All workers, all safe

Recent mine accidents underground are stark reminders of the need for better communications systems. Added to that, many of today's installations are poorly maintained and some improperly installed

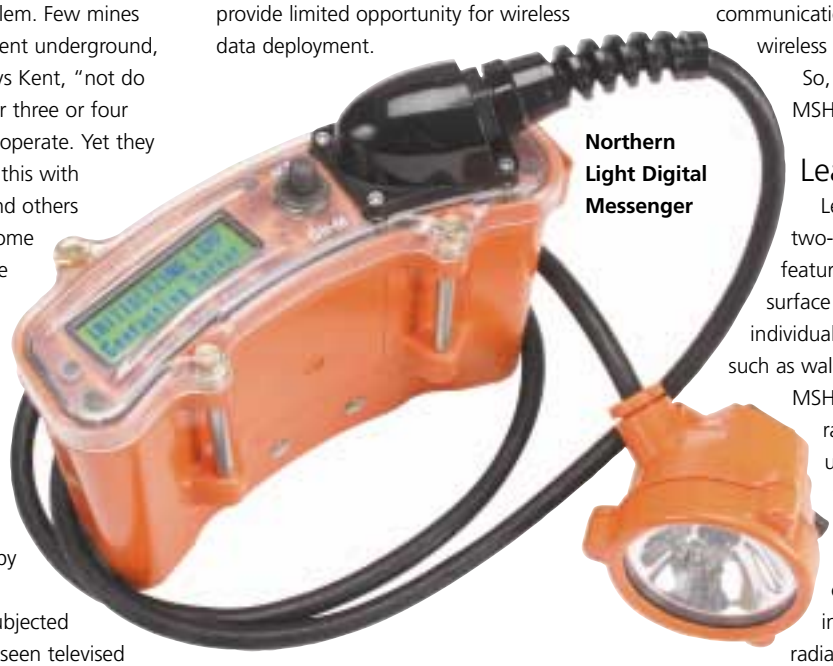
In the USA, the Mine Safety and Health Administration (MSHA) is currently studying proposals of communication and tracking systems from various vendors with the aim of providing reliable communications between the miners inside the mine and the outside, and providing location visibility of all miners working underground. MSHA is concerned that current wire-based systems may fail due to exposure to fires, roof falls or explosions tearing down wires, power failure or battery failure. MSHA's conclusions will provide lessons for the world's underground mines. Nevertheless, whatever MSHA's demands, as Mine Site Technologies' (MST) Denis Kent points out there is no such thing as 'wireless' technology underground – "every communication system requires a lot of cabling (be it power and/or data cables and/or antennas). One aspect of the system may be wireless, but the overall infrastructure is heavily dependant on hard wiring."

Irrespective of the technology provider, no communications system will work well, and it may fail the mine's communication needs, if system maintenance is not taken seriously by mine personnel. Poor maintenance is a surprisingly common problem. Few mines would put mobile equipment underground, for instance, and then, says Kent, "not do any (zero) maintenance for three or four years and still expect it to operate. Yet they seem to think you can do this with communications." MST and others have taken steps to overcome this. Kent again: "We have taken on some of the responsibility for this, and have changed our local distribution network over the last 12 months, and ensured mines take training seriously, etc."

MST has been surprised and somewhat dismayed by the exposure to which its technologies have been subjected in the USA. This has even seen televised US Senate exposure of MST. However, this has seen some naïve promotion of MST's equipment as a 'cure-all' by people who have become evangelical about mine safety but who really do not understand the underground environment. This has also resulted in MST being blamed for shortcomings in communications, in situations or with technologies over which the company has no control.

Zamel says "MST has been thrust into the centre of this debate about mine safety equipment through no action of our own, but simply because we appear to be one of the few companies in the world that has taken the development of a range of underground communication technologies through to operationally and commercially viable products. One thing that is apparent in all the comments we have received, and meetings we have participated in, is that most people's knowledge about underground communications is extremely limited."

James Hackwood VP Sales and Marketing for Northern Light Technologies (NLT) says IT adoption in mining lags all other industries. He also says that current RF-based networks provide limited opportunity for wireless data deployment.



