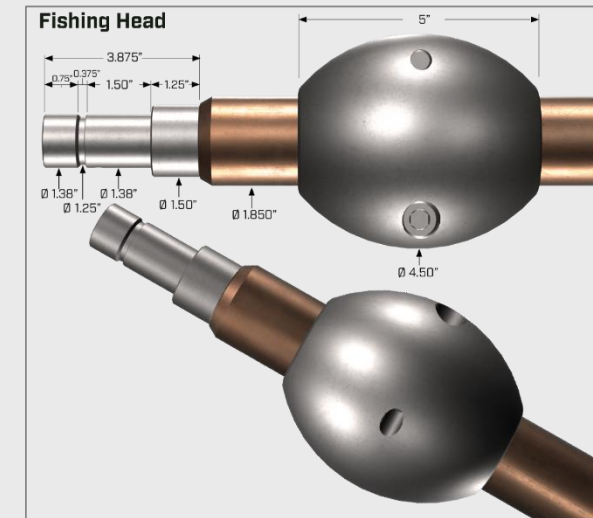
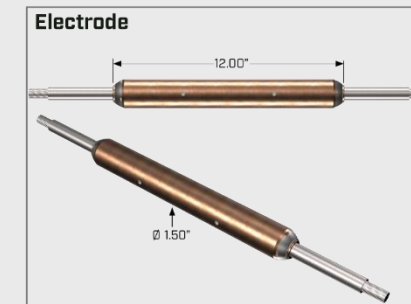
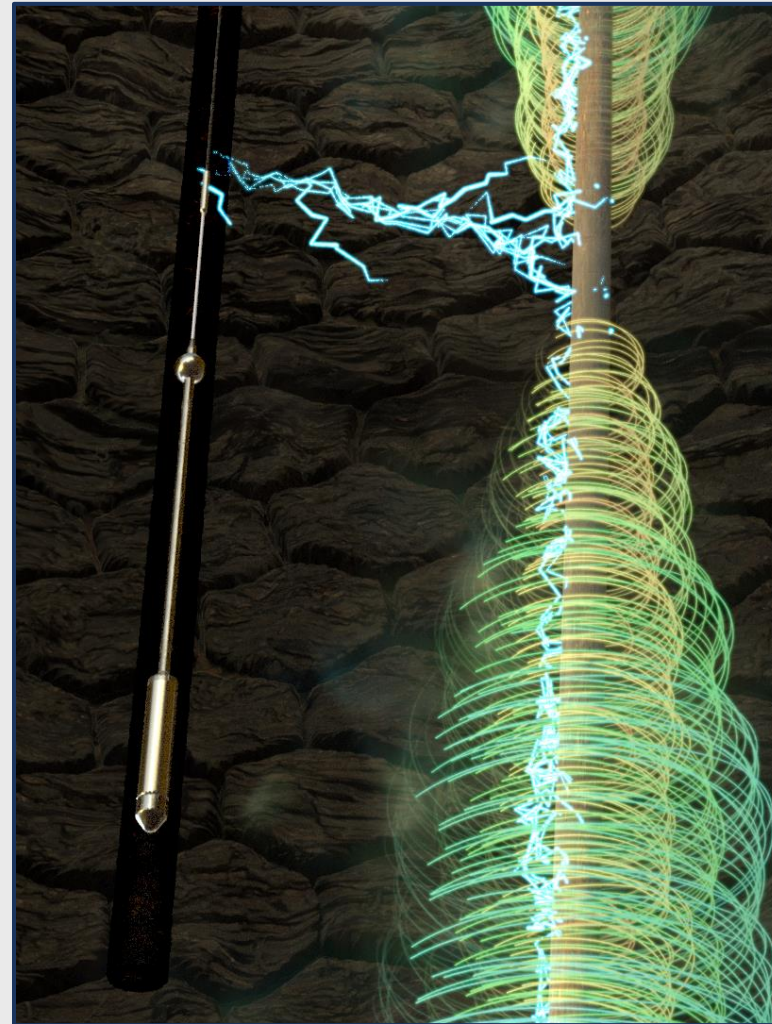
## Example Ranging and Intercept use case for CCS





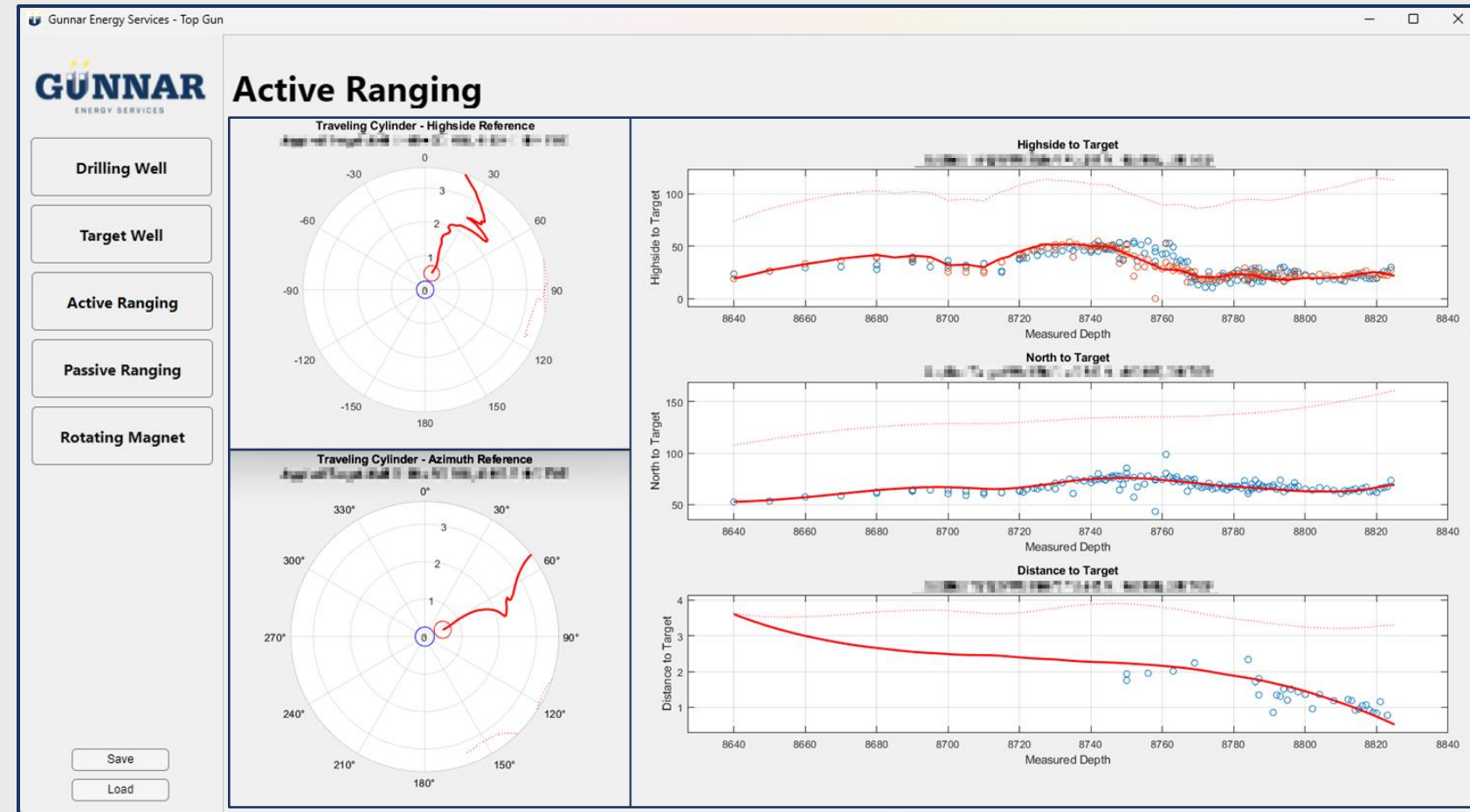
# Active Access Independent Wireline Ranging

