Electric Field Through-the-earth Communication Systems for Built-in-place Refuge Alternatives

Nicholas W. Damiano

Pittsburgh Mining Research Division
RA Partnership

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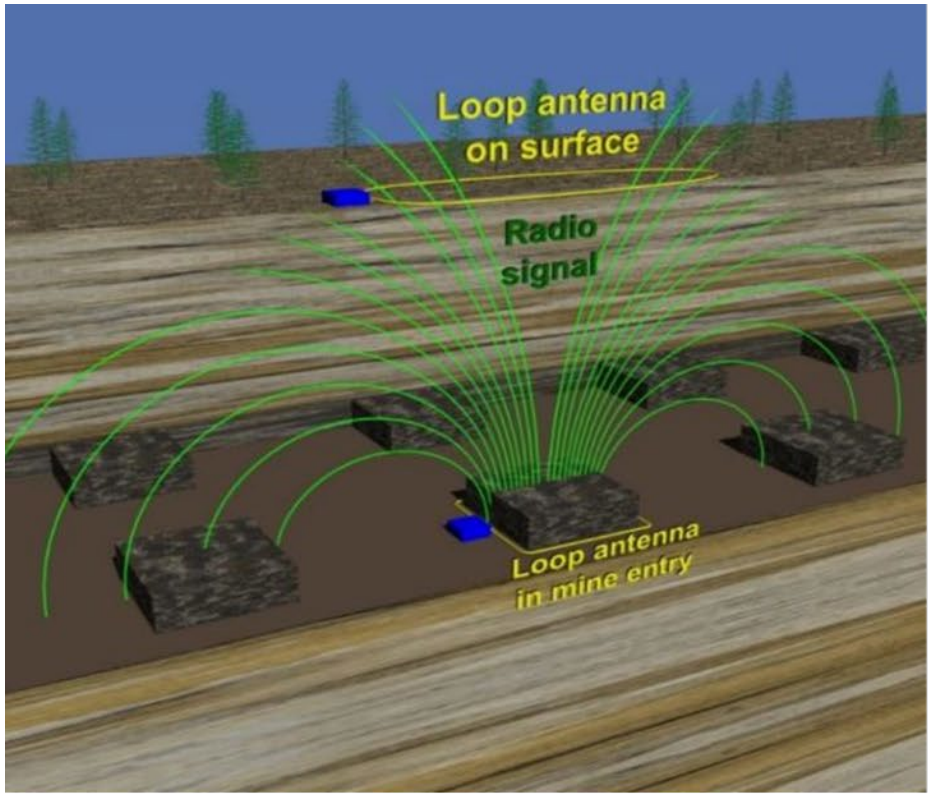
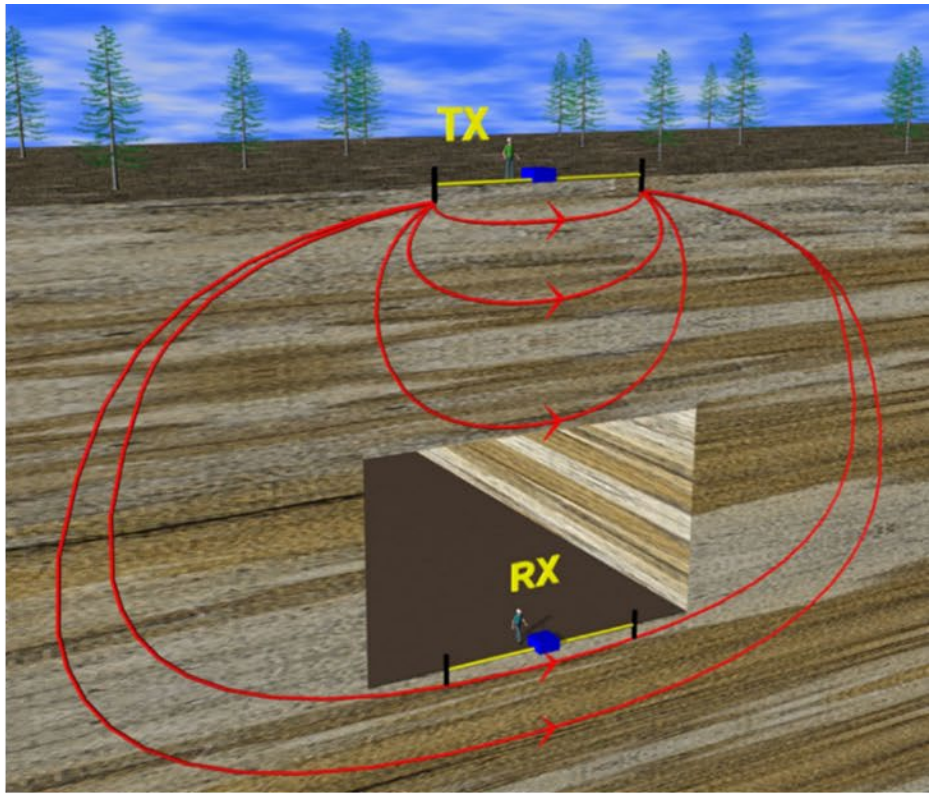
Objective