Northern Light Digital Messenger

Modern network approaches using wireless local area network (WLAN) technology (or WiFi) provide an opportunity to benefit from day-to-day 'two-way' voice, messaging, tracking, data and video services. Examples of intrinsically-safe networks of this nature are found in large underground coal mines in Europe and NLT's Northern Light Digital Network will incorporate these approved access points. Further, these technologies are easily configured in triple-redundant layouts to provide maximum up-time and automatic reconfiguration in case of fiber-optic cable breakage. Redundant approaches include multiple cable installation in 'ring' architecture, fibre-optic switch-overs, battery backup and wireless bridging. In the near future, networks of this nature will be integrated with through -the-earth transmission schemes to create another redundant communication path.

"The fact of the matter is that all systems require some level of cabling in the mine", says Hackwood. "Why not benefit from modern networking technologies for day-to-day productivity and safety communications benefits and configure the network with redundancy and to support mine rescue communications using portable wireless bridges, post event?"

So, lets take a look at what MSHA is looking at.

Leaky feeders

Leaky feeder systems are two-way radio systems that feature a base station on the surface that communicates with individual underground radio units, such as walkie-talkie radios. They are MSHA approved. To allow radio frequencies to function underground, it is necessary to replace a standard surface antenna system with a cable network. The cable networks should be installed to effectively radiate the signal throughout

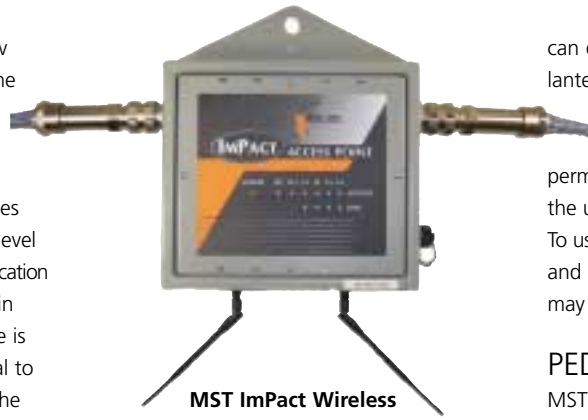
the mine. The cable is designed to allow radio transmissions to both leak from the cable and also enter the cable.

According to MSHA, the main limitation is that the frequency band for two-way voice and data is VHF. "These frequencies cannot penetrate rock due to the high level of attenuation that they suffer. Communication is problematic if the devices aren't within 'line of sight' of each other. An example is the inability of a commercial radio signal to broadcast through tunnels. Therefore, the walkie-talkie user must be fairly near the underground leaky feeder cable network to adequately communicate with the system." No supplier would disagree with MSHA on this.

Zamel says MST's "VDV is one of the most technologically advanced leaky feeder systems available, which provides opportunity for expanded functionality e.g. into applications such as telemetry control. Like any leaky feeder type radio system VDV only operates within line-of-site to the underground leaky coax antenna, thus cannot provide mine wide signal coverage in any practical installation (practical meaning a system that is realistic to install and maintain to a reasonable level of reliability).

"In reality this means communication is only achieved in the roadway where the antenna is installed and part of any adjacent cross cut, perhaps covering 20% of the mine with signal in a typical aerial layout. The signal is two-way, and is certainly better than the 5% signal coverage a typical, fixed location telephone system may offer."

His comments are based on MST's experience on installing over 100 leaky feeder systems around the world.



MST ImPact Wireless Access Point (WAP)

Mine page phones

Paging telephones, MSHA notes, are self-contained battery-powered units that provide loudspeaker paging and handset party line conversation over a two-conductor telephone line. In general, they operate from 12-V DC lantern batteries. When paging, the user's voice can be heard via loudspeaker at all telephones connected to the system.

There is no practical limit to the number of units that can be connected to a paging telephone system. The units can be placed kilometres apart or as close together as a few metres. The system arrangement need not be on a loop basis, but can include branch circuits as required for convenience.

These systems are MSHA approved and can provide two-way voice communication wherever telephone lines are installed.

The units are relatively immune to interference from other electrical systems. Small portable units are available, which connect to the telephone lines with alligator clips.

MSHA says the disadvantages include cables that are "subject to damage, which can disable portions of the system. The lantern batteries can be subject to frequent replacement. Most units are not carried by the user, but are mounted at permanent or temporary fixed sites, requiring the user to be at the device to communicate. To use the small portable units, one must find and connect to the telephone line, which may be difficult in an emergency."