- Wireline conveyed
- All-in-one magnetic ranging system
  - Formation current injection
  - Array of solid-state sensors
  - Active Magnetic Ranging (AMR), Passive Magnetic Ranging (PMR), Gyro Referencing
- Two sizes: 4.5" & 1.9"
- 175°C temperature rating



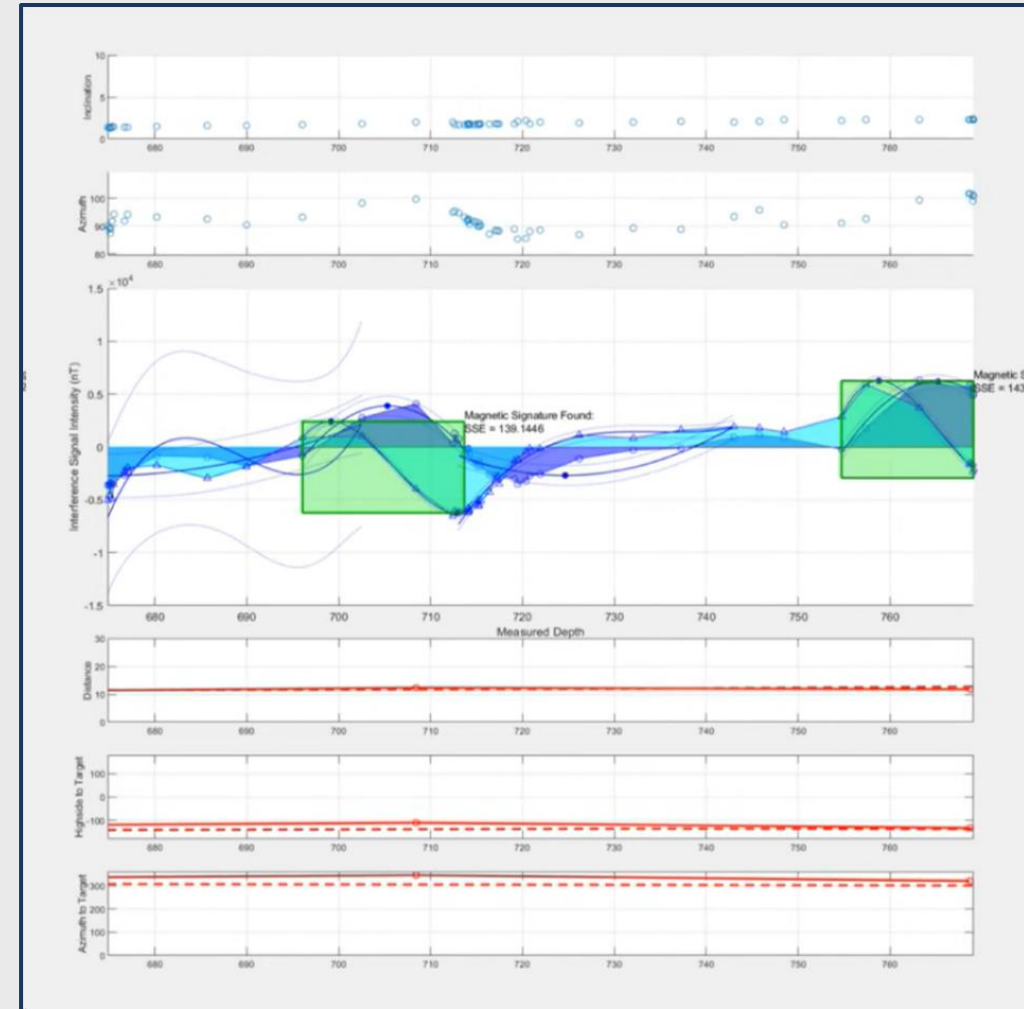
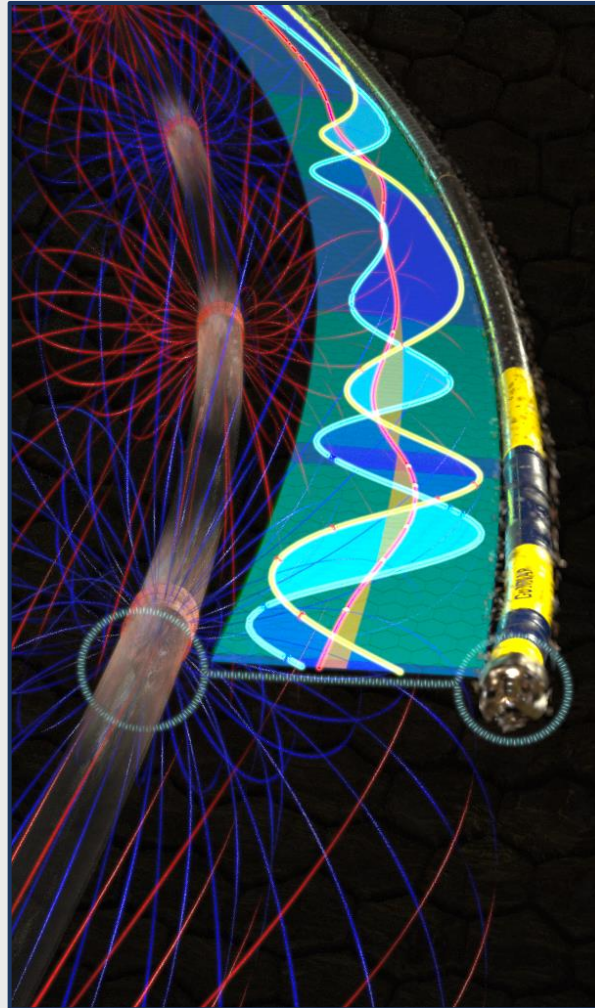
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# Continuous Passive Magnetic Ranging with SLB TruLink

- Proprietary magnetic interference interpretation for ranging distance and direction
- Only MWD/GWD data is required
- Dynamic XYZ data for continuous ranging
- Not affected by highly resistive formations such as salt
- No additional rig time