- To determine the difference in signal between a 200-foot antenna and a 40-foot antenna (electrode separation distance)
- To determine the effect of frequency for a 200-foot vs. 40-foot antenna



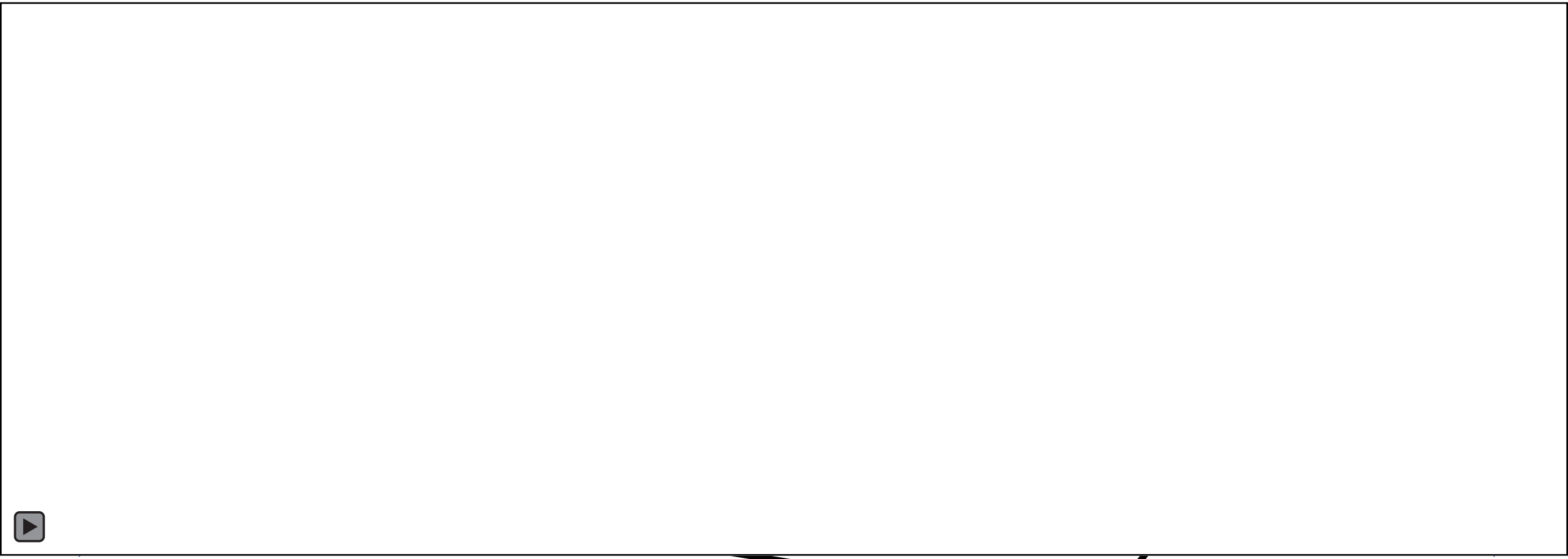
Magnetic



Electric

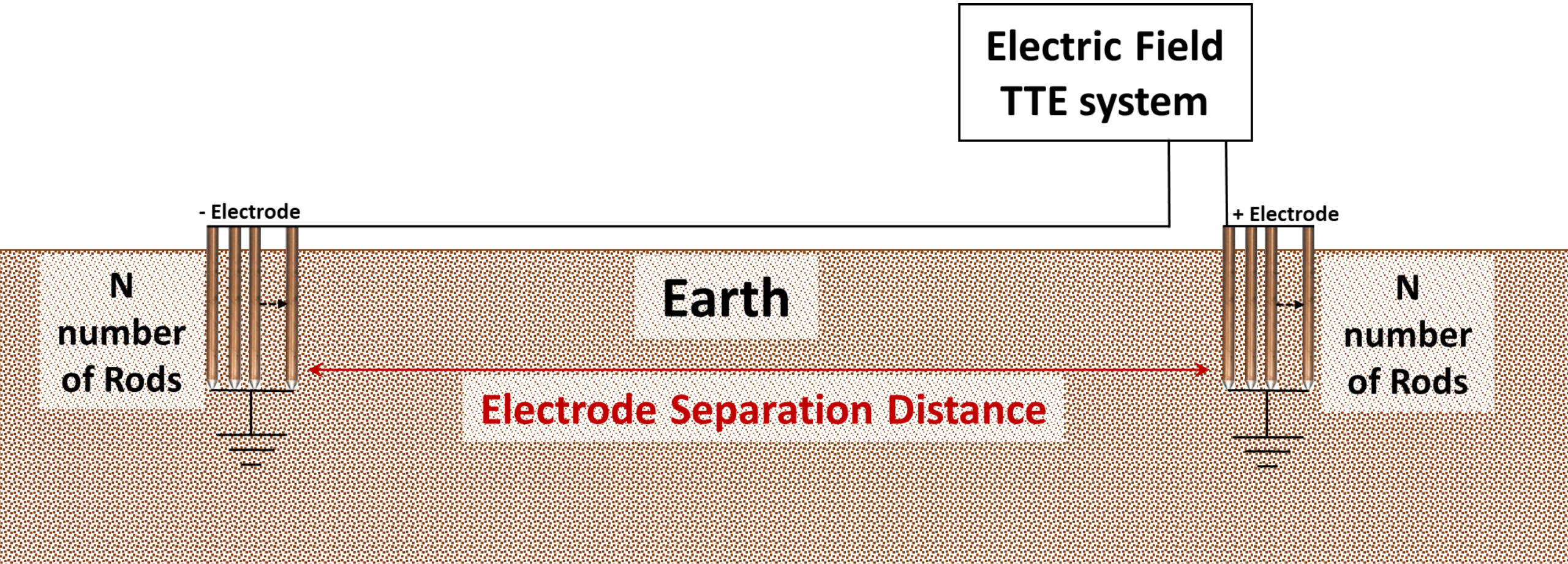
Simulation using FEKO will validate measurements