PED system

MST's PED system is a one-way 'Personal Emergency Device' communication system featuring a belt-wearable receiving unit for individual miners. MSHA approval was issued for the Model PED1 Paging Receiver/ Cap Lamp, "meaning that this system may be marketed for use and used in underground gassy atmospheres. The system generally consists of a transmitter capable of communications that can be received as a text message by miners through their PED. The PED system is currently used at about a dozen US underground mines and has also been deployed at mines in other countries, particularly Australia," MSHA noted.

It uses either a surface or underground antenna loop that radiates a radio frequency signal enabling one-way communication to underground. The system dims and flashes the lamp for about 10 seconds then sends a text message to the wearer. Individual, group or broadcast messages can be sent.

According to MSHA, the maximum amount of cover for a surface antenna to be effective is about 760 to 915 m. The battery life is normally eight to12 hours but if the lamp is turned off this time could be extended to days.

MSHA likes PED's enabling of text-message communication from a central control centre

on the surface to miners underground. "It uses a through the earth transmission system. The transmitting antenna can be installed either underground or on the surface. If installed on the surface, the system does not depend on any underground wiring.

"The system is relatively easy to use. It can convey a text message of up to 32 characters.

"The PED receiver is attached to the miner's cap lamp battery. This ensures the receiver is always with the miner.

"The system has the potential of providing messages to miners during the early stages of a mine fire including evaluation instructions.

"It can be retrofitted with existing cap lamp manufacturers lamps, Koehler, NLT and MSA.

"System can be deployed in an emergency by stringing antenna cable on the surface thus enabling one way communication from the surface in some cases. This deployment may take time, however."

MSHA cautions "installations incorporating underground antenna loops may be compromised in the event of a fire or explosion preventing communications.

"The PED System only provides one-way communication from a person sending a message to a person receiving a message. The person sending the message receives no confirmation that the message was received." Zamel responds: "A 'through-the-earth' two-way system allowing a response would be ideal, but currently this technology is still in the experimental stage with no proven, reliable system in the market today. Even with recent tests and discussions of 'possible systems' they will just not be commercially available, nor proven in daily operation at mine sites, in the near future."

To achieve two-way communication, MST is involved in developing a return through-the-earth signalling system to complement PED. The basic principle is to use underground base stations to relay messages from mobile transceivers through-the-earth to surface, either directly or via other underground base stations. R&D efforts to date have allowed successful field trails of a laboratory prototype at a coal mine. These tests proved the concept and the signalling techniques as being robust and practical to use.

Tracker Tagging

MST's Tracker IV system enables the identification of a miner's location underground. Miners wear transmitters, which send out a unique pulsed signal that is received by a receiver 'beacon'. MST was issued MSHA Approval for the Model TAG IV Transmitter, which sends coded signals to the beacons that are strategically spaced at various locations in the mine. The MSHA approval authorizes MST "to market the TAG IV Transmitter for use in underground gassy atmospheres." In Australia, the system has successfully been used for personnel and vehicle monitoring in a number of metal mines, and it has just been installed into one underground coal mine.

If the system is disrupted, it still provides the last location of all personnel and equipment underground up until that point in time. However, MSHA says the system "is subject to damage from fire and explosion which could compromise the ability to track and/or send messages on the data line. Tracking of personnel is limited to identifying their location in the 'zone' between two beacons where any given transmitter is located. Therefore, if the beacons are spaced (as commonly done) at [900 m] intervals, a signal is received when the transmitter passes

beacon A, but then not again until it passes beacon B. If the system is disrupted in an emergency and personnel need to be located, this limitation would create a potential search window of over [800 m]."

Zamel concludes that the search for one product to answer all a mine's communication requirements "is just not realistic. A number of complementary technologies should be installed in any mine to achieve a safe and productive operation. Some mines do this now, but many don't."

MSHA's research continues and can be followed at http://www.msha.gov/Techsupp/PEDLocatingDevices.asp

Hackwood reports that NLT expects approvals for RFID tracking using traditional RFID tags and WiFi tags (tags that use intrinsically-safe WiFi networks) by June this year. WiFi tracking is a modular addition to any WiFi (Wireless Ethernet) network. "Using a standards-based infrastructure that supports voice, video and data services avoids the associated costs of duplicating network cabling and support services – one redundantly configured network handles all the services from many vendors", he adds.