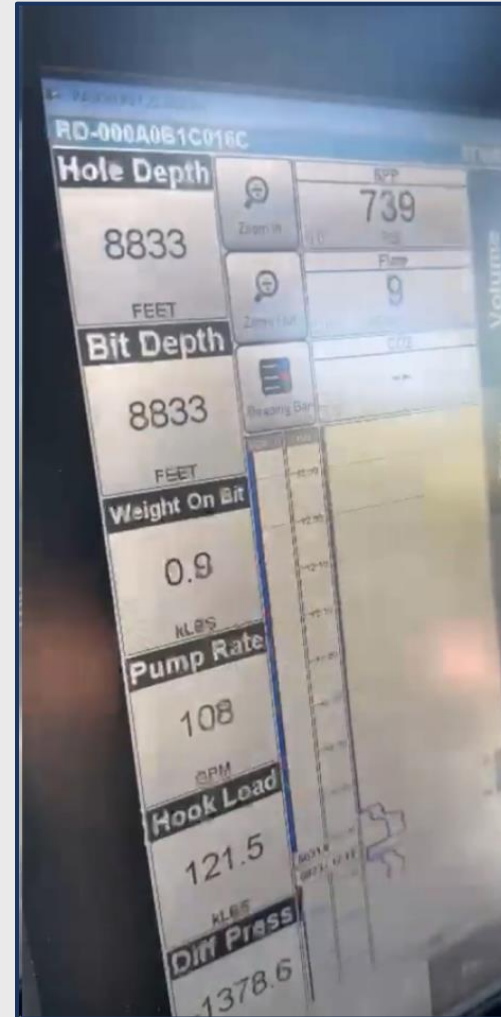
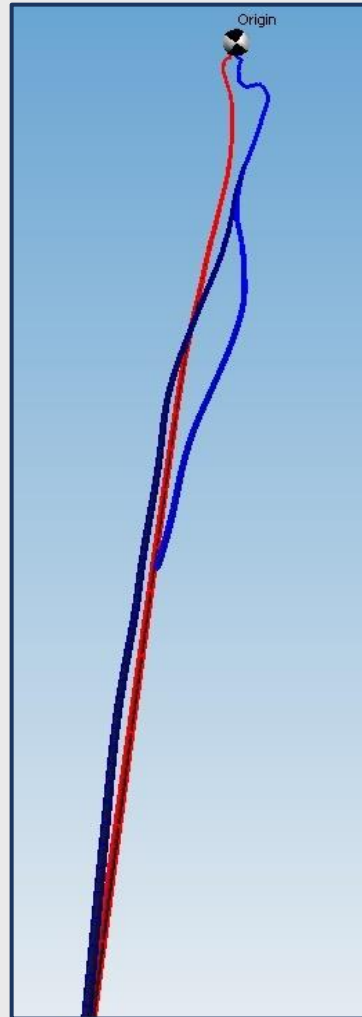




# Case History #1 – US Land Gas Storage P&A

## Objective:

- Dual intercept, re-entry and P&A
  - Sidetrack from the original wellbore at 2850 ft. MD
  - Bypass existing sidetracks and restrictions
  - Directionally drill and range in order to gain access to the target wellbore
  - Intercept 5.5" liner at 8825 ft. MD, mill, re-enter and P&A
  - Intercept 7" x 2 3/8" at 8690 ft. MD, mill, re-enter and P&A



## Ranging Technology:

- No-access AMR System
- Gyro MWD + PMR

## Challenges:

- Absence of target surveys at the intercept interval

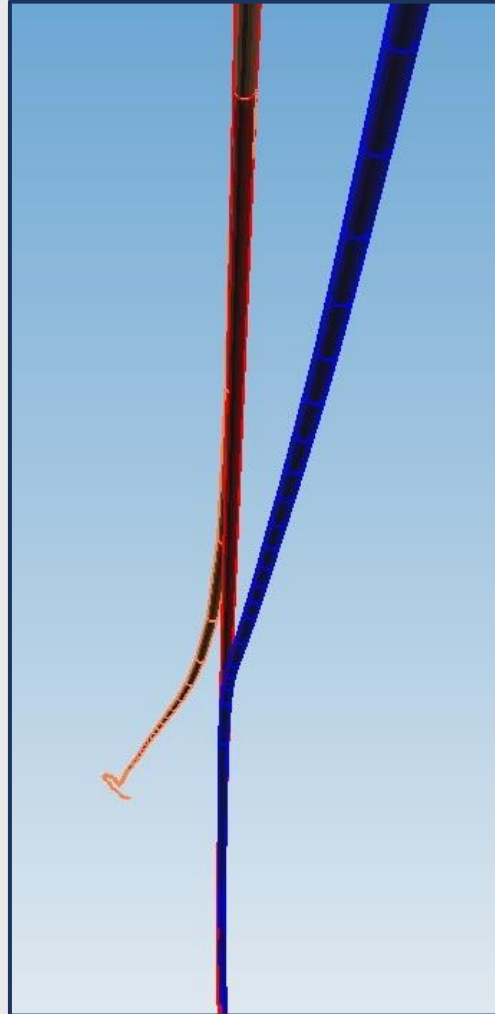
## Results:

- Milled, re-entered and tripped tubing into the target wellbore for permanent P&A at planned intervals
  - All steps have been witnessed and approved by the California state regulator
  - Evidence of successful P&A will be available on California government websites

# Case History #2 – US Land Gas Storage P&A

## Objective:

- Re-enter 6 5/8" production casing and P&A the original vertical wellbore
  - Sidetrack from the existing wellbore at 5440'
  - Bypass existing sidetracks and restrictions
  - Directionally drill and range to intersect the target wellbore at 6166'
  - Mill and re-enter to clean out to 7262'
  - Run WL gyro survey of re-entered target wellbore
  - P&A the wellbore through tubing stinger