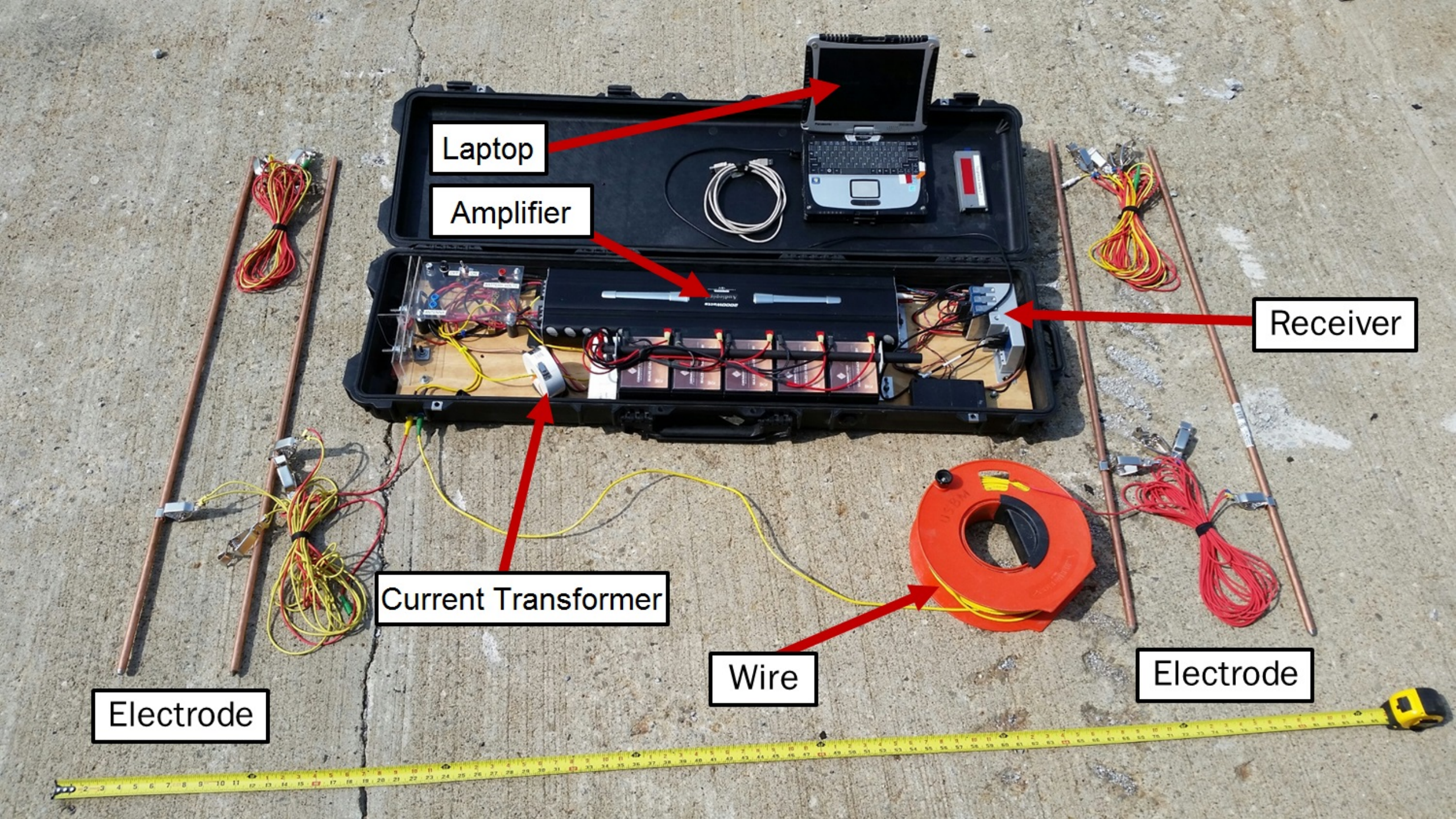
Red=Strong Signal, Green=Weak Signal, Blue=No Signal



Signal strength changes with Frequency (Hz)

A diagram of an electric field TTE system deployed on the surface




Laptop
Amplifier
Receiver
Current Transformer
Wire
Electrode
Electrode

Conducted low-frequency E-field measurements in the SRCM and at a commercial coal mine (late 2019)

