Update on NIOSH Refuge Alternatives Communications Research

Nick Damiano

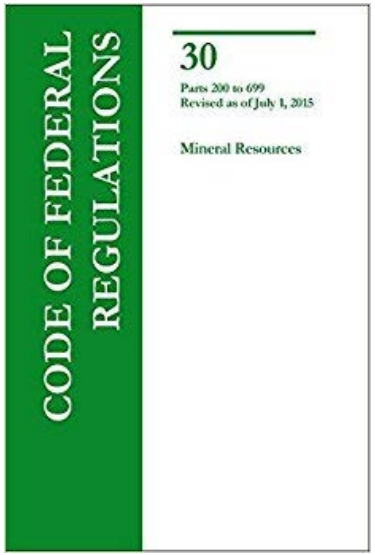
Electrical Engineer

Pittsburgh Mining Research Division

Outline

1. Introduction/background
2. Signal attenuation in metal RA
3. Signal attenuation in BIP
4. Summary & conclusions

Post-accident Communications are required in underground RAs



Subpart Q—Communications

§75.1600-3 Communications facilities; refuge alternatives.

(a) Refuge alternatives shall be provided with a communications system that consists of—

(1) A two-way communication facility that is a part of the mine communication system, which can be used from inside the refuge alternative; and

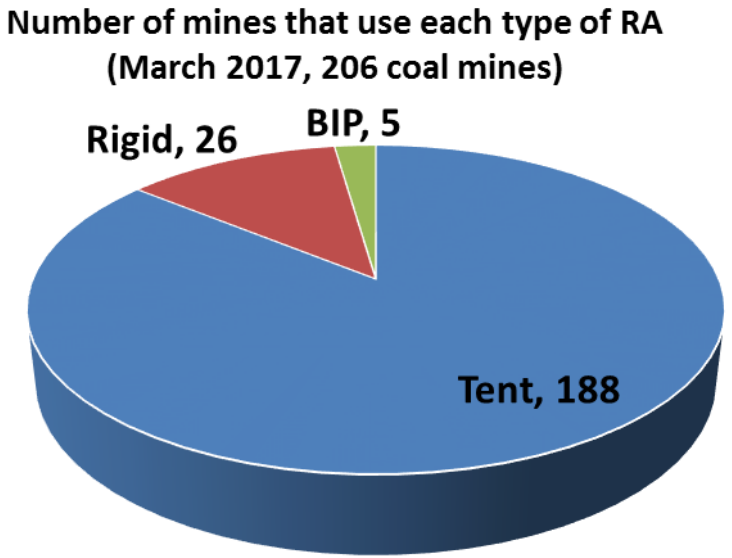
(2) An additional communication system and other requirements as defined in the communications portion of the operator's approved Emergency Response Plan.

RA Types

- RA types

1. Tent-type (canvas-metal housing)
2. Rigid-type (metal walls)
3. Built-in-Place (concrete block & metal door)

- In all cases, radio signal within the RA could be reduced compared to that available immediately outside the RA.



NIOSH has conducted tests on signal attenuation

- Test signal attenuation (loss) on:
    1. Metal-type Refuge Alternative (mRA) with:
        a) Door open
        b) Door closed (includes seal gap)
        c) Steel plate in place of door
    2. Built-in-place RA

- Data has been used to
    - Determine signal loss
    - Determine loss at multiple locations
    - Determine loss from inside the RA
    - Determine loss from outside the RA

