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

<table>
<thead>
<tr>
<th>Material</th>
<th>Conductivity, S/m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Limestone</td>
<td>0.001</td>
</tr>
<tr>
<td>Sandstone</td>
<td>0.01</td>
</tr>
<tr>
<td>Salt</td>
<td>0.15</td>
</tr>
<tr>
<td>Coal</td>
<td>0.25</td>
</tr>
<tr>
<td>Salt water</td>
<td>5</td>
</tr>
</tbody>
</table>

Higher Conductivity = Less Range

Signal Range
TTE Transmission: Nature of Overburden

- Typical overburdends 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

<table>
<thead>
<tr>
<th>Rock Type</th>
<th>Real-Time Voice</th>
<th>Voicemail</th>
<th>Data and Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry-Limestone</td>
<td>2000 feet</td>
<td>2000 feet</td>
<td>2000 feet at 2.5 kbps</td>
</tr>
<tr>
<td>Sandstone</td>
<td>1200 feet</td>
<td>1500 feet</td>
<td>2000 feet at 100 bps</td>
</tr>
</tbody>
</table>
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
- Loop of wire
- Loop of wire
- Underground Transmitter

**Poor Coupling**
- Surface Receiver
- Loop of wire
- 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

Diagram showing surface transmission through the earth with loop antennas and radio signals.
Transmission Through-the-Mine

- trapped miner
- emergency TTE communicator
- roof fall
- Rescue TTE communicator
Deployment during Escape

- Communicate with underground and surface
- Multiple units available
- Loop around coal pillar
- Beacon mode

(This information will be depicted in a drawing)
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