Safety Research Coal Mine (SRCM) ~50’ deep

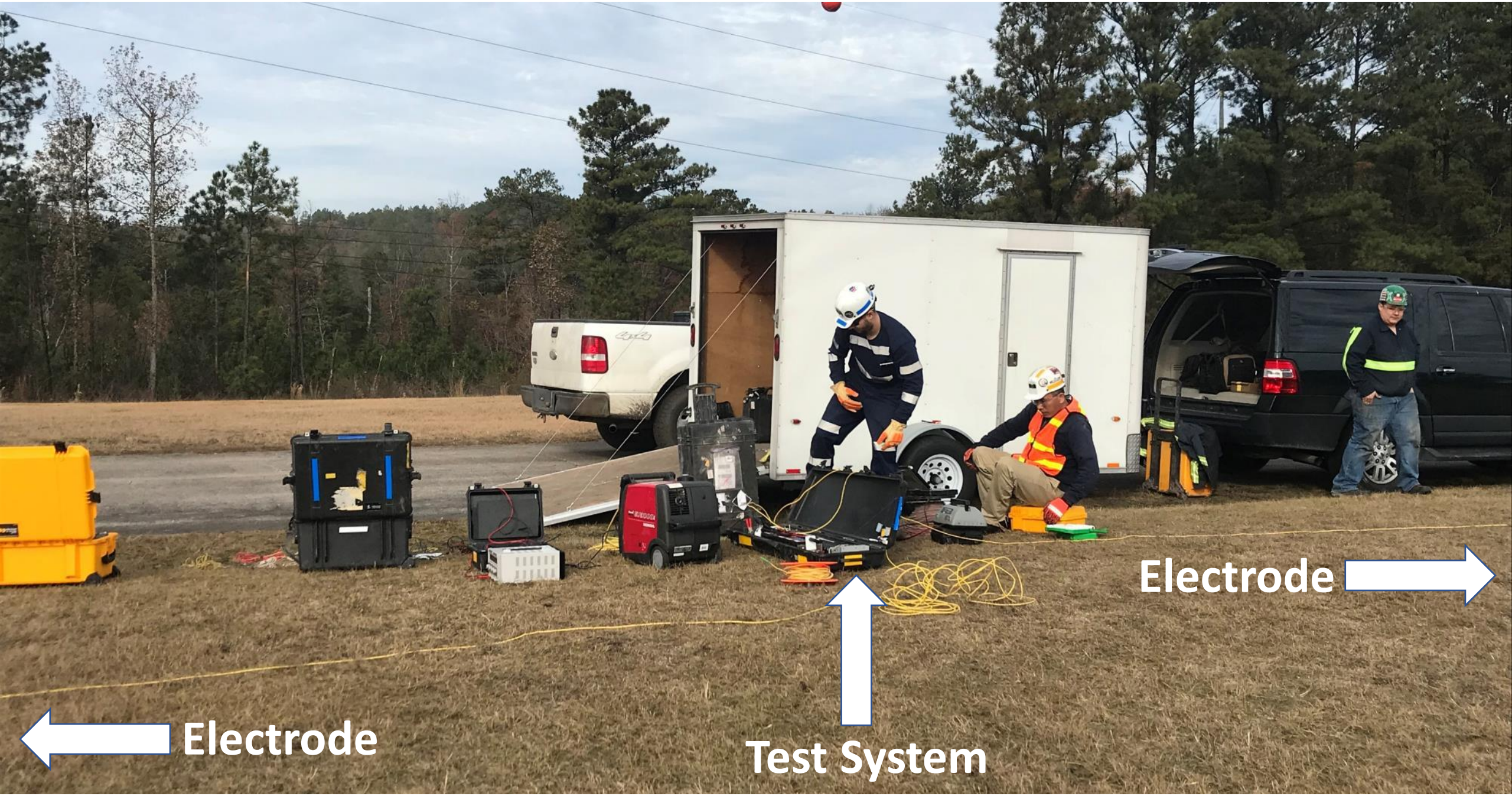
The difference between 200-foot and 40-foot separation distance is about **10 dB**