NIOSH characterizes signal loss to determine the factors that affect propagation

HF Antenna

Laptop

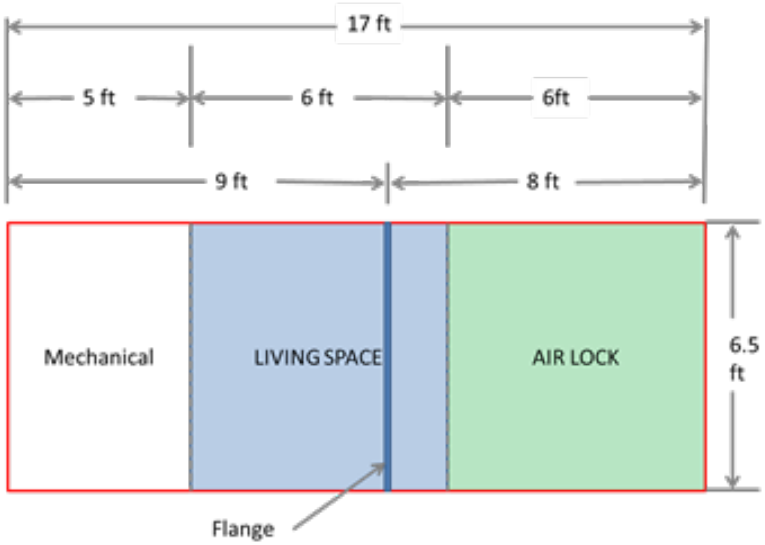
LF Antenna

Signal Generator

Spectrum Analyzer

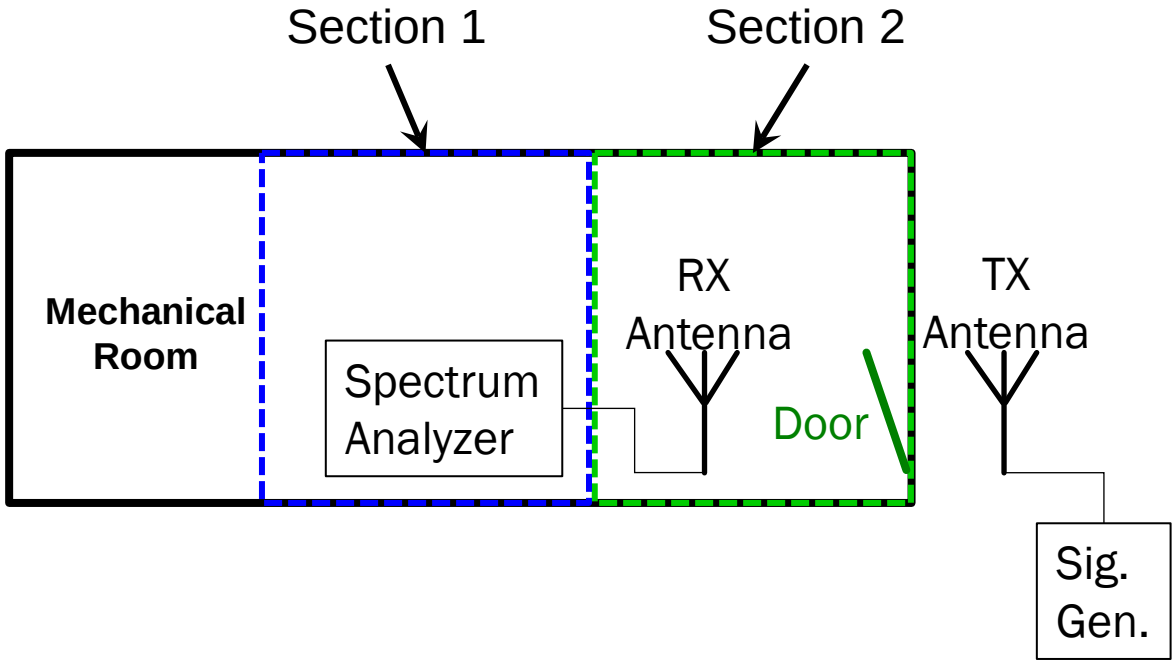
6-Person Mobile Metal-type RA Test

- Tests conducted by NIOSH in Experimental Mine (EM)