Voices of reason

Coal industry representatives have told MSHA officials that improving emergency communications for underground is best accomplished through a flexible approach that tests technologies in real mine environments to ensure reliability. At a March 13 MSHA hearing in Washington, D.C., industry representatives outlined the dangers of using a 'one-size fits all' solution that fails to take into account the unique characteristics of mines throughout the USA.

Tony Bumbico, Corporate Safety Director for Arch Coal noted that varying geological conditions and issues such as seam height, depth of cover and surface terrain all impact how well communication technologies work.

Bumbico pointed to Arch Coal's experience with PED as evidence of the need to conduct tests in actual mine environments. He testified that the installation of PED systems in two of Arch's underground coal mines in Utah has produced "mixed results." At one mine, the system has been "fairly reliable." However, at a second mine, Bumbico said the PED system caused continuous interference with the mine's pager phone and mine monitoring system, which lead Arch in 2004 to abandon the system.

Though, as Zamel points out, in relation to certain reports of phone noise and lack of signal coverage, "some underground antennas have been installed incorrectly by running adjacent to phone and data lines, against the recommendation of the OEM. Additionally on many installations it is apparent the phone and data lines have not been installed in accordance with their respective OEM recommendations, for example exposing them to interference through incorrect grounding procedures."

Bumbico said technology is needed that allows for two-way communication with underground miners that can precisely track a miner's location and is built with infrastructure capable of surviving a fire or explosion.

David Beerbower, Vice President of Safety for Peabody Energy testified that while the PED system is reliable in most situations, it does not meet the criteria laid down in recently approved legislation in West Virginia and proposed rules in Kentucky. Beerbower emphasized that no technology exists that can meet the requirements contained in the West Virginia law and the proposed Kentucky legislation. Those requirements mandate that miners be equipped with one

device capable of receiving emergency communications from the surface at any mine location and another that provides real-time tracking of every underground miner.

David Chirdon, Chief of MSHA's Electrical Safety Division, said the agency has received more than 80 communication and tracking technology proposals and is currently evaluating which proposals warrant further study.

One of these involves Northern Light Technologies (NLT), another leading innovator of underground communication and safety systems and Embigence, a pioneer in multimedia networked automation. They announced a partnership to deliver a proven communication and safety solution to the coal industry. The solution, already installed in coal mines in Europe, includes Internationally-approved intrinsically safe access points that support applications that are proven to improve safety by enabling early warning, enhance response in emergency situations and support automation.

NLT and Embigence note that over the past ten years huge progress has been made in terms of mobile communication, as evidenced by the reliance on wireless networks, cellular telephones and other mobile communication devices. "However, none of this progress has resulted in communication systems certified by MSHA for use in coal mines. In part 23 of the approved or certified product listings 'Telephone' only two new products have been approved in the last six years: one an audio amplifier and the other, a 'traditional' leaky feeder system. NLT and Embigence anticipate that their partnered offering will change this."

They say the solution, already approved in Europe, "proves that leading edge communication technology can be adapted to underground hazardous environments where it positively impacts safety and efficiency.

MST's Integrated Communications Cap Lamp (ICCL)

NLT and Embigence are making this technology available to the US market. "Intrinsic safety of many of the devices is cost efficiently reached by encapsulation, according to the European ATEX directive or the new international IECEx standards. To benefit from the latest technologies available and ready for use in the underground environment, North America should be open to international practices in terms of protection standards," says Christoph Mueller, the Managing Director of Embigence.

"The acceptance of devices and systems produced to worldwide-accepted standards is crucial to the safety and efficiency of coal operations in North America," added Hackwood.

On behalf of Embigence and NLT, Hackwood presented their communication and safety solution at MSHA's March 13 Public Forum on Underground Mine Rescue Equipment and Technology.

Australian installations

In Australia, AMCI's Carborough Downs in Queensland's Bowen Basin has chosen NLT to supply communications and lighting products for its new underground mine.

NLT's equipment delivers Wi-Fi tracking of personnel and equipment, environmental monitoring and two-way messaging using its Northern Light cap lamp. A critical feature of the NLT products is that they all run on the same network and use the fibre optics already being installed in the mine.