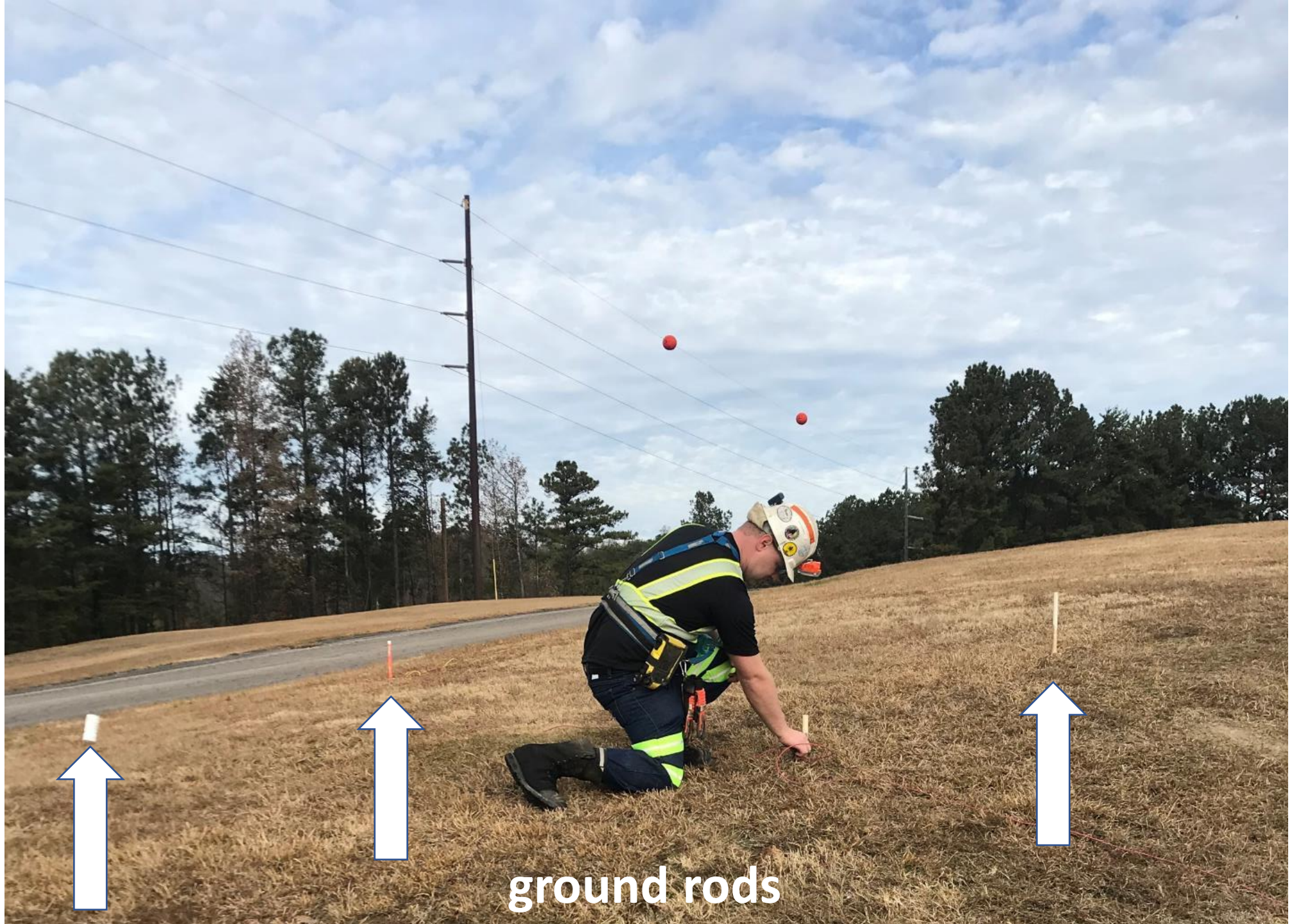
Commercial coal mine ~1860’ deep

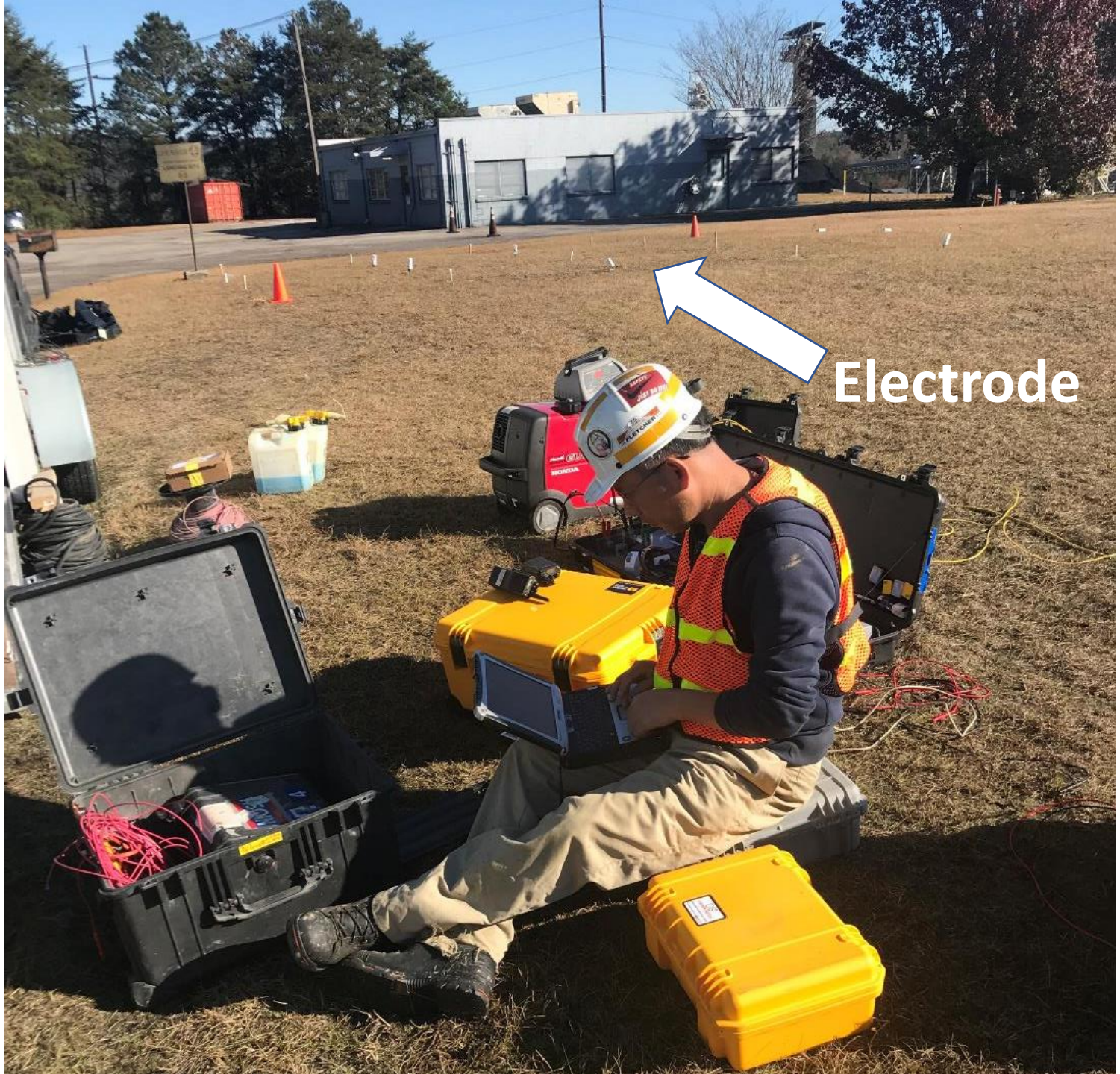
?

The findings and conclusions in this report/presentation have not been formally disseminated by the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention and should not be construed to represent any agency determination or policy..

