Through-the Earth Mine Communication Systems

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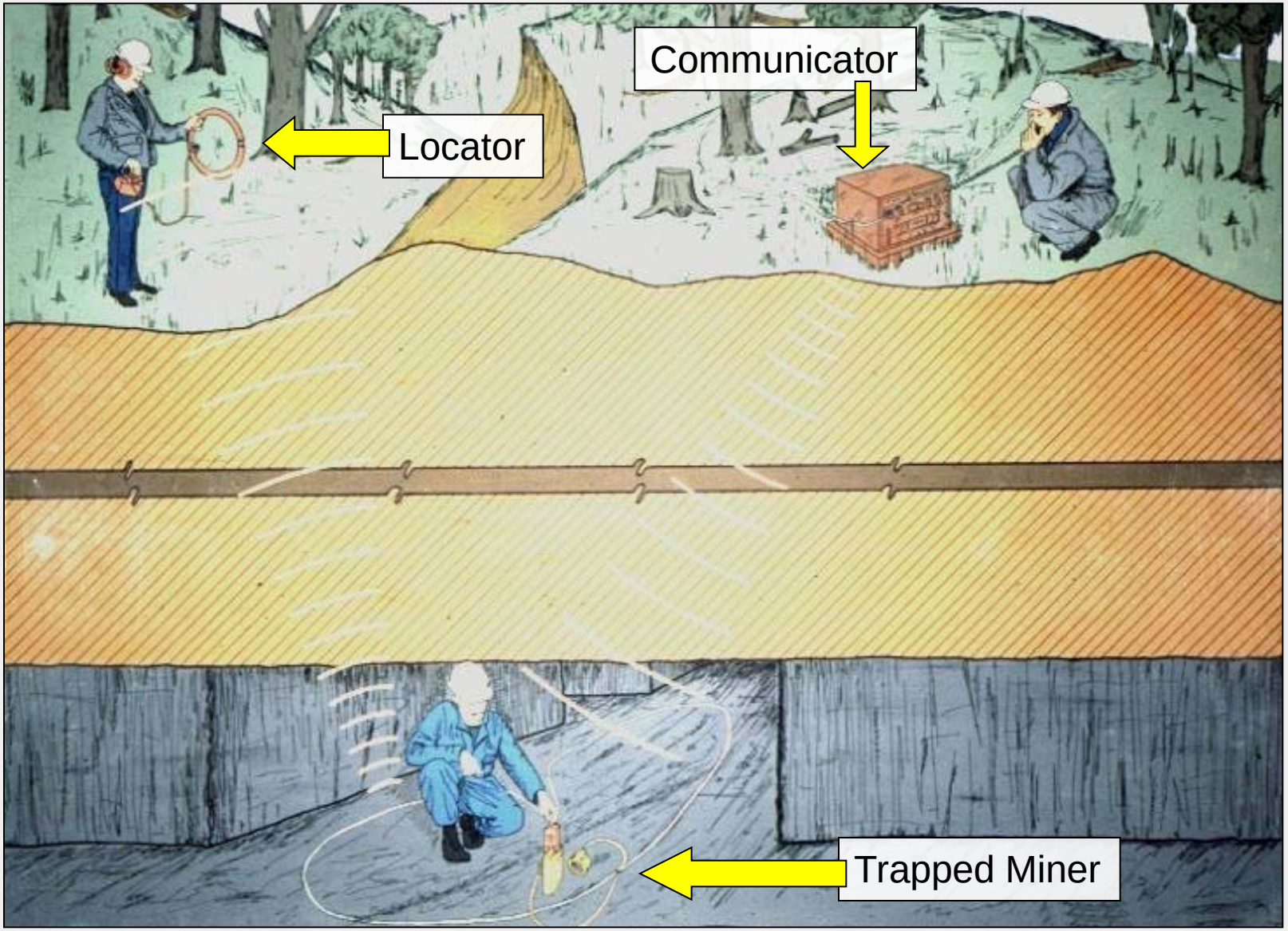
Through-the-Earth Communications



Through-the-Earth Communications

- **Frequencies less than 10,000 Hz**
- **Long wavelengths in the thousands of feet**
- **Transmission Path**
  - Through overburden
  - Through coal pillars

Transmission Mode

- **Real-time voice**
- **Voice message**
- **Text message**
- **Beacon**

Transmission Rates

- **2.5 kbps – Real-time digitized voice**
- **500 bps – Voice mail with data & text**
- **100 bps – Digital data & text**
- **10 bps – Text @ 1 keystroke per second**

Through-the-Earth Transmission is affected by:

- **Frequency**
- **Transmitter power**
- **Nature of overburden**
  - Earth conductivity
  - Depth of cover
  - Strata anomalies
- **Electrical Noise**
- **Antenna**