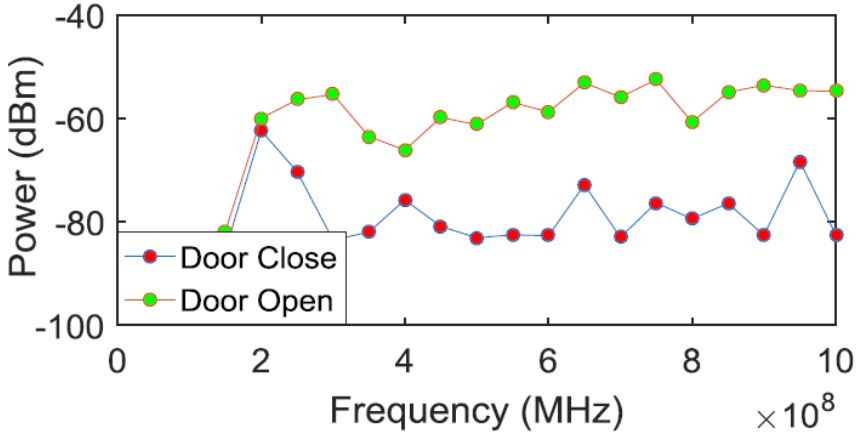
6-Person Mobile Rigid-type mRA Signal Test

- General test setup in the Experimental Mine



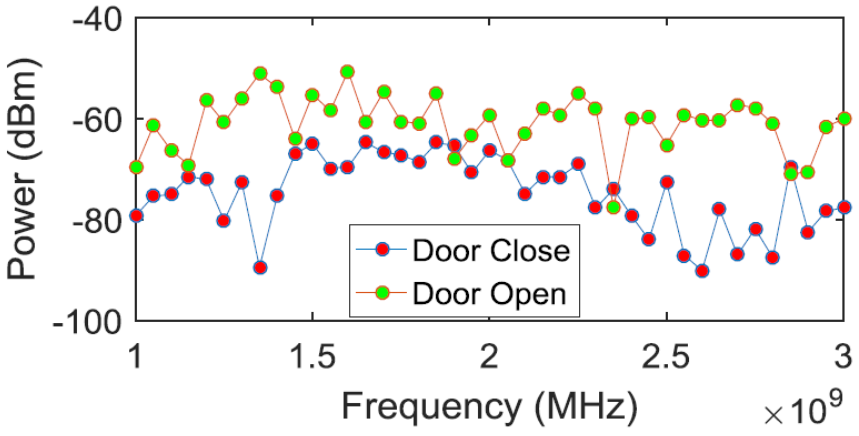
Rigid mRA Received Signal vs. Frequency

150-1000 MHz



In the 100-1000 MHz, the power attenuation ranges from 30 dB to -1 dB with an average of **18 dB**.

1000-3000 MHz



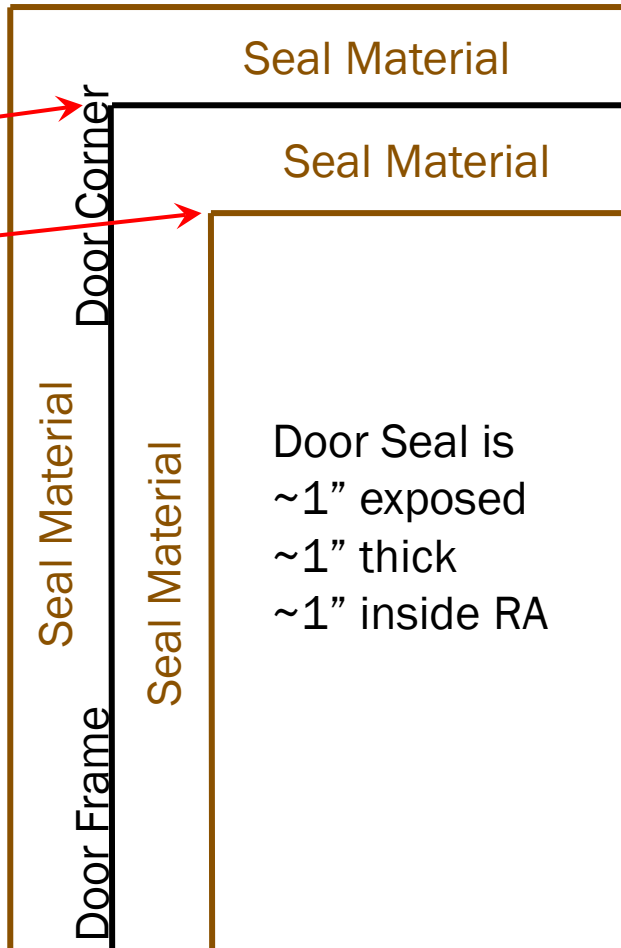
In the 1000-3000 MHz band, the power attenuation due to the RA door blockage ranges from 38 dB to -4 dB with an average of **14 dB**.

