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Through-the-Earth, Post-Accident Communications—an Emerging Technology

Objective

The objective is to provide a two-way communications system that can improve miners' ability to communicate with personnel on the surface after an underground mine accident or emergency. This type of system could allow miners to directly communicate with others outside the mine without the need for any underground infrastructure other than a transceiver and an antenna.

Background on Through-the-Earth

In June 2006, Congress passed the Mine Improvement and New Emergency Response Act (MINER Act), requiring that underground coal mines develop emergency response plans that specify two-way wireless communications and electronic tracking systems. In the years following the MINER Act, the National Institute for Occupational Safety and Health (NIOSH) supported the development of a variety of communications and tracking technologies. Most communications systems use hand-held, high frequency (HF) radios similar to systems used in other industries. These HF systems require the installation of extended underground infrastructure that may be susceptible to damage from fires or explosions. In contrast, through-the-earth (TTE) systems typically feature only a conductor encircling a coal pillar for the transmit antenna. Also, TTE systems can communicate directly through obstacles in the mine. They are considered highly survivable because the underground TTE components reside in a single location making them less susceptible to wide-scale damage.

TTE systems generally operate in radio frequency bands ranging from 300 to 5,000 Hertz (Hz). These low frequencies are required for radio waves to achieve significant penetration through the mine overburden. With TTE communications, there is a single, direct wireless link between the underground and surface transceivers. TTE radios are commonly half-duplex devices, able to communicate in only one direction at a time.

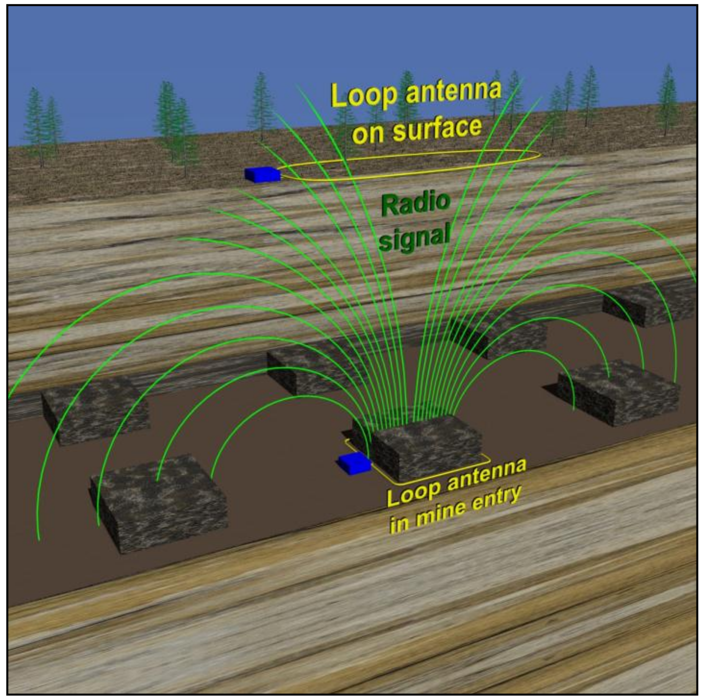

Figure 1. An example of through-the-earth (TTE) communications depicted at a mine site.

Evaluating Through-the-Earth Performance

As shown in Figure 1, the transmit antenna is typically a loop(s) of wire oriented in the horizontal plane. To achieve successful communication, TTE signals must penetrate the layers of the earth above the mine. For the strongest signal, the surface transceiver should be directly above the subsurface TTE transceiver. Although these systems are fairly tolerant of some misalignment, at some point the signal falls off. This is a known issue, but each location is unique and can be tested ahead of time. Obtaining an adequate surface location requires that the mine have knowledge of the location and depth of the subsurface unit and access to the surface above it. Because permissible TTE systems are not very mobile, a system would likely be installed prior to an emergency and accurately marked on a mine map which could be overlaid on a map of the surface.

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There are many surface and underground considerations when communicating through the overburden depth and the constituents in the strata. Underground coal mines can vary dramatically in depth at different locations. The overburden can also contain mined-out seams or aquifers that may limit the distance TTE signals can propagate. Generally, the lower the frequency of TTE signals, the less the attenuation and the greater the allowable separation of the transmitter and receiver. However, lowering the TTE frequency will reduce the amount of information that can be sent in a given period of time (sometimes referred to as system bandwidth). Due to this limited bandwidth, some TTE systems use text messaging instead of voice communications to further reduce the time it takes to transfer a message. Electromagnetic noise from sources such as large motors and power lines on the surface or underground can affect TTE performance. TTE systems should be installed away from potential noise sources as the effects from noise drop off quickly with increasing separation distance.

The size of the antennas limits the locations for transmission of TTE messages. Some TTE systems can achieve greater depths by using a larger transmit loop on the surface, but in the underground environment the loop must be placed around a coal pillar to maximize the area within the antenna as there are few locations wide enough in the mine to deploy such a large antenna. This may not be possible in some locations within the mine thereby limiting where or how the antenna can be deployed.

Increasing power levels in the transmit antennas both on the surface and underground can improve TTE performance. However, the amount of power used underground is limited by permissibility requirements. This factor limits the distance underground TTE systems can transmit back to the surface even though the surface unit can operate at much higher power.

Available Through-the-Earth Technology

Since 2006, NIOSH has sponsored the development of several different TTE technologies through a series of competitive contracts and awards via Broad Agency Announcements (BAAs). Several prototype TTE systems have been tested at various underground coal mines. It was observed that some TTE prototypes could receive voice messages through approximately 1,000 ft of overburden. Text messages could be received from even farther distances—through overburdens of about 2,000 ft. Other tests have shown that a system could reach as far as 5,000 ft; however, these tests were taken point-to-point horizontally in a mine and not directly through overburden. Results such as these may vary from mine to mine or even at different locations within the mine itself.

Of the five systems selected for BAA contracts, the MagneLink® Magnetic Communications System (MSC) (Figure 2) developed by Lockheed Martin is the only one that has received Mine Safety and Health Administration (MSHA) permissibility approval. This system contains a transmit antenna which is a length of wire that could be deployed around a coal pillar. The 3-axis orthogonal receive antenna and other receive electronics are in a separate housing (box on the left in Figure 2). The backup batteries and computer control are in an explosion-proof box which is about 3 x 3 x 2 ft in size. This underground system was designed to be installed in a fixed location perhaps near a refuge alternative or other strategic location underground.

Figure 2. MagneLink® Magnetic Communications System.

Currently, Magnelink® is the only MSHA approved TTE communication system available to the underground coal mining industry. It has been tested at ranges up to 1,500 ft for voice and approximately 2,000 ft for text. The technology described in this article is available from Lockheed Martin (http://www.lockheedmartin.com).

For More Information

For more information on this technology and its use, contact Nick Damiano (ndamiano@cdc.gov) or the Health Communications Coordinator (OMSHR@cdc.gov), NIOSH Office of Mine Safety and Health Research, P.O. Box 18070, Pittsburgh, PA 15236-0070.

To receive NIOSH documents or for more information about occupational safety and health topics, contact: 1-800-CDC-INFO (1-800-232-4636), 1-888-232-6348 (TTY), e-mail: **cdcinfo@cdc.gov**, or visit the NIOSH web site at **http://www.cdc.gov/niosh**.

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