TTE Transmission: Frequency

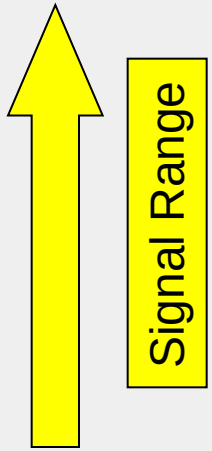
- **Lower frequencies transmit easily through solid material**
- **At low frequencies there is a trade-off with transmission rate and range**

TTE Transmission: Transmitter Power

- **Limited by safety considerations**
- **Permissibility**

TTE Transmission: Nature of Overburden

Material	Conductivity, S/m
Dry Limestone	0.001
Sandstone	0.01
Salt	0.15
Coal	0.25
Salt water	5



Higher Conductivity = Less Range

TTE Transmission: Nature of Overburden

- **Typical overburdens range from 300 ft. to 2000 ft .**

- **Strata Anomalies**
  - Aquifers
  - Mined-out seams

TTE Transmission: Electrical Noise

- **Underground**
  - 60 Hz and harmonics (motors, transformers, etc.)
  - Decreases during emergency

- **Surface**
  - Lightning
  - High-voltage power lines
  - Generators

Signal level must exceed noise level

Surface Noise Reduction

- **Conventional Analog Filtering: 20 dB reduction**
- **Advanced Digital Filtering: 40 dB reduction**

Performance goal of 40 to 50 dB for the deepest mines (2000 ft/)

Depth vs. Rock Type and Data Rates

Rock Type	Real-Time Voice	Voicemail	Data and Text
Dry-Limestone	2000 feet	2000 feet	2000 feet at 2.5 kbps
Sandstone	1200 feet	1500 feet	2000 feet at 100 bps

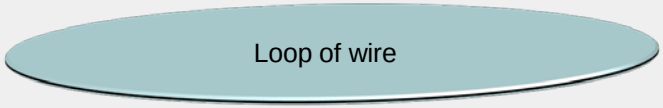
TTE Transmission: Antenna

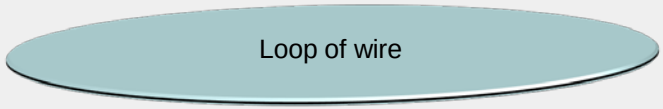
- **Large loop of wire (air core)**
  - Encompasses large surface area
  - Around coal block
- **Multiple winding ferrite core**
  - Compact
  - Portable

