This submission is in response to the call for comments on FR25JA06-32
"Underground Mine Rescue Equipment and Technology".
The comments are specifically directed at section E. Communications.

Underground Wireless Communications

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We have developed a wireless technology to communicate voice through the earth. Our technique uses very low frequency electromagnetic waves to carry digitally compressed voice to underground areas. The carrier frequencies of several kilohertz typically penetrate hundreds of meters into the rock mass. The voice has typically been digitally compressed to a bandwidth of 500 Hz and placed on the earth-penetrating carrier. This carrier has been successfully received and voice extracted at distances in excess of one hundred meters through solid rock. The technology is discussed in greater detail below. This invention is at a critical stage of technology development and, with appropriate support, will be commercially available in one year.

The current configuration for audio testing is shown in fig. 1. We have two radios that are used to test and validate the through-the-earth concept. The blue areas represent drifts and stick figures are mine workers. The interface is an audio headset and microphone plugged into the radio. The demonstrated range is well over 100 meters. In fig. 2 we show several radios that are a small part of a projected commercial installation.

Figure 1. Current configuration of the underground radio during testing.

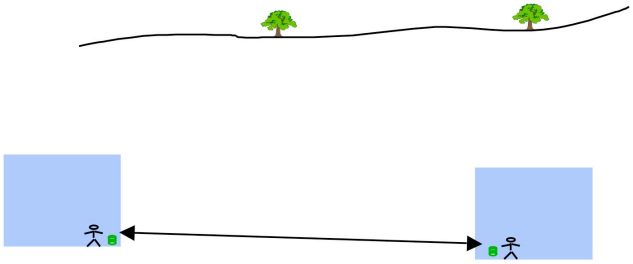
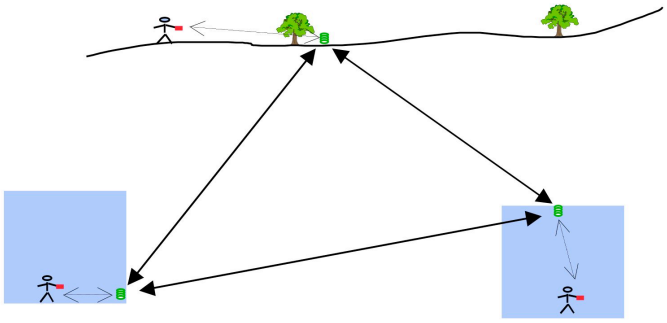


Figure 2. The planned commercial configuration of the underground radio.



The through-the-earth radio is necessary, but works best as a fixed station that routes communication signals. The users then carry small portable devices that can operate in any common communication band. The commercial version of the radio will be internet-ready. The station on the surface can then be placed directly on a network and, with appropriate security measures, be accessed over the internet. The full mine system would have a number of surface units at convenient locations for redundancy. The underground base stations could include sensors for CO, methane, etc. and those can be read out as part of the communications. In a mine the user of the radio can be located by using the relative strengths of the radio signals detected by several base stations. These systems form a three-dimensional network such that the failure of any given base station is bypassed by other links in the network. Thus, the voice communications, worker locations, and sensor data will continue to flow over the through-the-earth link.

The key advantage of this system is the ability to achieve high reliability by using signal paths that are not dependent on intact cables or open-airspace. The radio frequency and antenna design are chosen so that we send our radio waves into the rock mass. This bypasses any drift obstructions by providing a number of signal paths out of the underground area. This also bypasses the presence of flame and smoke in the drift, since these are known from firefighting experience to be obstructions to radio communication. This underground communications problem is closely connected to the radio problems encountered by firefighters during the world trade center collapse. The lack of a penetrating carrier inhibited communications at critical times and led to the loss of a large number of firefighters. Our technology should solve help to solve this problem as well.

This technology has been developed with support from a consortium of mining companies and funding from the DOE. The mining companies supported this effort because this system should provide significant value in normal operations and improved worker safety. We strongly support the continued operational role as a method to ensure continuous maintenance and testing of the communication system. The DOE funded project involved the measurement of background noise and signal propagation in numerous mining environments. From this we developed a plan to introduce audio links that work with the noise backgrounds and the signal attenuations commonly observed. We developed simulations of the signal channel that validated some robust digital algorithms. We then developed field radios using low cost digital signal processor technology for the audio processing and a number of receiver technologies. Several of these radio models were successfully tested in actual mines. The underground radio is not in a commercial ready state. It is still the first prototype, frequently called an alpha in industry, and can only be operated by expert users. It has been at this stage for nearly two years with a little funded recent progress. The next stage is to develop a beta model that will be evaluated by users.

Vital Alert Communication, Inc. (contact: J. Miller, jmiller@vitalalert.com, 705-644-0908) has licensed the technology with the intent to prepare a fully commercial product. Due to the relatively small market in mining it is likely that federal funding will be required to transition this technology into a high performance commercial product.