



Office of  
Mine Safety and  
Health Research

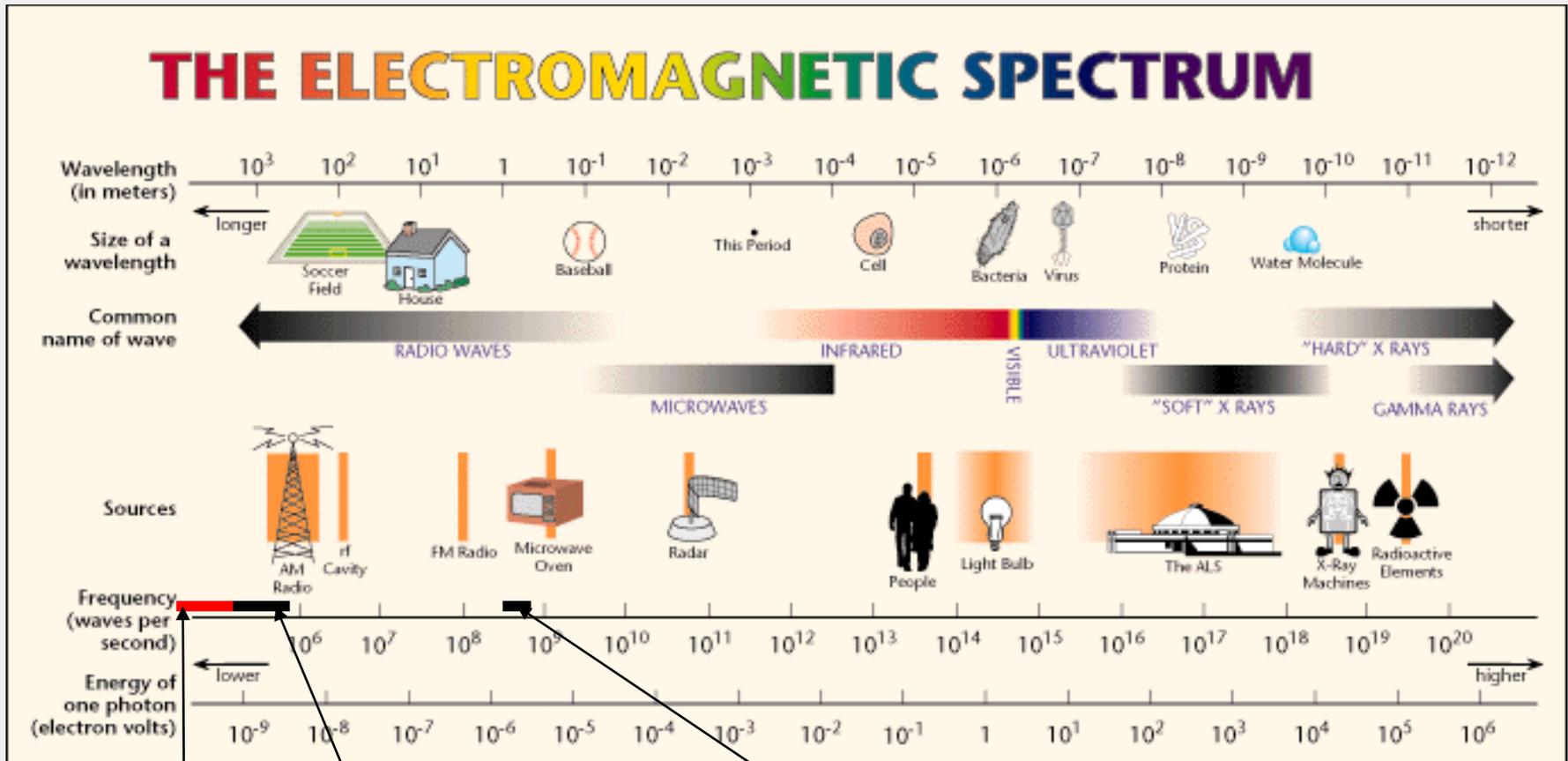
# Medium Frequency (MF) Mine Communication Systems