## Ranging Technology:

- No-access AMR System
- Gyro MWD + PMR

## Challenges:

- Electrically continuous parasite sidetrack nearby

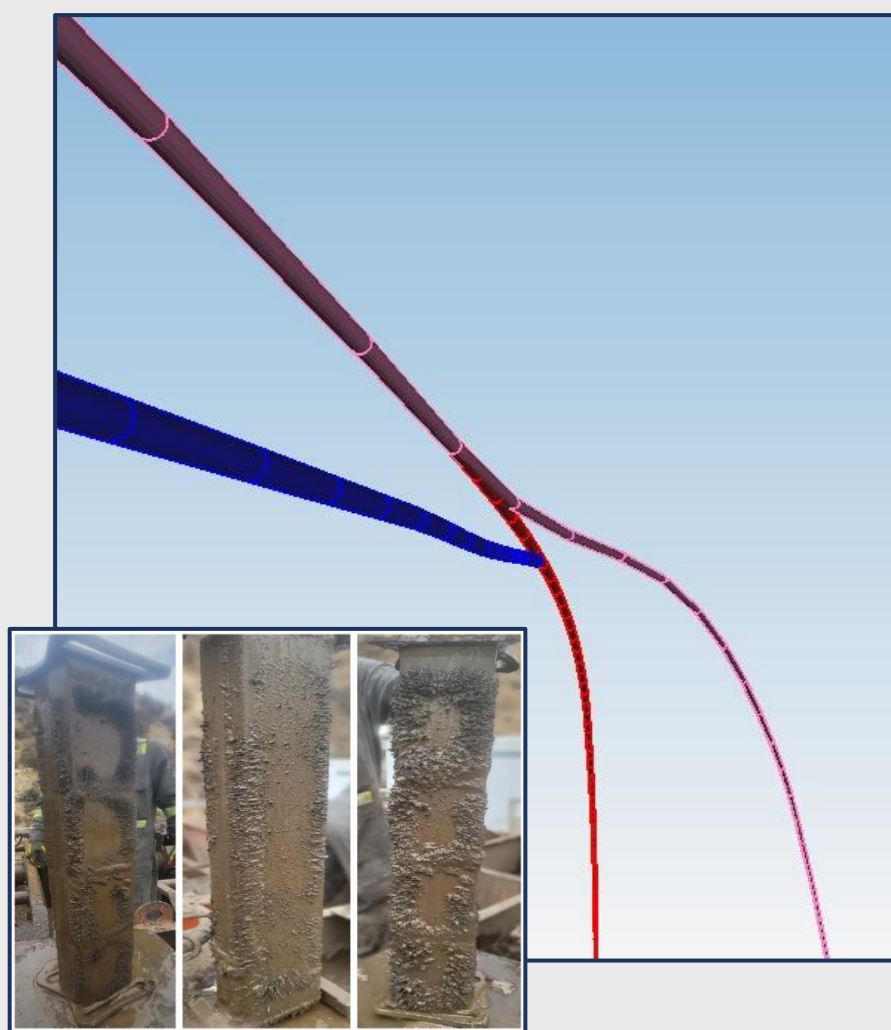
## Results:

- Milled, re-entered and tripped tubing into the target wellbore for permanent P&A at planned intervals
  - All steps have been witnessed and approved by the California state regulator
  - Evidence of successful P&A will be available on California government websites

# Case History #3 – US Land Gas Storage P&A

## Objective:

- Re-enter 8 5/8" production casing and P&A the ST #1 deviated wellbore
  - Sidetrack from the existing wellbore at 6356'
  - Bypass other sidetracks and restrictions
  - Directionally drill and range to intersect the target wellbore at 7600'
  - Mill and re-enter to clean out to 7742'
  - Run WL gyro survey of re-entered target wellbore
  - P&A the wellbore through tubing stinger



## Ranging Technology:

- No-access AMR System
- Gyro MWD + PMR

## Challenges:

- Electrically continuous parasite sidetrack nearby
- Poor target surveys

## Results:

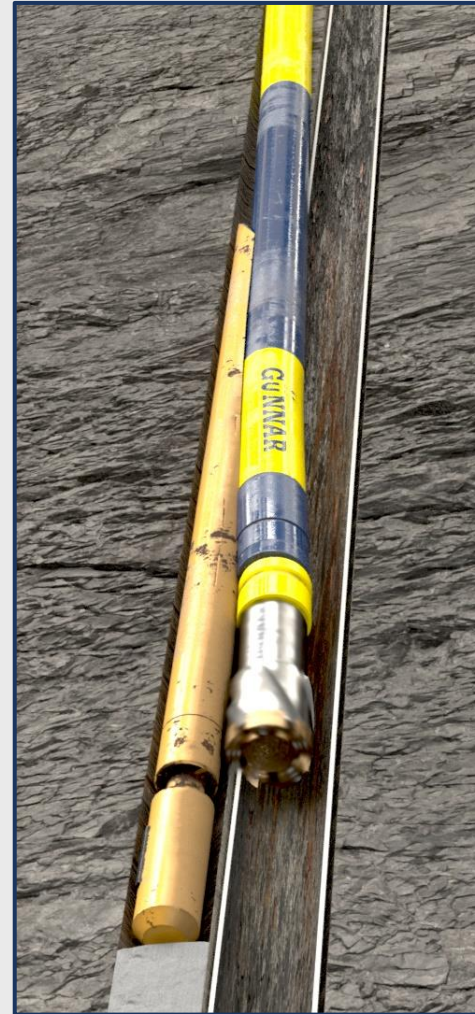
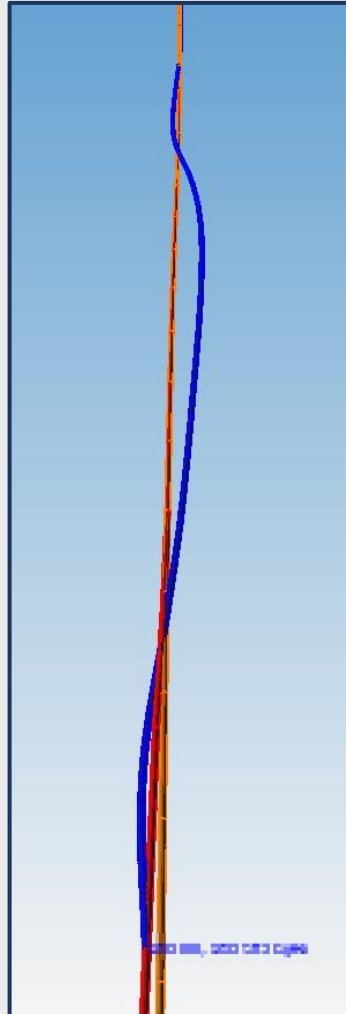
- Milled and re-entered the target wellbore for permanent P&A at planned intervals
  - All steps have been witnessed and approved by the California state regulator
  - Evidence of successful P&A will be available on California government websites



# Case History #4 – Whipstock to Re-Entry

## Objective:

- Plug & Abandon an existing sidetrack wellbore (conventionally)
- Sidetrack from the existing wellbore
- Re-abandon Original Hole below the Sidetrack.
  - Cut a window at  $\pm 7500'$  to sidetrack and re-enter the OH 7" casing stub at 7885-7905' (on opposite side of the 7" casing away from the 5" casing in ST)