How much is 18 dB?

- For every 3 dB below 0 dBm, you get half your power
- A signal of +10 dBm is 10 dB above a 1 milliwatt (0 dBm) signal
- This equates to about 10 times stronger than 0 dBm
- +20 dBm would be 100 times stronger than 0 dBm

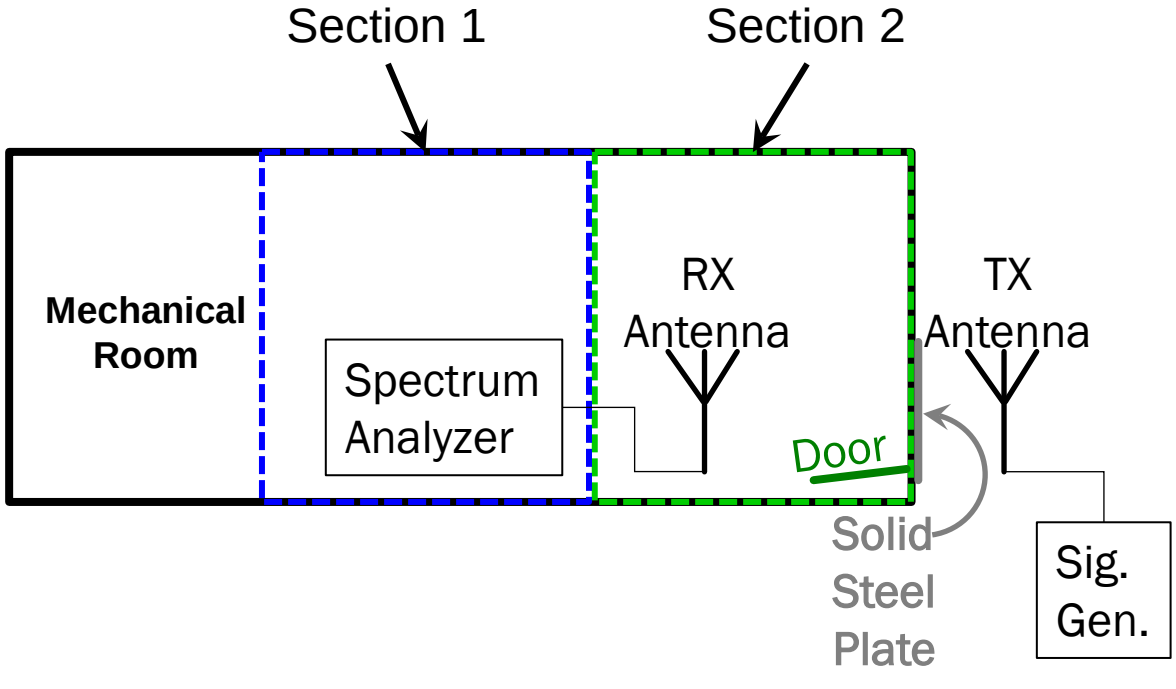
- An average of 18 dB less signal with mRA door closed would be approximately 93 times weaker than the original signal with the door open
- However, the signal is still able to be received

