Emergency Communication and Tracking Committee
Underground Communication and Tracking Systems Tests at CONSOL Energy Inc., McElroy Mine
Report of Findings

Summary of Results

MSHA evaluated and performed field testing of six (6) communication and/or tracking systems. All but one system that was tested were prototypes and are not currently commercially available. The systems operated using one of the following technologies (in no particular order):

- medium frequency radio (<3 MHz)
- ultra-wide band radio
- very low frequency (<10kHz), through-the-earth
- wireless mesh network (IEEE 802.11b or 802.15.4 standards)

Field testing was conducted to determine:

- how well signals propagate (maximum distance between nodes)
- how much overburden systems can penetrate if capable of through-the-earth communication
- mine coverage area (i.e. are there blind spots and why?)
- accuracy of tracking features
- if interference would be an issue

The testing that was conducted resulted in the following observations (Note that some results are specific to this test area in this mine. Propagation distances may be longer or shorter at other mine sites depending on differences in entry geometry and mine infrastructure):

<u>Medium Frequency Radios</u>

1. The signal from a medium frequency radio system was found to couple onto existing metallic mine infrastructure and could propagate more than one mile.
2. Systems that use medium frequencies have the potential to provide two-way voice and data communications.
3. Other communication systems and electrical systems already installed in the mine did produce some level of interference, but the effects could be mitigated by using correct filtering and signal amplification.

4. Further study is needed to determine what types of conductors propagate the signal most effectively.

   *Separate tests conducted by CONSOL Energy, Inc. at their Enlow Fork Mine on June 1, 2006 resulted in voice communication at a range of more than two miles. This range was limited by the track entry length. The only conductors present in the last 300ft of the track entry test area were the mine page phone line, the carbon monoxide monitoring system line, and a twisted pair phone line.

Ultra-Wide Band (UWB) Radio

1. In this test area, range was approximately 1,200ft with uninterrupted reception and approximately 2,000ft with some dead spots. The signals produced do not turn corners well; therefore system design must address how to provide coverage in adjacent entries.
2. UWB systems have the potential to provide two-way voice communications and tracking to within 20ft or better accuracy, as well as data transmission.
3. In order to outfit the sample test area with communications using ultra-wide band systems, access points would have to be installed in each entry at distances of a maximum of every 2,000ft. Redundancy would also have to be engineered to ensure that the system would continue to function in the event of an explosion or fire.
4. Interference from other communication systems and electrical systems already installed in the mine did not seem to be an issue. The factors that governed signal propagation distance could be attributed to entry geometry in the case of the track entry and both entry geometry and the presence of an abundance of metallic structures in the belt entry.

Very Low Frequency, Through-The-Earth

1. Through-the-earth (TTE) voice communication signals could penetrate overburden of 270 ft and a beacon signal could be received from underground.
2. None of the TTE systems tested could verify receiving a signal (voice or beacon) through more than 270 ft of overburden.
3. Based upon published literature and theoretical calculations, receiving signals at depths greater than 270ft may be possible.
4. Other communication systems, electrical systems, and/or other infrastructure already installed at the mine site did produce some level of interference.
5. Off-axis tests demonstrated that the signal could be received when the underground and surface units were not directly in line with each other.
6. Further study and system development is needed to achieve greater depths and mitigate the effects of interference.

* Separate tests conducted by CONSOL Energy, Inc. at their Enlow Fork Mine on May 31, 2006 resulted in two-way text communication at depths of 558ft and 631ft. One-way text communication was received underground from the surface at a depth of 900ft. At the 558ft and 631ft locations, reception speed was 20-30 characters per minute with some lost (~20%) characters. At the 900ft location, text speed was 2-3 characters per minute with many lost (>50%) characters. The system under test was a proof of concept and had no error correction built into the software.

Wireless Mesh Networks

1. Wireless mesh network type systems that utilize 802.11b protocol at 2.4 GHz propagated up to 1,500 ft in this test area. The signals produced do not turn corners well; therefore system design must address how to provide coverage in adjacent entries.
2. Wireless mesh network type systems that utilize 802.15.4 protocol at 900 MHz propagated up to 1,800 ft in this test area. The signals produced do not turn corners well; therefore system design must address how to provide coverage in adjacent entries.
3. Wireless mesh networks have the potential to provide two-way voice communications and tracking to the nearest node, as well as data transmission.
4. In order to outfit the sample test area with communications using wireless mesh network systems, access points would have to be installed in each entry at distances of a maximum of every 1,500 to 1,800 ft. Redundancy would also have to be engineered to ensure that the system would continue to function in the event of an explosion or fire.
5. Interference from other communication systems and electrical systems already installed in the mine did not seem to be an issue. The factors that governed signal propagation distance could be attributed to entry geometry in the case of the track entry and both entry geometry and the presence of an abundance of metallic structures in the belt entry.