Antenna Orientation

Good Coupling

Surface Receiver

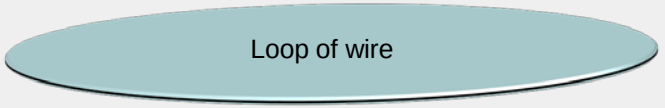




Underground Transmitter

Poor Coupling

Surface Receiver



Underground Transmitter

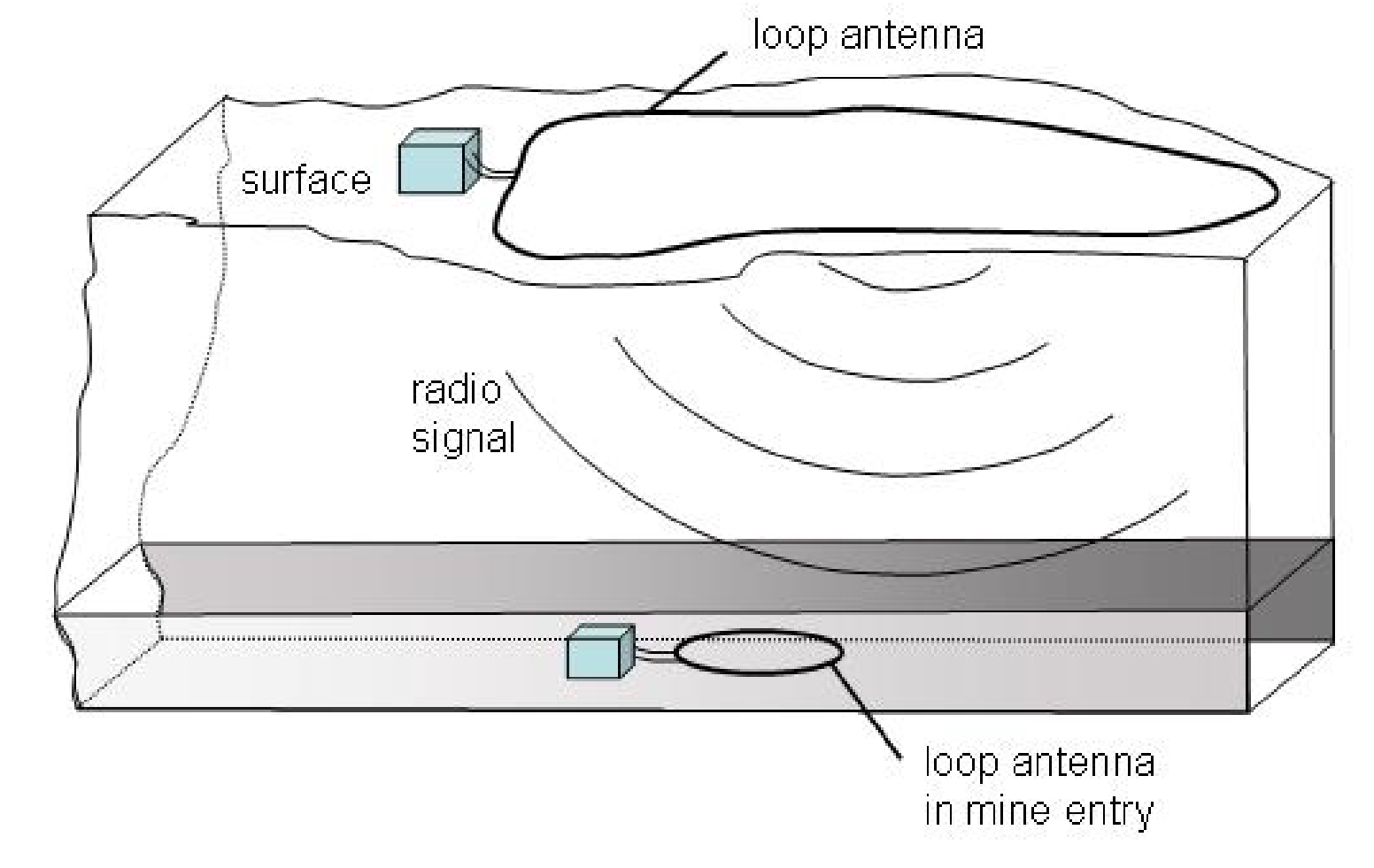
Underground Transceiver

- **Through-the-earth and through-the-mine**
- **Low power to ensure permissibility**
- **Portable or fixed location**
- **Voice, text, or beacon**

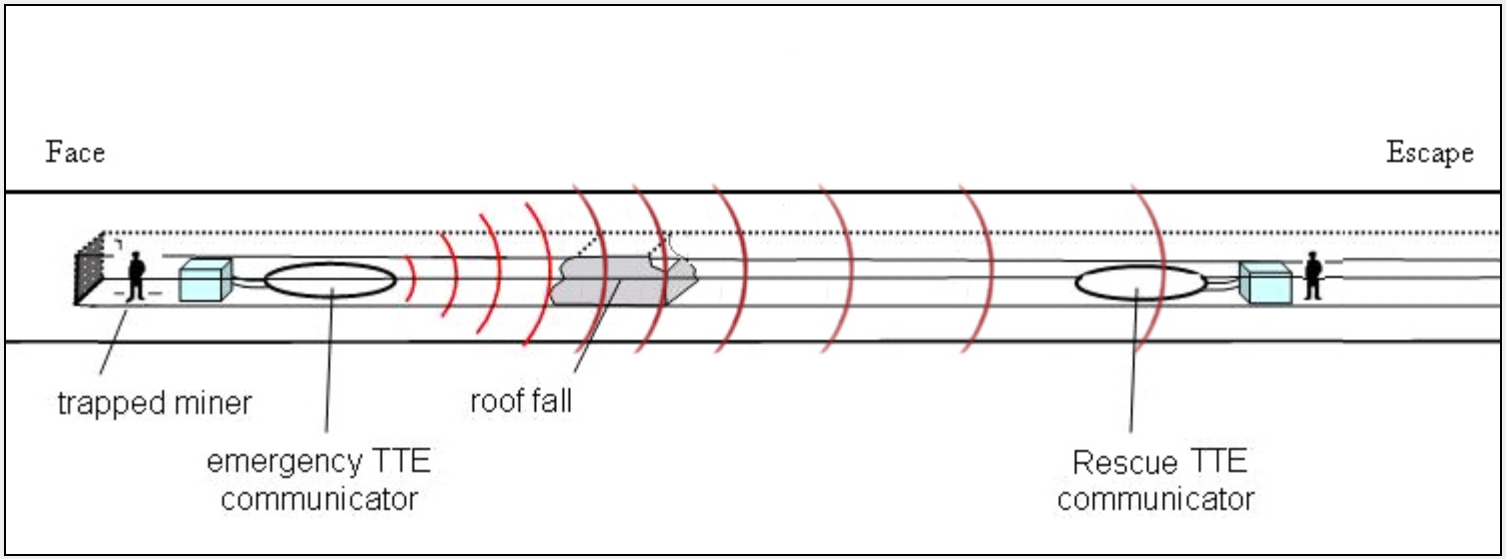
Surface Transceiver

- **Can have larger antenna**
  - Could encompass most of mine
  - Limited by terrain
  - Located above stationary transceivers underground
- **Can have greater power**
  - Higher frequencies
    - Higher data rates