Door Seam Seal



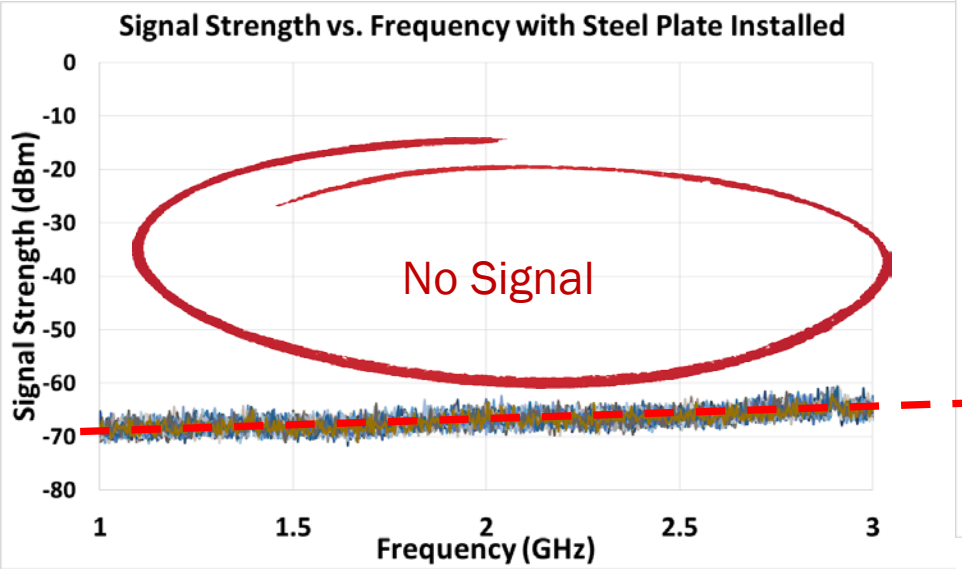
6-Person Mobile Rigid-type RA Signal Test

- Install a solid metal plate to cover the door seals to determine if eliminating the exposed seal would eliminate the signal