## Ranging Technology:

- No-access AMR System
- Gyro MWD + PMR

## Challenges:

- Poor original hole surveys
- Parasite sidetrack at the intercept interval

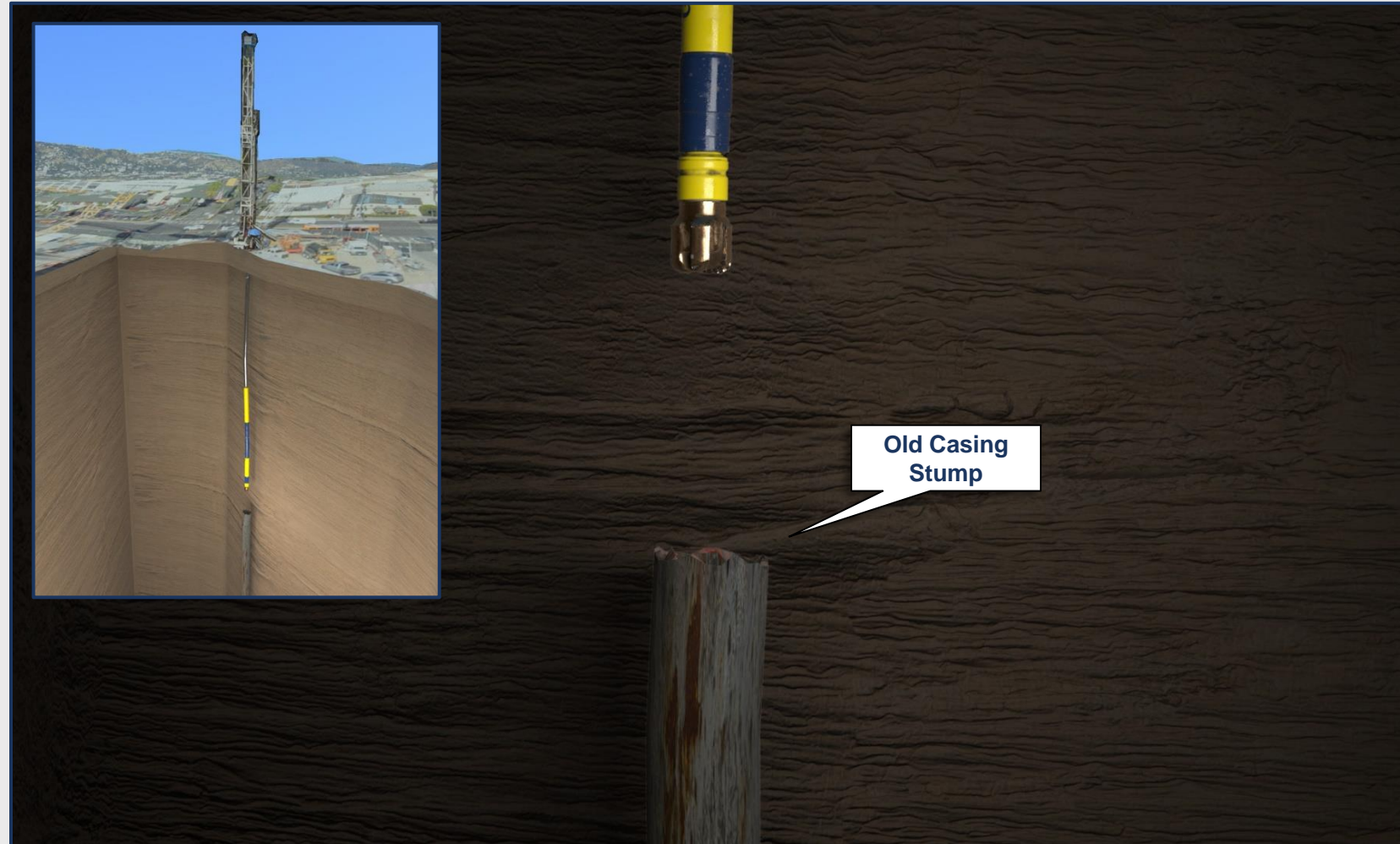
## Results:

- Set whipstock to re-enter, re-entered with tubing and plugged for permanent P&A
  - All steps have been witnessed and approved by the California state regulator
  - Evidence of successful P&A will be available on California government websites

# Case History #5 – Old Casing Stump Re-Entry

## Objective:

- Locate and map old 10" casing stump ~200 ft. below the surface in an urban metropolitan area by drilling a new well near the original surface location based on historic record
  - Original hole spudded in 1906
  - No target surveys available
  - The top of the casing was detonated off and retrieved from the hole in 1930
- Re-enter the stump and permanently P&A the well

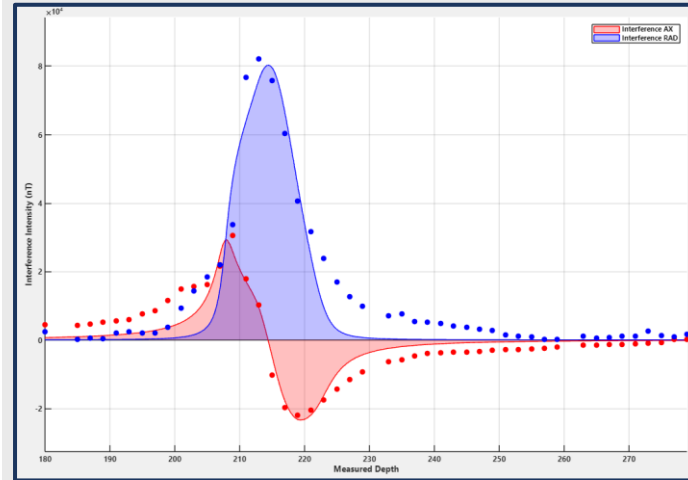


# Case History #5 – Old Casing Stump Re-Entry

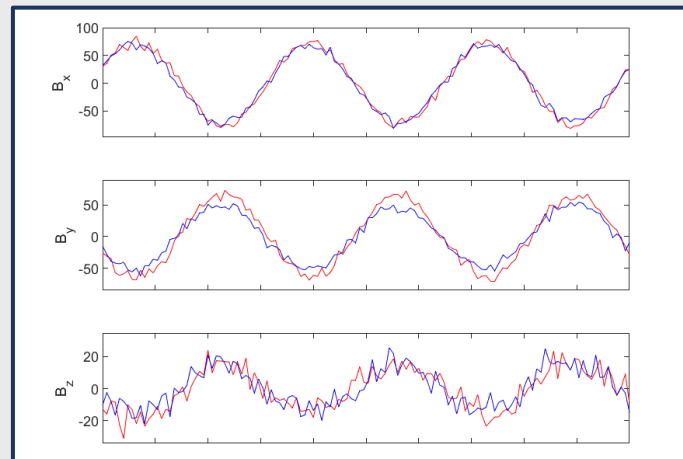
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- Original hole spudded in 1906
- No target surveys available
- The top of the casing was detonated off and retrieved from the hole in 1930
- Re-enter the stump and permanently P&A the well

Passive signal at the stump, nT



Active signal 100ft below the stump, nT



## Ranging Technology:

- No-access AMR System
- Gyro MWD + PMR

## Challenges:

- Absence of target surveys
- Over 100-year-old target casing
- 10" stump re-entry

## Results:

- Created a synthetic survey of the target well based on ranging
- Re-entered the target wellbore at the stump for permanent P&A
  - All steps have been witnessed and approved by the state regulator
  - Evidence of successful P&A will be available on government websites