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# Electromagnetic Spectrum



TTE (ELF – LF)

MF "Parasitic Propagation"

VHF/UHF Mine Entry Waveguide Propagation

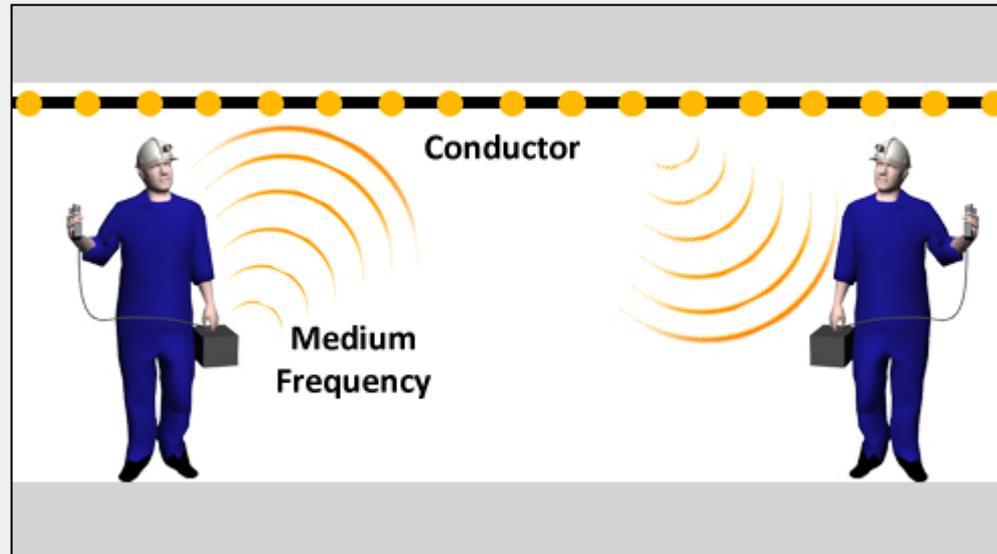
# Electromagnetic Spectrum

## Medium Frequency Band

- **300 kHz to 3000 kHz**
- **Wavelengths between 100 to 1000 meters**
- **Antenna much smaller than the wavelength (for portability)**
- **Antenna inefficient (requires proximity to conductors)**
- **Propagates by coupling to conductors**

# Simple Medium-Frequency System

- Medium frequency waves have strong magnetic properties at lower frequencies
- This property allows for the wireless signal to magnetically couple to metallic conductors
- This is sometimes called “parasitic” coupling
- Can communicate several miles with no extra equipment