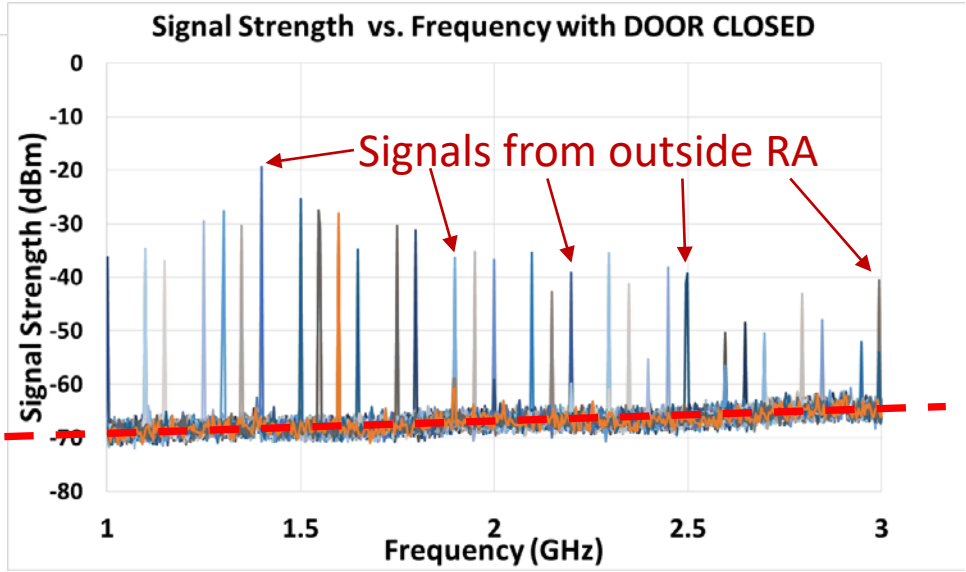


Rigid RA Signal Loss vs. Frequency with and without steel plate

Door Plate Installed



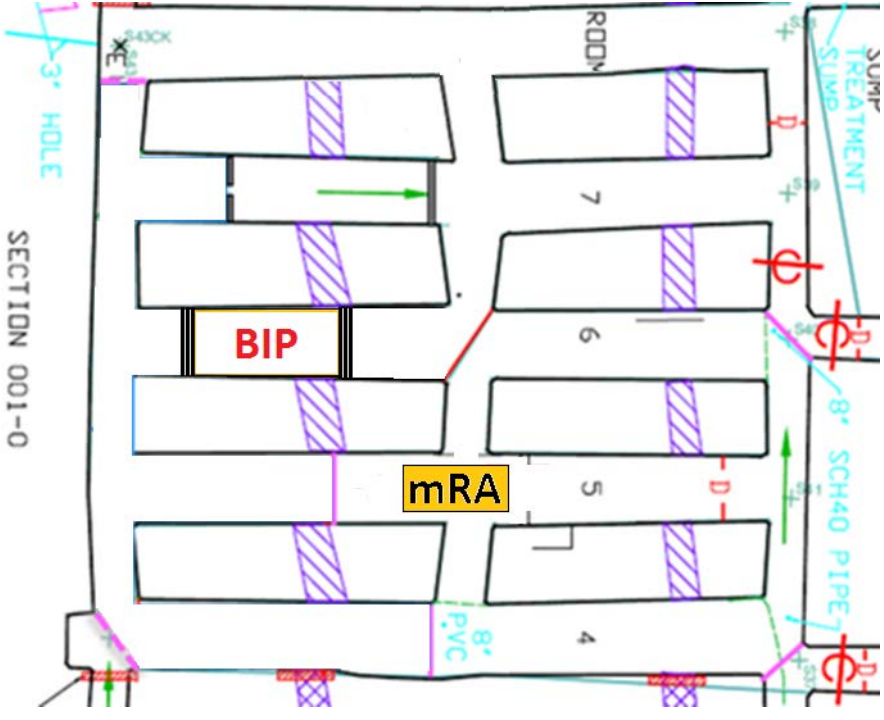
No Door Plate

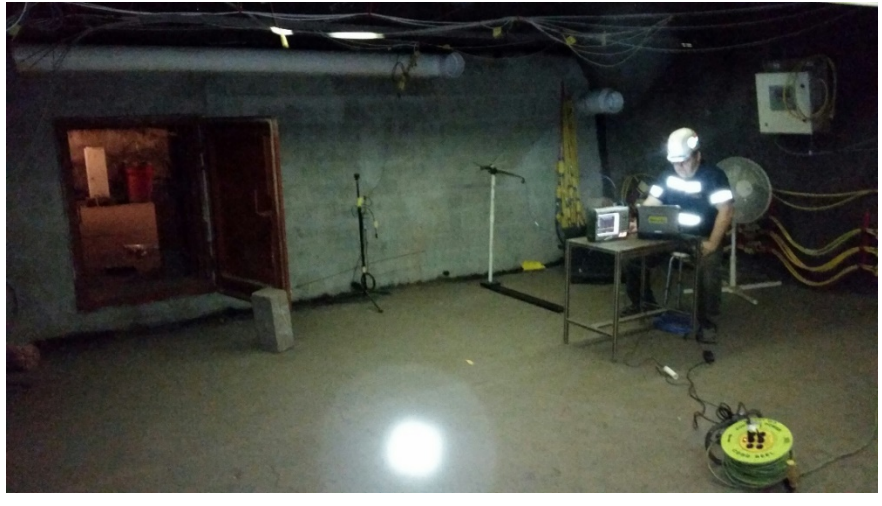


Dashed red line is noise level of measurement system.
Peaks (spikes) represent signal transmitted from outside the RA.