Mine Engineering Manager Peter Binnie: "The NLT cap lamps have been around for years and their track record for quality and support coupled with innovation is very good. Our plan is to take the already purchased Exia-approved lamp and upgrade to the Wi-Fi Tracking and two-way messaging system," Binnie said.

Ease of rollout and a lower up-front commitment were a couple of added reasons for the decision. The network required for these products can be provided in a staged, as-required approach. This keeps capital expenditure down and will enable the mine to grow its commitment as the output ramps up.

Xstrata's new coal mine in Queensland, New North, has ordered MST's new Integrated Communications Cap Lamp (ICCL) with both PED Paging and Tracker Tagging electronics.

To complement the PED system and other communication devices in use at the mine, Newlands North is also incorporating Tracker tags in each ICCL unit. These active tags transmit to read beacons, installed at strategic locations underground, and enable the movement of people and equipment to be monitored throughout the mine in real time.

Another new system, SIAMnet, offers an alternative to fibre optic and leaky feeder technologies for voice and data communications underground says Cattron Group International. "Using Cable Modem technology and coaxial cable, the SIAMnet system is more versatile and provides as much band width as fibre optic networks at a fraction of the cost."

One SIAMnet coaxial cable can support up to 32 simultaneous voice transmissions, three 1.5 Mbps Mobile Data sub-networks, each supporting up to 64 vehicles, and twelve DOCSIS 1.1 Cable Modem channels for a total of 360 Mbps downstream and 120 Mbps upstream. DOCSIS 2.0 and EURODOCSIS 2.0 are also supported when more bandwidth is required. The cable modems can also support IP camera and VOIP transmission.

The digital age

Hackwood describes Northern Light Digital as the next step towards the digital mine. He says it is flexible and modular – easily deployed and expanded. It is cost-effective and easily maintained by first-line service personnel. It is also, he says, a multi-vendor product selection, embracing 'best of class' from a number of sources. Finally, it is "mine-ready and robust."

It offers guaranteed service quality for voice and mission critical data. VLAN segregates traffic, offering greater security. The coherent design principles offer maximum RF coverage.

It offers visibility for rescue co-ordination and portable repeaters can be used to 'heal' the network during an emergency. However, these systems are heavily dependant on underground infrastructure which can be disrupted during an emergency. This reinforces the need for more than one technology base to be used to ensure high levels of redundancy in al communication system.

Similarly MST's ImPact Digital WLAN is a system designed specifically to allow the WLAN 802.11 protocol to be taken underground using proprietary WAP interfaces (Wireless Access Points). These WAPs enable wireless interface/access to all types of IP devices such as VoIP phones, lap tops, PDA's, video cameras, etc. ImPact also provides diagnostic interfaces to major underground equipment.

Zamel explains, "ImPact is dependent on underground data links (optic fibre cable) between the WAPs, and hence is intended for day to day operational use, rather than providing post-disaster communications. Due to the signal coverage around each access point a typical ImPact System can provide very high quality, high bandwidth communications to 30% of the roadways underground .

"Higher levels of signal coverage are theoretically possible with the installation of additional WAPs. But the complexity of the subsequent fibre network and power network to support such an expansion means it is not practical to actually do or try to maintain over time."

Cargill Salt has one of the first ImPacts, installed last year at the Lansing mine in New York State, USA. The initial installation last year had set up a number of WAPs, to provide personal communications around the mine using VoIP phones. A recently announced expansion involves 30 additional WAPs, and the associated composite fibre/power cables, for the network to provide continuous coverage throughout the main underground entries.

With this broad digital network now established, with the VoIP phone system providing an extensive two-way communication system for miners underground, the next phase will be to implement ImPact VIP onto the mine's vehicle fleet. This will start with the LHDs. The ImPact VIP, or Vehicle Intelligence Platform, interfaces to the vehicle's diagnostic and payload systems so the information can be continuously sent in real time to the main database. From there the information is displayed on management software for analysis and reporting, as well as instantaneous alarms on any system issues.

The extensive ImPact network will also be used for a number of other applications:

- Data collection from various conveyor belt drives.
- Video monitoring using IP video cameras.
- PDAs will be introduced to replace paper reporting forms in a number of areas. The PDAs will allow inspection reports, etc to be immediately downloaded to the database rather than passing throng several process for the information to be entered into the database.***IM***