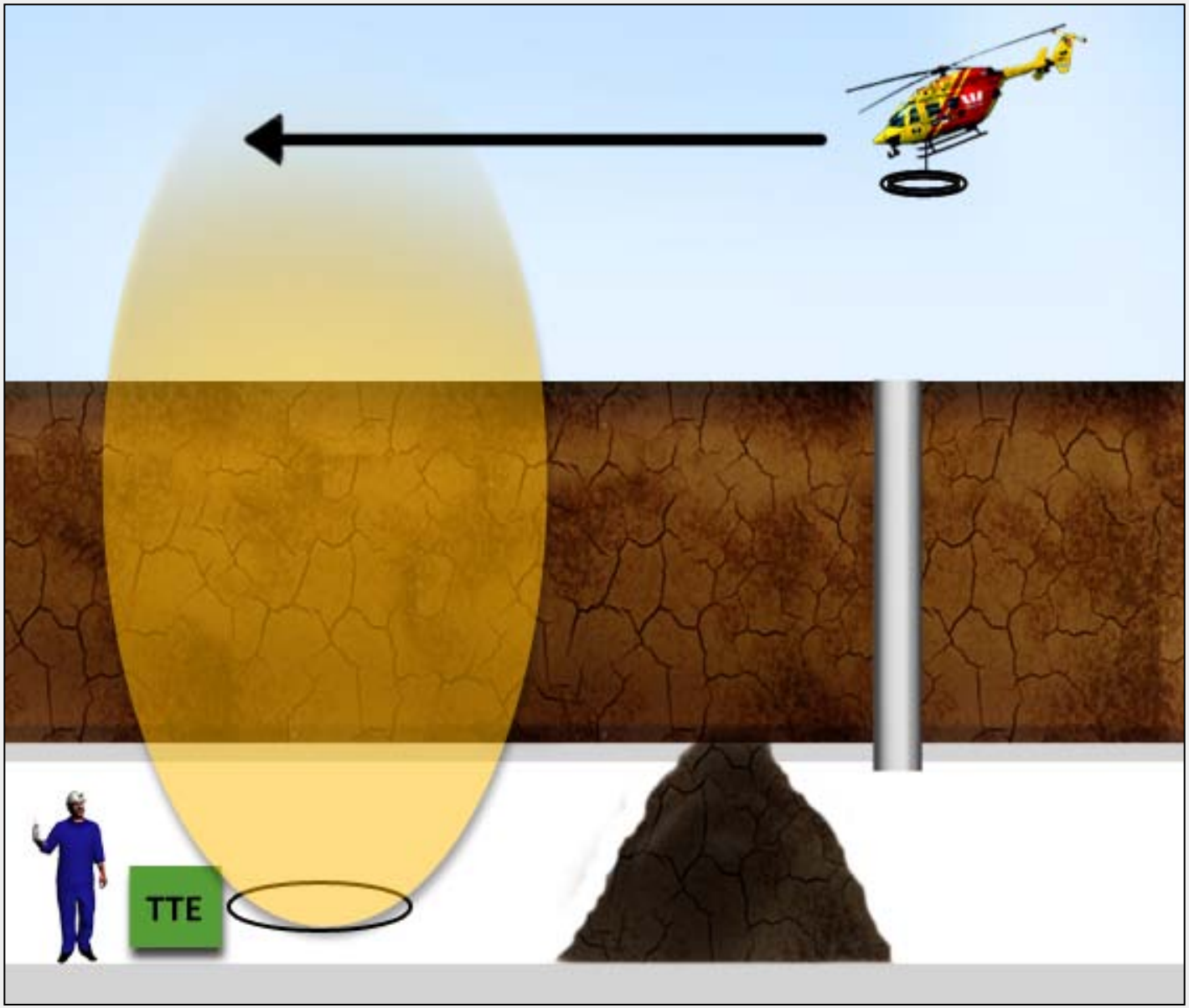
Surface Transmission Through-the-Earth



Transmission Through-the-Mine



Deployment during Escape



Deployment in Rescue Chamber

- **Communicate with surface and/or rescue teams**
- **Conserve battery life**

Maintenance

Routine Periodic Function Tests

- **Verify Through-the-Earth and Through-the-Mine communications periodically**
- **Confirm communication with surface each time chamber is moved**

A Magnetic Communication System for Use in Mine Environments

- **Competitive BAA award**
- **Lockheed Martin Corporation, Syracuse, NY**

Objective:
To develop and demonstrate a two-way through-the-earth communication system for mines

- **Laboratory prototypes**
- **Field demonstrations**