Built-In Place (BIP) RA Tests

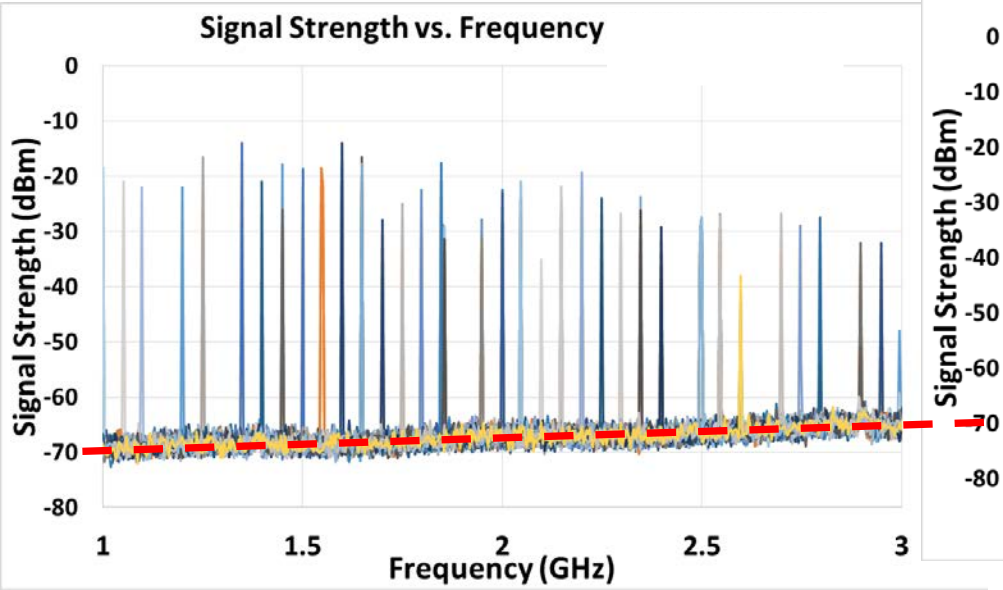
- Outside antenna stationary
- Inside antenna - variable placement