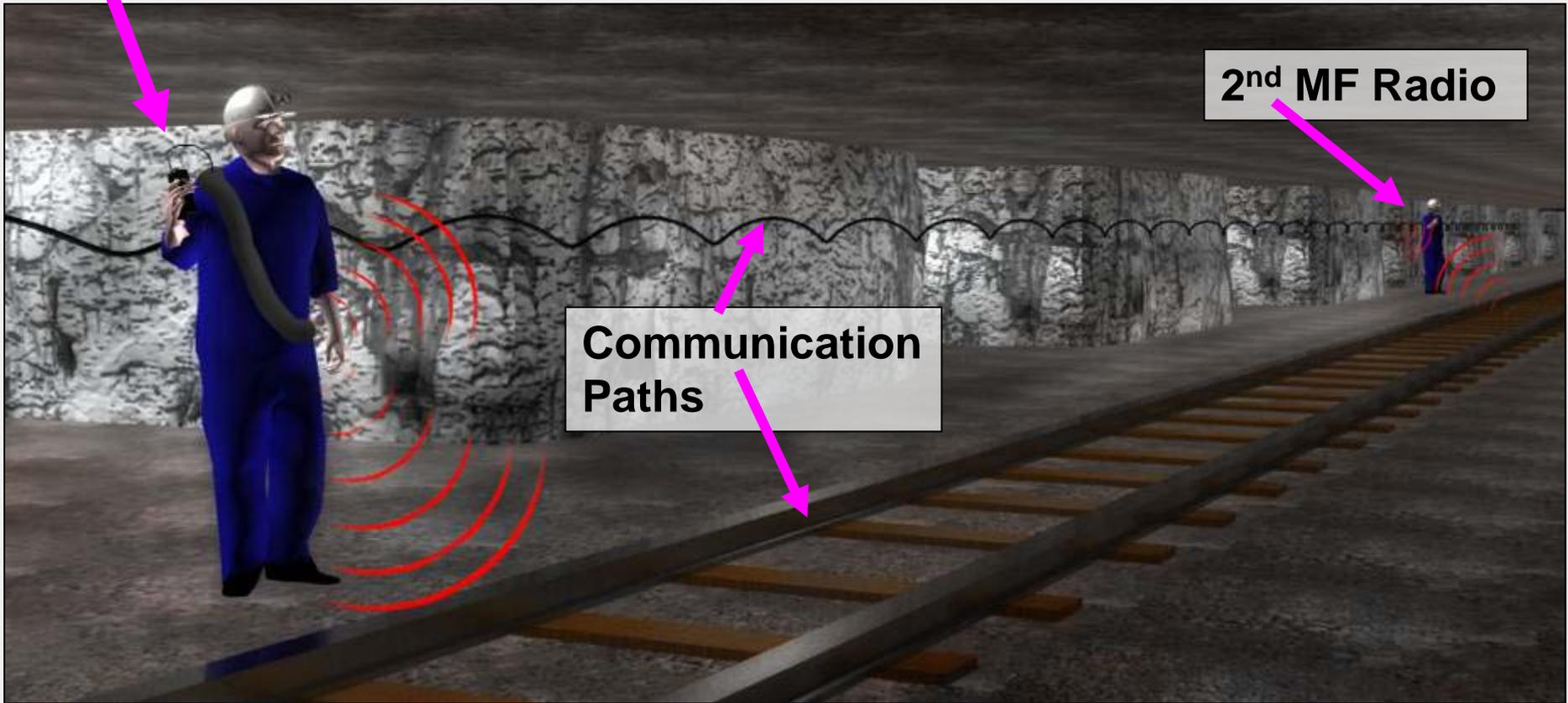


# Medium Frequency Operations Model

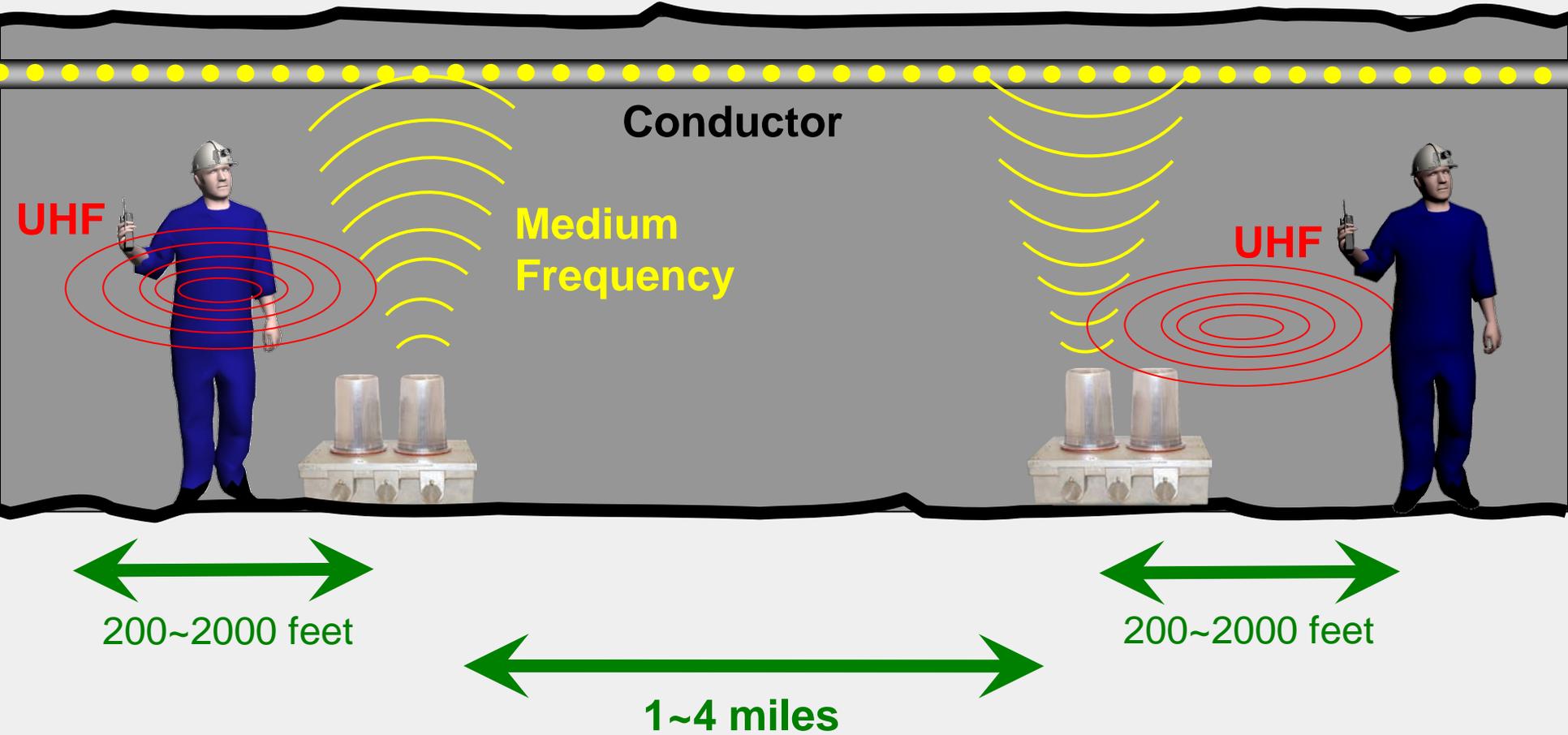
1<sup>st</sup> MF Radio

2<sup>nd</sup> MF Radio

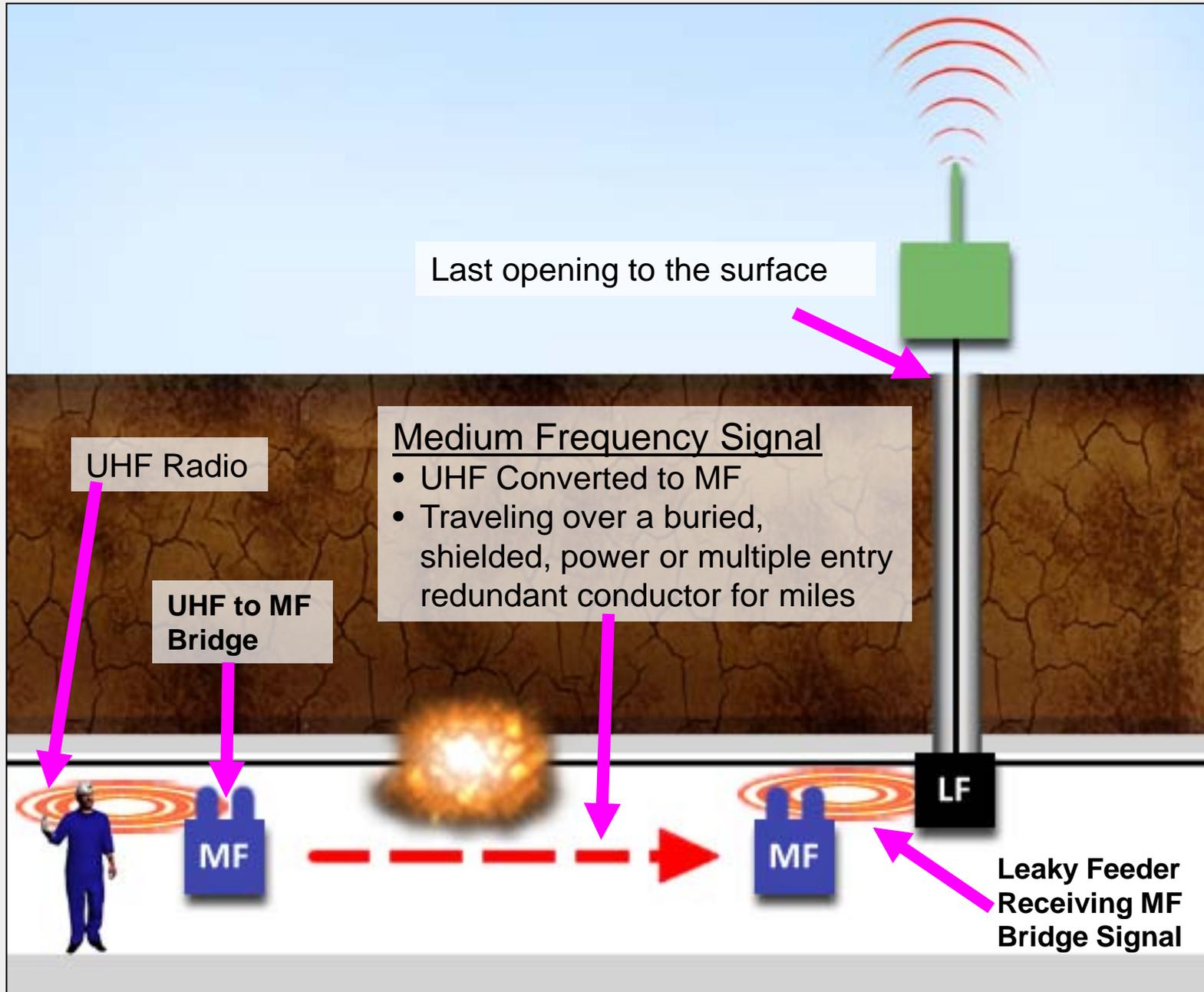
Communication  
Paths



# Medium Frequency-UHF Bridge

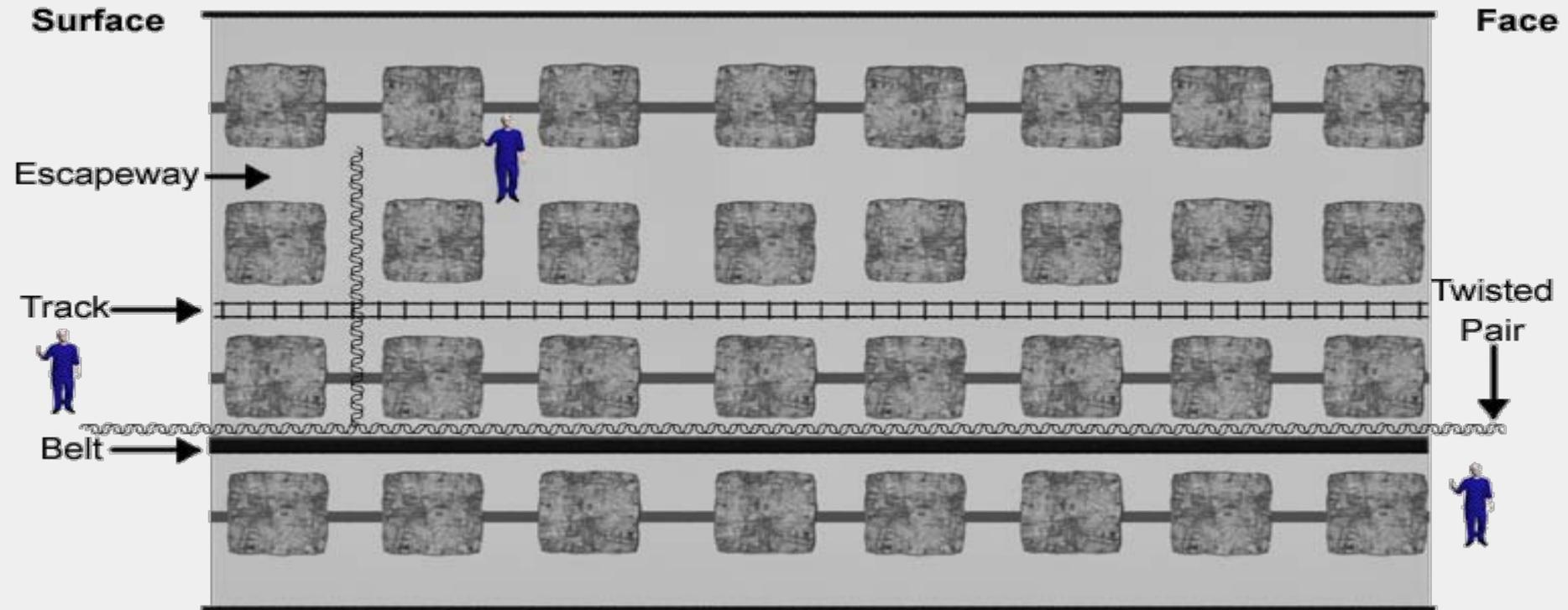


# Medium Frequency Under Emergency Operations



# Medium Frequency Installation Considerations

- If installed properly, MF can travel for several miles along a conductor



- Short length conductors ( $< 2000$  feet) carry signals better if properly connected and grounded

# Medium Frequency Installation Considerations

- **Grounding one end of the conductor can help even distribution of the signal over short distances.**