Commercial mine - surface satellite image with underground (UG) antennas shown


Electrode
Test System
Electrode


ground rods

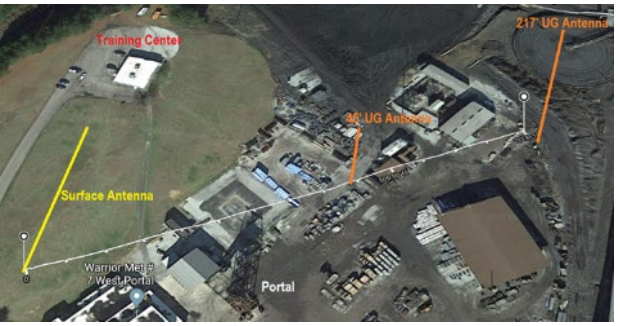

Electrode


roof bolt

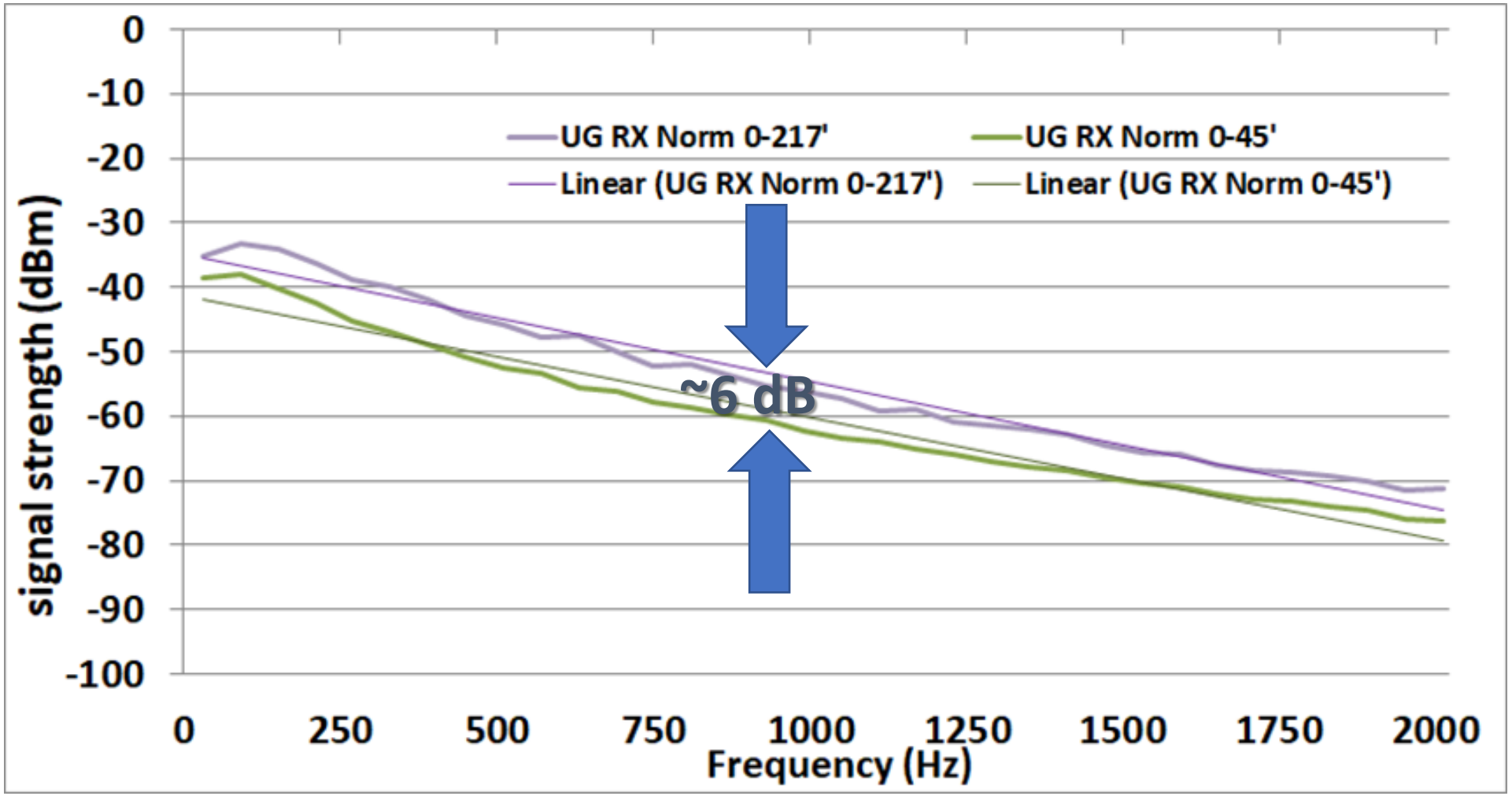

roof strap

Commercial coal mine received signal underground with roof bolts shows a difference of about 6 dB when comparing 45 to 217-foot separation

commercial coal mine
~1860 feet deep



sending signal to underground



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Summary

Measurements:

- *About 10 dB less signal for a 40-foot than a 200-foot antenna (50 feet deep)*
- *About 6 dB less signal for a 45-foot than a 217-foot antenna (1860 feet deep)*

Simulation:

- *5 to 12 dB less signal for a 40-foot than a 200-foot antenna for 2000 feet of overburden*

Variables:

- Conductivity of earth, impedance of antenna, underground vs. surface, 3D orientation

Questions?

Nick Damiano

NDamiano@cdc.gov

412-386-6650

References:

C Zhou and N, Damiano, "Electromagnetic Environments and Wireless Channels for through -the-Earth (TTE) Communications in an Underground Coal Mine: Modeling and Measurements," Progress In Electromagnetics Research M, Vol. 103, 91-101, 2021.

Damiano NW, Whisner BG, Yan L, Zhou C [2017]. Simulation and measurement of through-the-earth (TTE), extremely low-frequency signals using copper-clad, steel ground rods. IEEE Transactions on Industry Applications 53(5):5088-5095.

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