CDC NIOSH Workplace Safety and Health
Technology News
No. 547 Milestones in Mining Safety and Health Technology December 2011

Cost-Effective, Off-the-Shelf Wireless Links for Surface Integrated Mine Emergency Communications

Objective

To provide a reliable and timely method of establishing a secure, wireless surface network that includes voice, video, and control information and links: (1) a command center to remote surface communications sites, and (2) alternate surface connection points to the existing in-mine communications systems. With viable workarounds to address possible line-of-sight obstructions, this type of network would effectively provide integrated mine emergency communications, thereby facilitating successful and timely mine rescue operations.

Background

Immediately following mine emergency events, a critical need exists to provide effective, reliable, and secure communications among emergency management personnel (usually located at a command center, or CC), other surface first responders located at remote sites, and underground miners. Depending on the nature of the incident, normal communications between the surface and underground may be inoperative; however, underground communications may reach the surface at an alternate location, possibly far from the CC. Often, it is necessary to drill an emergency borehole at a remote site to reach trapped miners. A borehole camera may be inserted into the borehole to assess the conditions in the mine. Ideally, the CC would be the hub of a centralized communications system or network that could access and link all the communications devices, data sources, and control functions that might be separated by miles in rugged terrain. The wireless communications systems brought by emergency responders frequently do not work due to obstructions to the communications path. These systems often do not offer easily deployed workarounds to resolve obstruction-related problems. If a communications path can be established using the emergency responder's system, a difficult challenge still exists to link various sources such as video and data to the CC and alternative sites. With the proposed integrated communications technology and trained personnel to overcome potential obstructions, an effective network could be put into successful operation with sufficient security to prevent unwanted intrusion.

Approach

During a mine emergency, a successful integrated communications system could use cost-effective, off-the-shelf wireless surface network equipment that can be quickly assembled onsite to provide the critical communications links for the mine rescue operation. The resulting network can be made secure so that only those directly involved in the rescue operation have access to information obtained from the system. The example in Figure 1 shows the configuration of an effective integrated communications system and illustrates how the recordings of a video camera at a borehole drilling operation can be displayed on a laptop computer located at a CC, possibly five or more miles from the borehole site. To test the effectiveness of such an integrated network, researchers at the National Institute for Occupational Safety and Health (NIOSH) built and tested a test network using off-the-shelf hardware components at NIOSH's Pittsburgh research facility. Motorola Canopy™ 900 MHz devices were used to provide the wireless link using a carrier frequency of 900 MHz, +/- 2 MHz. The Motorola Canopy™ system also integrated the voice, video, and control signals into the network. The Motorola Canopy™ system was chosen because of the ease with which the voice, video, and control information are integrated into the system and transmitted to remote sites over possibly multiple wireless links. The Canopy™ system can also be easily reconfigured by adding appropriate hardware modules and reconfiguring the software via a few programming procedures using a configuration laptop attached by cable to the device.

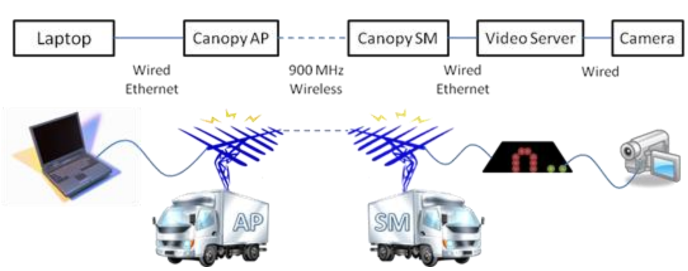

Figure 1. Network configured to transmit video from a remote site subscriber module (SM) to the command center access point (AP).

For this test, a Motorola Canopy™ Access Point Module (AP) with a directional antenna was located at a test site representing the CC. Two Motorola Canopy™ Subscriber Modules (SMs) with directional antennas were used to simulate radio sources that were remote from the CC.

Test results showed that the AP was able to send voice, video, and control signals to each of the individual SMs. The AP was able to receive voice and video from each of the SMs. An Internet access point was extended from the CC to the SM locations. The effectiveness of the system depends on: (1) the terrain between the CC (location of the AP) and the remote locations (location of the SMs), (2) the degree of precision in orienting the directional antennas of the APs and SMs for maximum signal strength, and (3) the bandwidth requirements for the information channels. Figure 2 shows a Motorola Canopy™ Subscriber Module (SM) with a directional high-gain antenna. The antenna is approximately 3 feet in length and is mounted 6 feet above the ground. Not shown is the configuration laptop computer connected via cable to the SM used to initially configure the SM software. Once the SM is configured, the laptop is no longer needed.

Figure 2. A Canopy™ Subscriber Module (SM) / Directional Antenna typically deployed at a remote site from the command center (CC).

The wireless surface network test system was used to communicate over a distance of 1–5 miles over terrain similar to that found at remote mining sites. The range could be increased to up to 40 miles, if necessary, by using a repeater located on high land roughly half the distance between the transmitter and receiver. Although higher frequencies are sometimes used, 900 MHz was chosen because communications at that frequency are less affected by foliage. A Canopy™ device has the capability of transmitting both locally generated information, such as video from a camera, and information from other legacy video sources using Internet Protocol (IP). When a webcam is used as the video capture device, it can be connected directly to the Canopy. Legacy video or voice has to be converted to IP using a conversion device (i.e., a video or voice server). Although there are other possible commercial manufacturers, one legacy video converter device is the Slingbox® by Sling Media, Inc. Laptop computers are used to transmit, receive, interpret, and distribute the transmitted information. Thus, the issue of incompatibility of signal sources such as voice, video, or control signals is handled by the Canopy™ device, the IP converting devices, and the laptops. The system can also extend Internet service to the remote sites (if desired) provided that Internet service is available at the CC. To enable Internet service, two wired or wireless routers are used—one at the CC and another at the remote surface site.

Summary

A surface network system using off-the-shelf components, consisting of two Motorola Canopy™ Subscriber Modules (SMs), one Canopy™ Access Module (AP), associated antennas, and legacy video converter, successfully established strategic communications links in a limited mine-simulated environment. When needed, the system could be expanded with additional hardware to establish a communications path over greater distances to link multiple communications devices and other monitor and control devices and their data to a CC. A person with experience in aiming antennas and configuring wireless local area networks would be capable of setting up a secure system in a timely manner, and also address issues relating to obstructions due to local topography and foliage. The CC would be the hub of a secure centralized communications system that could link all the communications devices, data sources, and control functions. In a situation where the normal communications between the surface and underground are interrupted and an alternative communications path to the surface is established, the technology provides a least-cost solution for connecting the alternative communications path to the CC.

For More Information

For more information on wireless links for integrated mine emergency communications, contact Frank Duda (FDuda@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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