- **When branching off shorter conductors from the main line, they need to be connected in series, not shorted in parallel.**
- **Leaving a spool of conductor connected at the ends of the conductor may be desirable for both MF propagation as well as expanding the length of the system in the future.**
- **Training the miner to properly use the system is important.**

## **Medium Frequency Installation Issues**

- **Those areas where conductors do not exist may have poor MF signal.**
- **Improper grounding and terminating of conductors may impede MF signal transmission.**
- **Try to avoid communicating at the very ends of a conductor using MF, if possible.**
- **Periodic testing on installed and existing mine conductors may be needed to determine adequate communication to certain areas of the mine.**

# MF can propagate to buried conductors

PVC conduit going into dirt filled trench



PVC conduit going into Concrete filled trench



Bare cable going into PVC conduit in trench



PVC conduit going into foam filled trench

# Medium Frequency using Buried Conductors

- **Medium Frequency can couple to a trenched or shielded conductor with some signal loss.**
- **Getting closer in distance to the conductor can mitigate obstructions blocking the line-of-sight of that conductor.**

## Buried Conductor MF Tests

- **Signal follows continuous single conductor, twisted pair, TV twin lead wire.**
- **Buried conductors radiate less signal than free-hanging counterparts partly due to isolation from direct contact.**
- **Testing is necessary to determine whether signal strength is adequate in specific areas of the mine.**

# Development History

- **Previous Bureau of Mines work showed that MF can be used for underground communications.**
- **Kutta Technologies was developing a MF system under contract to US Army.**
- **NIOSH signed an Interagency Agreement with US Army Communications\* CERDEC in January 2007.**
- **Kutta Technologies contract was modified to develop a MF system for underground coal mines.**