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Technology News

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Reverse Implementation of Radio Frequency Identification (RFID) Technology for Personnel Tracking in Underground Mines

Objective

To develop a method for tracking underground mine workers that provides: (1) potential improvements in accuracy when compared to conventional, zone-based radio frequency identification (RFID) methods, (2) the ability to interface to a variety of mine communications infrastructures, (3) a higher degree of survivability after a mine disaster, and (4) ease of installation and maintenance.

Background

The Mine Improvement and New Emergency Response Act (MINER Act) of 2006 calls for improvements in underground coal mine accident preparedness and response. One of the requirements is that each mine provide a method for aboveground personnel to determine the location of all underground personnel after an accident or mine emergency. Researchers at the National Institute for Occupational Safety and Health (NIOSH) Office of Mine Safety and Health Research initiated a study of personnel tracking systems that could be applied to underground mining. A new methodology was proposed that reverses the way conventional RFID tracking systems are normally implemented. A conventional RFID system uses fixed tag readers (which are typically line powered, mounted in the mine, and connected via wire, fiber, or through a wireless link) to transmit location data to a surface tracking system computer. Battery-powered tags, worn by the miners, transmit an ID that is detected as a miner walks near an RFID tag reader. This allows the system to locate a miner within a certain zone where the zone size is determined by the spacing between readers. A reverse RFID system reverses the conventional implementation of RFID components by locating the RFID tags at fixed, known locations in the mine, and making the tag readers portable and worn by the miners (Figure 1).

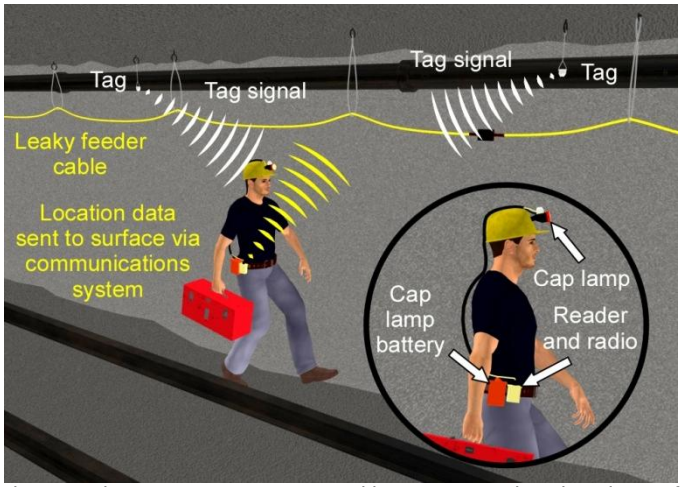

Figure 1. The reverse RFID concept with tags mounted on the mine roof and portable, belt-worn readers.

Approach

In 2007, NIOSH awarded a contract to L3 Communications (Chantilly, Virginia) to develop and test the reverse RFID concept. L3's prototype was implemented with ultra-wideband (UWB) technology. Each tag broadcasts its location identifier five times per second. The system's tag readers (worn by the miners) receive this information and sense the received UWB signal strength associated with the tag transmissions. This measurement of signal strength allows an estimation of distance between the reader and the nearest tags. A UWB transmission scheme was used because its low power requirements allowed long tag battery life, and the pulsed signal offered decreased interference from multipath signal reflections.

The miner's location information is sent via a radio from the miner's tag reader to the existing mine communications system. The information is then processed and displayed on a mine map by the tracking system computer located at the surface. The distance estimation technique and the provision for a high density of tags throughout the mine can provide location tracking

accuracies that surpass those of other conventional tracking systems.

Test Results

Using a NIOSH-approved test plan, L3 Communications conducted tests of the final mine-ready system at an underground coal mine in Pennsylvania. The test area consisted of two entries and extended approximately 2,000 ft. Tags were mounted on the roof with various spacings. Installation time averaged around three minutes for each tag and consisted of hanging the tag in the center of a crosscut and recording the tag ID and location of the tag into the tracking system database. Most of the testing was conducted with tags mounted at every other crosscut, which achieved a balance of accuracy and practicality.

The miner's tag reader was worn on the belt with the UWB antenna tethered to the cap lamp. A radio was packaged inside the same enclosure as the tag reader, which transmitted the location information to the mine's existing leaky feeder communications system. The leaky feeder system then relayed the position estimate to the tracking system computer at the surface. With tags at every other crosscut (approximately 200 ft between tags), the location of a miner was determined to within an average of 42 ft as the miner walked down the entry (Figure 2).

These initial tests also highlighted some challenges related to system updates and component packaging. Tracking information could only be updated if the miner was within range of and had a link to the mine's communications system (in this case, the leaky feeder system). Also, components worn on miners' belts (tag reader and radio) can be cumbersome. To lighten the burden, the additional components can be integrated with existing cap lamp components.

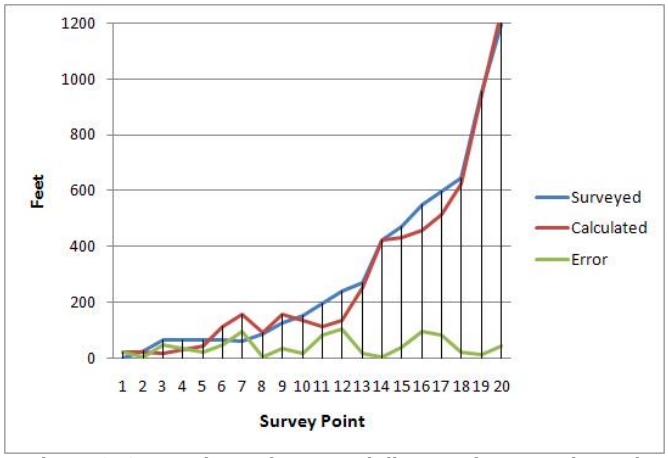

Figure 2. Comparison of surveyed distance from starting point and the tracking system's calculated distance for tags at every other crosscut.

Summary

Possible benefits of the reverse RFID approach include: (1) higher tracking accuracies that can average under 50 ft with tags at every other crosscut, (2) the flexibility to use a mine's existing communications infrastructure, (3) potentially higher system survivability because the tracking tags mounted in the mine are self-contained and wireless (Figure 3), i.e., there are no interconnecting wires to be damaged and, if some tags are lost in a fall of ground or explosion, tracking will resume when other intact tags are encountered, and (4) low-cost tags that can be quickly and easily mounted and recorded at fixed, known locations in the mine, which allows for easy expansion as mining progresses. However, as with many other tracking systems, a disadvantage is that tracking information will not be updated after a mine incident or emergency if the communications infrastructure is not operational.

The technology described in this article is available through L3 Communications (Chantilly, Virginia) and is marketed as the Tru-Tracker Precision Location System [http://www.gses.l-3com.com/mine_safety/tracking.php]. The reverse RFID approach is also being tested by other personnel tracking system manufacturers.

Figure 3. MSHA-approved UWB RFID tag with an estimated 10-year battery life.

For More Information

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