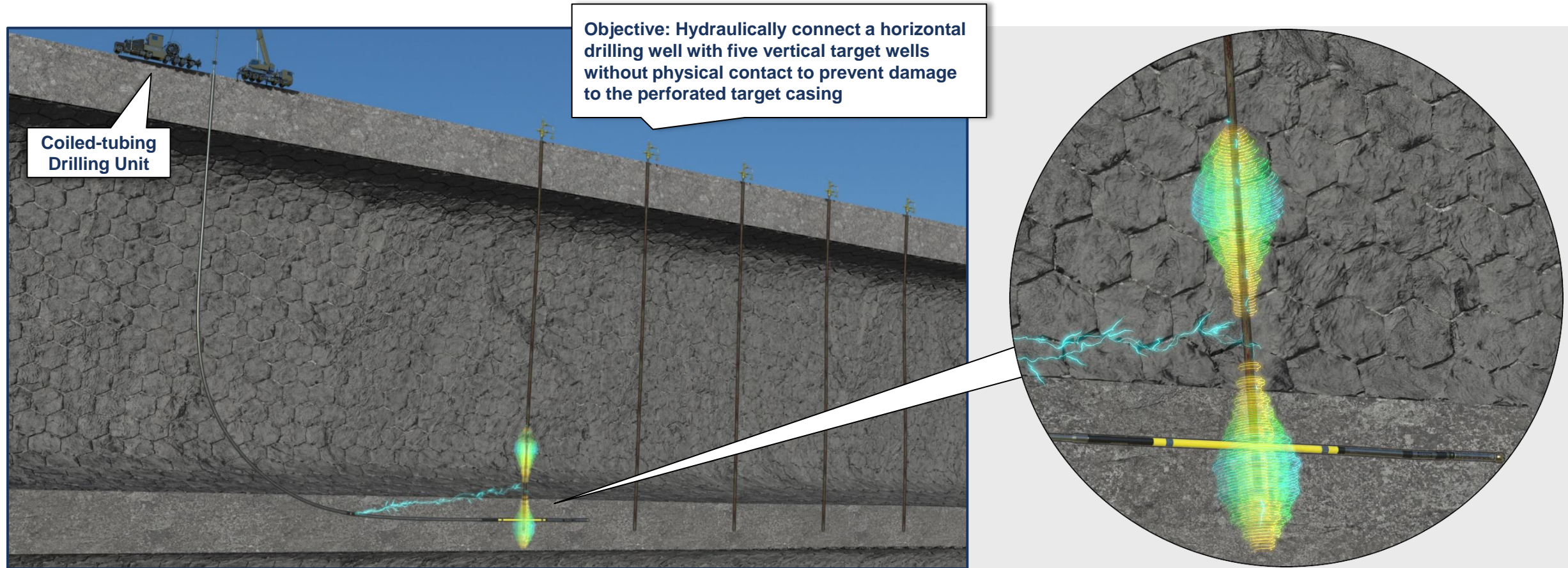


“Smiling” impression block after contact with the stump



# New Technology – CTRWD. Case History #6

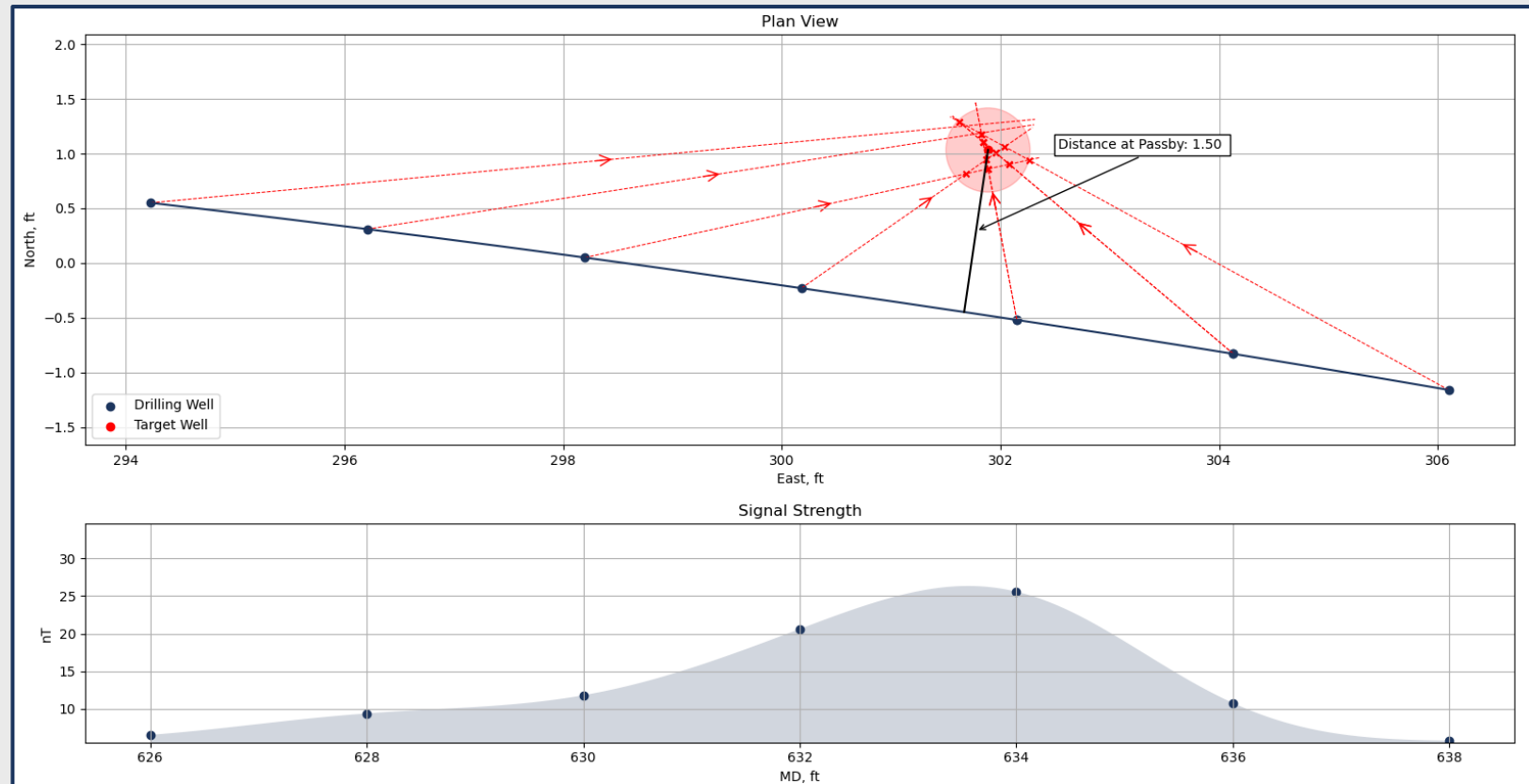
## Coiled-Tubing Ranging While-Drilling: Access Independent AMR



# New Technology – CTRWD. Case History #6

## Coiled-Tubing Ranging While-Drilling: Access Independent AMR

- CTRWD AMR physical principle is similar to traditional AMR but while-drilling
  - No access to the target well required
  - Downhole formation current injection
- Current injection and sensor modules in the same coiled-tubing drilling BHA
  - No dedicated wireline runs!
  - No time-consuming BHA trips!
- Array of measurements collected
- Passby @ 633.7 ft. MD
  - Distance to target:  $1.50 \pm 0.22$  ft.
  - Azimuth to target:  $8.5 \pm 8.3$  deg
- Excellent correlation with other ranging methods deployed on the project:
  - Rotating Magnet
  - Surface Current Injection
- Strong 25.6 nT signal considering:
  - The worst possible geometry for downhole current injection
  - Salt formation



