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Technology News

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New Measurement Tool to Validate Wireless Communications and Tracking Radio Signal Coverage in Mines

Objective

The objective is to develop a tool to accurately measure, store, and plot on a mine map the radio signal strength of wireless communications and tracking systems in underground mines. This capability would allow mines to identify areas where radio signal coverage may be weak or missing, enabling them to correct these coverage gaps before an emergency occurs.

Validating Radio Signal Coverage in Mines

In June 2006, Congress passed the Mine Improvement and New Emergency Response (MINER) Act, mandating that underground coal mines provide emergency response plans that include two-way wireless communications and electronic tracking systems within three years. Since that time, most underground coal mine operators have installed these systems using guidelines set forth in the Mine Safety and Health Administration (MSHA) program policy letters (PPL) that followed.

Depending on the size and complexity of the mine, the process of verifying the actual radio signal coverage of communications and tracking systems can be difficult and time-consuming. The only way to ensure coverage is to perform many manual radio signal "spot checks" while walking to different locations throughout the mine, thus verifying two-way communications with the surface. This is a crude way to ensure the overall dynamic coverage of an emergency communications and tracking system, and this procedure only verifies coverage in those areas that have been checked. To address this problem, the MineComms Mapper™ (MCM) was developed under a National Institute for Occupational Safety and Health (NIOSH) contract in 2009 by Helium Networks. The MCM (Figure 1) provides a faster, more comprehensive approach for verifying communications and tracking system signal coverage in underground mines.

Figure 1. MineComms Mapper (MCM) being towed in a mine.

Background on the MineComms Mapper

In searching for a better method to map radio signal coverage, NIOSH researchers recognized the need to develop a mobile tool to determine the position coordinates at any location in the mine, measure the radio signal strength at that location, and record the data for future processing. The MCM uses an Agilent N9340A spectrum analyzer (see Figure 2) to scan signal frequencies for communications and tracking systems ranging from 100 kHz to 3 GHz. With a mine map overlay (e.g., AutoCAD) loaded into the computer, the MCM can

Figure 2. Inside the MineComms Mapper.

indicate the signal strength for any location through which it travels. The MCM was also designed to fit through mandoors measuring 2 feet by 2 feet for maximum portability underground.

The primary method of location tracking by the MCM uses two rotary wheel-turn encoders designed for accuracy over long distances. To complement this tracking system, the MCM also employs micro-electromechanical systems (MEMS) technology for inertial navigation to determine the cart's location without any fixed external references. The inertial technology is used when the MCM turns sharply and its wheels slip, causing false position measurements.

The MCM has rubber tires so it can be attached to any haulage vehicle and towed for long distances. Therefore, a mine consisting of many miles of tunnel can be covered much faster when compared to the time required for manual "spot checks" of two-way communication with the surface. Further, the automated data accumulation minimizes human error associated with conventional methods of measuring communications or tracking coverage.

NIOSH Evaluation of the MineComms Mapper

The MCM was delivered in 2009 and NIOSH has evaluated it in underground mines for radio signal data gathering and storage. For a mine covering several miles, the survey time was significantly less than that required using manual methods. In one test, the MCM collected 2,643 data points covering a distance of over 3,000 feet in about 19 minutes (about 2.3 samples per second). Also, because the survey data were electronically entered in the database, there was no chance for human error and the MCM's location was automatically calculated.

The software that drives the MCM takes measurements of both position and signal strength and joins them using a timestamp. The information is then stored in a database that can be exported to a spreadsheet for easy analysis. Once the data are exported from the database, they can be displayed in a variety of forms to produce clear

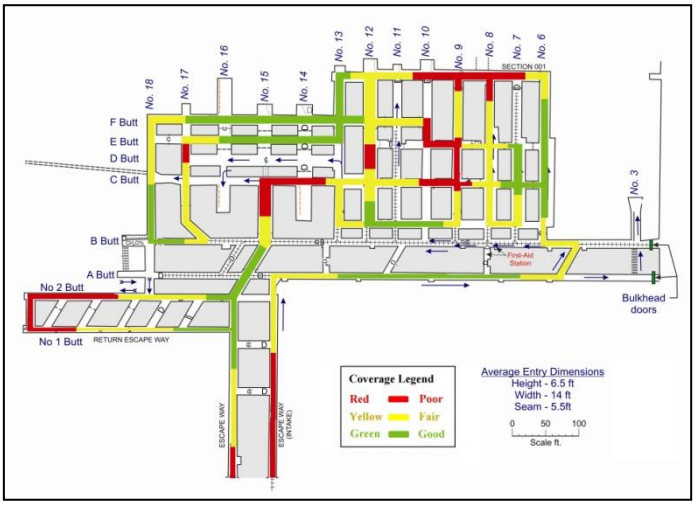

Figure 3. Mine communications coverage map with data generated from the MCM.

representations of system performance. The mine operator can see exactly where the communication system's coverage problems are underground, in real time, and can also retain the raw data for long-term comparisons.

Figure 3 shows an example of a map created from data generated by the MCM, representing the range of radio signal coverage in a particular mine. The MCM offers a variety of preset programs that can be applied to most common communications and tracking systems being installed under the MINER Act, including leaky feeder, 900-MHz node-based, medium-frequency, and Wi-Fi systems. Each MCM is customized by the manufacturer for size, weight, and frequency spectrum.

For More Information

For more information on the MCM and its use, contact Nicholas W. 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.

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