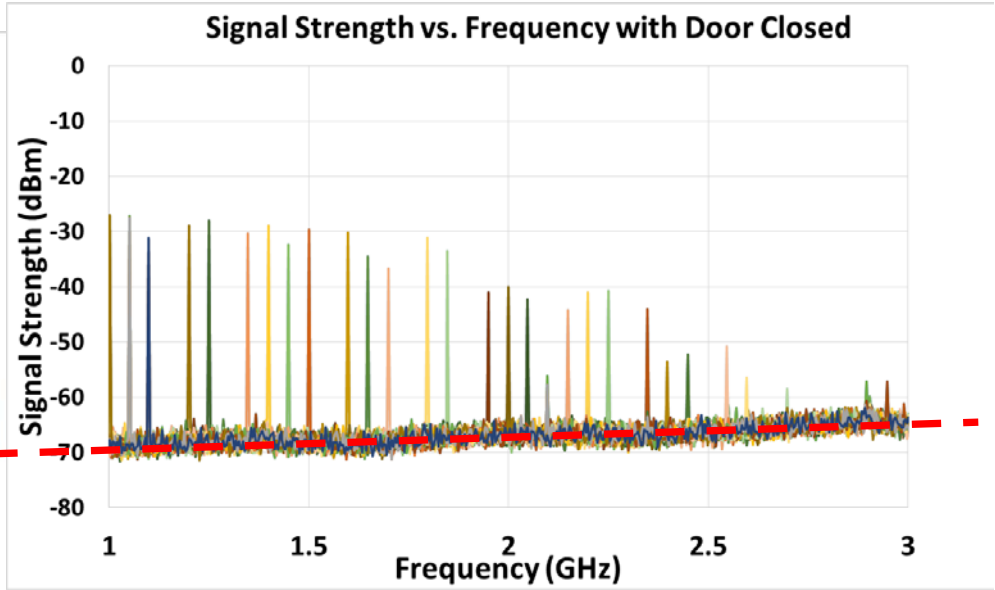


Signal received – BIP RA

Outside the BIP

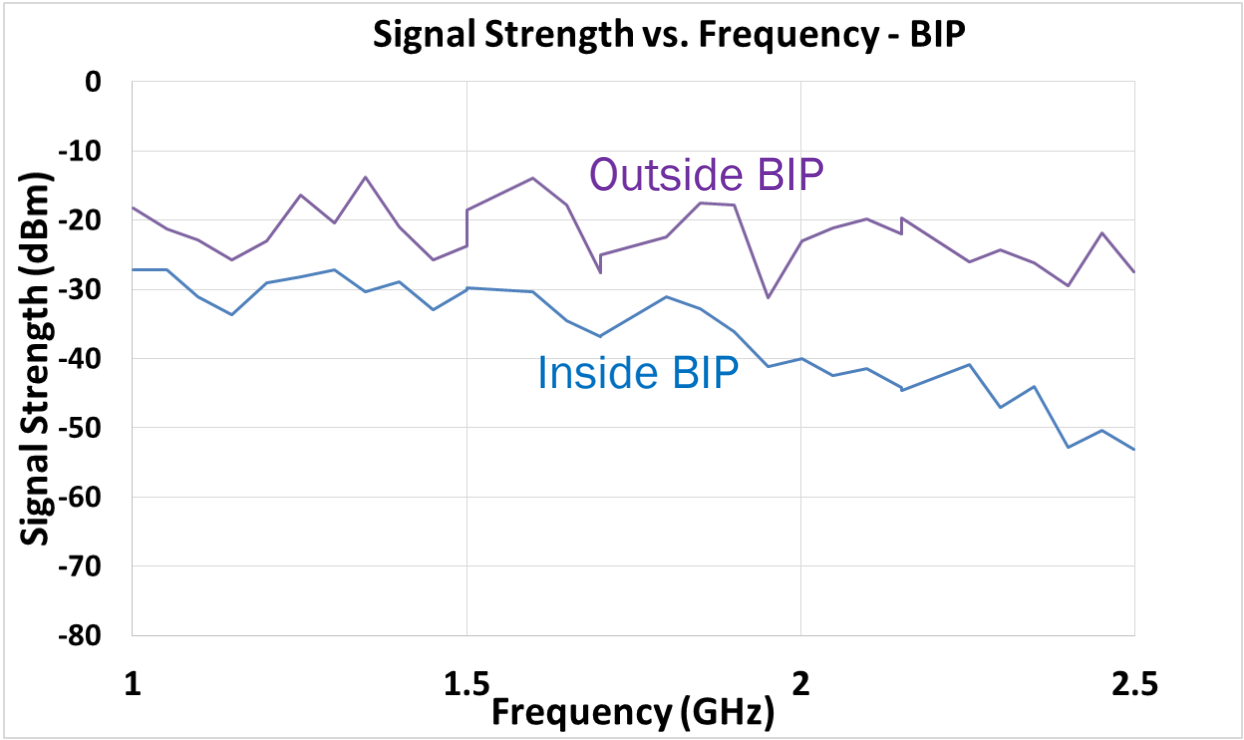


Inside the BIP



Dashed red line is noise level of measurement system.
Peaks (spikes) represent signal transmitted.

Results of BIP RA attenuation versus frequency



In the 1-2.5 GHz band, the signal attenuation due to the RA ranges from 6 to 26 dB with an average of **15 dB loss**.

Summary & Conclusions

- NIOSH mobile rigid-type mRA door attenuates signal about 15 dB for common mine communication frequencies (150 to 3000 MHz)
- If the mRA door has no seal gap (metal plate over opening), losses are high
- Gap could be vital to transmission in and out of the mRA; maintain door seam with large gaps and non-metallic seal material
- BIP RA average loss is about 15 dB
- BIP RA signal loss is likely caused by the block stoppings

Questions?

Nick Damiano

ndamiano@cdc.gov