See details in our ISCWSA #58 Presentation: <https://www.iscwsa.net/files/896/>

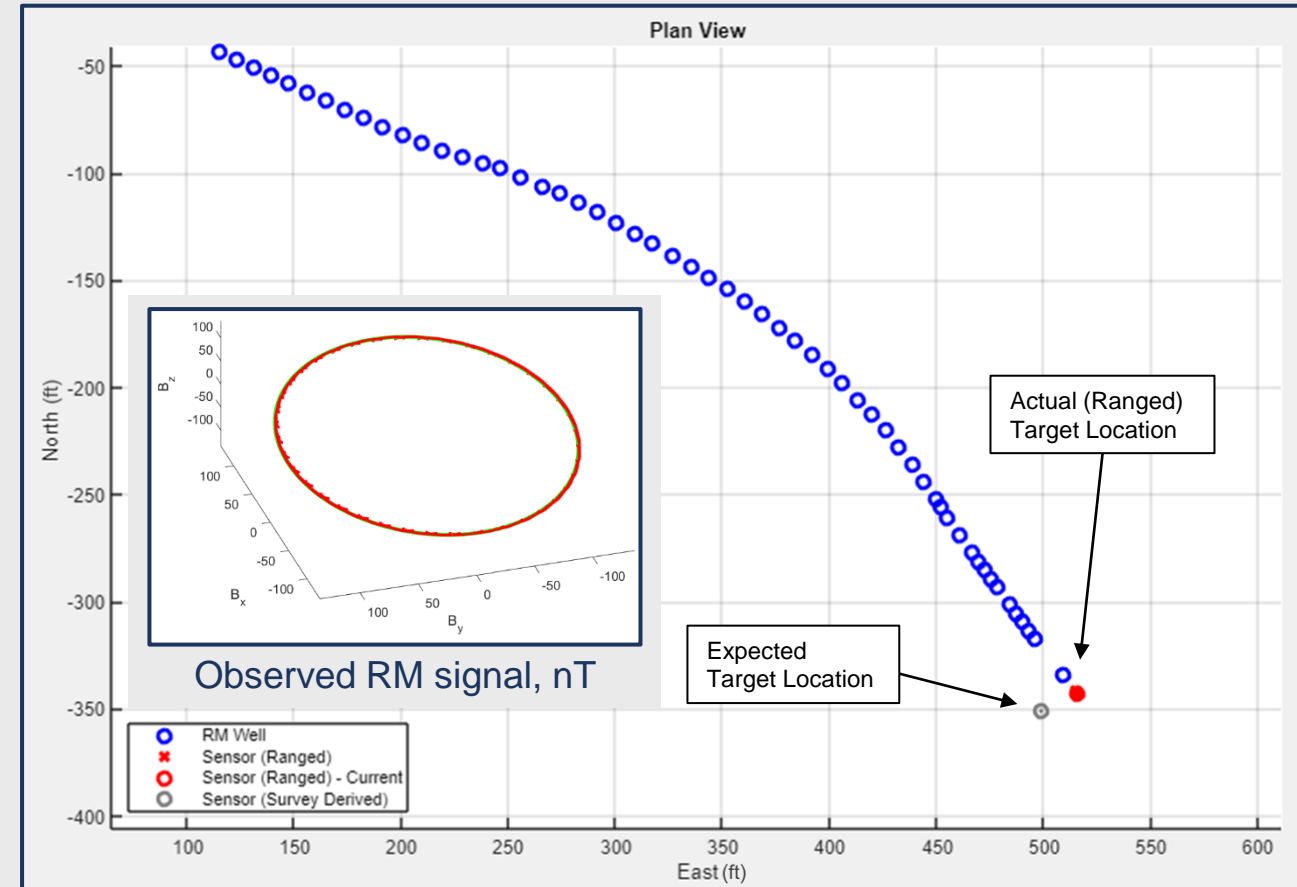
# New Technology – CTRWD. Case History #7

## Coiled-Tubing Ranging While-Drilling: Rotating Magnet (RM)

- Connect horizontal drilling well with existing vertical target well
  - 20" vertical hole size
  - 4.75" horizontal hole size
- Use coiled-tubing drilling unit with motorized BHA for the horizontal well
  - Instantaneous high-density measurements via wired coiled-tubing
- Near-bit magnet sub in the BHA
- Ranging sensor in the target well
- Intersection achieved at 922 ft MD
  - Noticeable drilling break
  - Instant hydraulic communication
- Downhole camera footage of the junction obtained after the intersection



Near-bit magnet sub

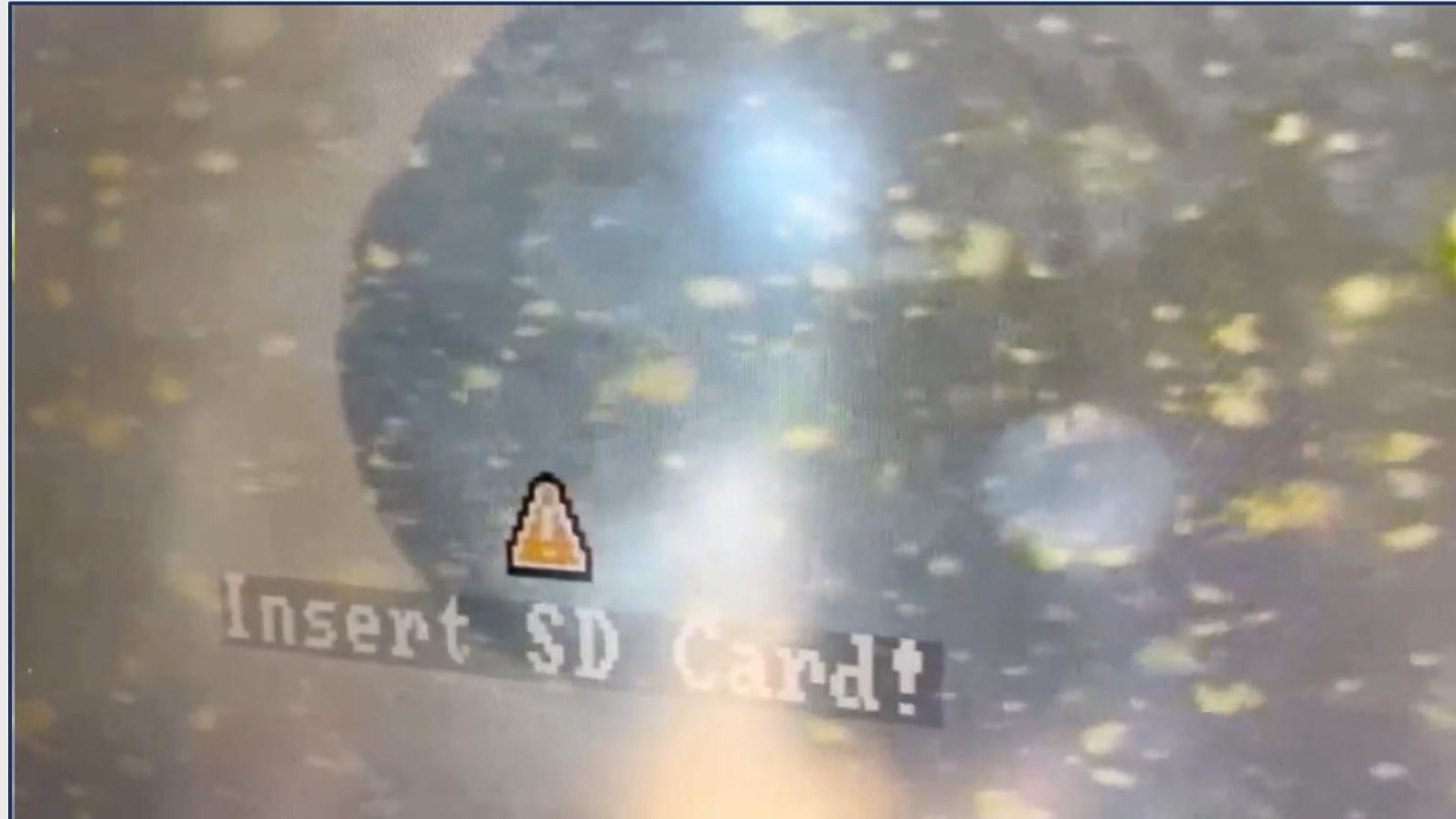




# New Technology – CTRWD. Case History #7

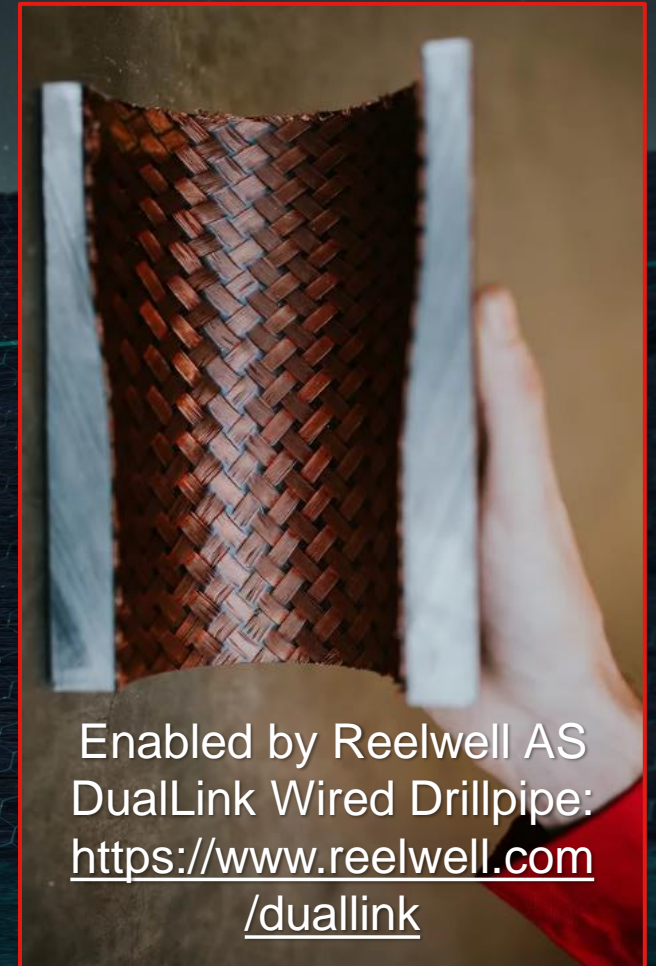
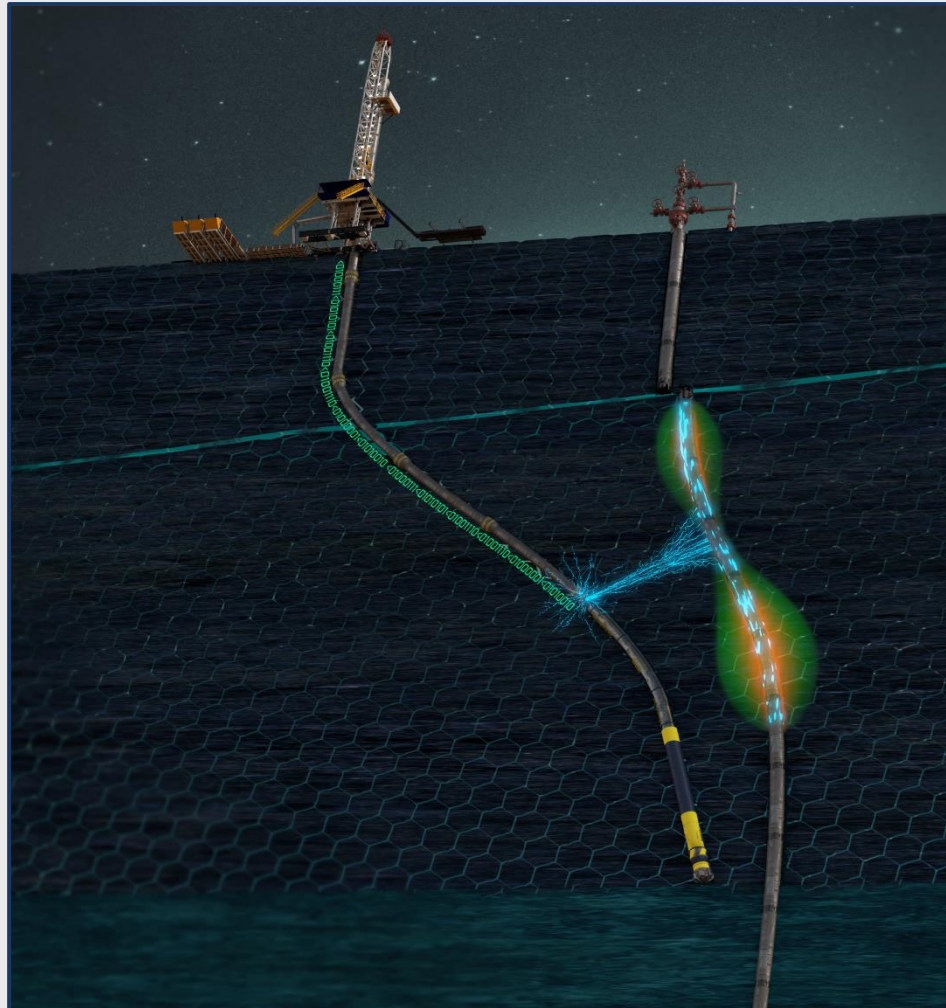
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# Coming Soon – Wired Drillpipe AMR While-Drilling

- Depth of investigation (range) of ranging systems is limited by power injected into the formation
- Wired pipe allows for:
  - 18x increase in power delivery
  - Wireline runs and BHA trips eliminated!
  - 150m depth of investigation (range)
  - Will work in salt
  - First field trial Q2 2024 (West Texas)
  - Patent # US-11781421-B2



Enabled by Reelwell AS  
DualLink Wired Drillpipe:  
<https://www.reelwell.com/duallink>

# Questions?