REPORT OF THE
DEPARTMENT OF MINES, MINERALS AND ENERGY

Assessment of the Availability of Effective Underground Wireless Communication and Miner Locator Systems

TO THE GOVERNOR AND
THE GENERAL ASSEMBLY OF VIRGINIA

HOUSE DOCUMENT NO. 82

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December 15, 2006

The Honorable M. Kirkland Cox
Chairman, House Committee on Agriculture, Chesapeake, and Natural Resources
General Assembly Building, Room 321
Richmond, VA 23219

The Honorable Charles R. Hawkins
Chairman, Senate Committee on Agriculture, Conservation, and Natural Resources
General Assembly Building, Room 515
Richmond, VA 23219

Dear Delegate Cox and Senator Hawkins:

The 2006 Virginia General Assembly, through House Bill 1443, instructed the Department of Mines, Minerals and Energy (DMME) to assess the effectiveness and availability of underground wireless communication systems and miner locator systems.

Enclosed for your consideration is the final report resulting from this assessment. Please let me know if you have any questions or require additional information

Sincerely,

George P. Willis

c: The Honorable Patrick O. Gottschalk
Secretary of Commerce and Trade

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Submitted to the House Committee on Agriculture, Chesapeake, and Natural Resources and the Senate Committee on Agriculture, Conservation, and Natural Resources

EXECUTIVE SUMMARY

In early 2006, coal mine disasters in the Appalachian region resulting in multiple fatalities demonstrated a need for improvements in equipment and technology that would improve mine emergency response. HB1443 directed the Virginia Department of Mines, Minerals and Energy (DMME) to provide an assessment of wireless communication systems and miner locator systems to determine their effectiveness and availability.

DMME believes that Virginia mines are doing a lot of things right; however, we can still learn from recent incidents. DMME strives to keep Virginia underground coal mines on the cutting edge of developing communication technology.

DMME respectfully submits this report, evaluating the capabilities and availability of effective underground coal mine wireless communication and miner tracking systems. DMME expects that the recommendations of this report will be beneficial to the Virginia General Assembly in shaping future policies and funding that will protect a precious Virginia resource, the lives of our coal miners.

INTRODUCTION

House Bill 1443, an act to amend and reenact §45.1-161.202 relating to emergency response plans for underground coal mines, was approved and signed into effect by Governor Timothy M. Kaine on March 30, 2006. The Bill directs DMME to evaluate the capabilities and availability of effective underground coal mine wireless communication and miner tracking systems, and to prepare a report of findings and recommendations. The bill contained an emergency clause that put the act in force upon its passage.

> *That the Department of Mines, Minerals and Energy shall assess wireless communication and miner locator systems to determine their effectiveness and availability. Upon conclusion of the assessment, the Department shall prepare a report of the findings and recommendations resulting from the assessment and provide copies of the assessment to the Chairmen of the House Committee on Agriculture, Chesapeake and Natural Resources and the Senate Committee on Agriculture, Conservation and Natural Resources. Following submission of the assessment to the committee chairmen, the Chief of the Division of Mines may require the use of such systems as part of the operator's mine emergency response plan. [§45.1-161.202, Section 2]*

January 2006 had seen several coal mine disasters in the Appalachian region resulting in multiple fatalities; occurrences that today are infrequent. An explosion at the Sago Mines on January 2, 2006, in Tallmansville, West Virginia, killed twelve miners and left one survivor in a coma for weeks. Wire-based communication was disrupted by the explosion, preventing the miners from knowing information related to the extent of the explosion.

The Aracoma Alma Mine fire followed on January 19, 2006, in Logan County, West Virginia, leaving two fatalities. Also, an explosion at the Darby Mine No.1 in Holmes Mill, Kentucky, caused five fatalities on May 20, 2006.

These occurrences caused miners, industry leaders, and government officials to call attention to the need for an increased focus on mine safety. Such disasters have usually preceded changes in mining standards or regulation. Historically, it has been these disasters that have led to safety advancements.

The West Virginia region near the Sago coal mine has witnessed a tragic history of coal mining accidents. Ten miles away from Sago, in Monongah, West Virginia, the nation's worst coal mining accident killed 362 men and boys in 1907. The catastrophe prompted Congress to establish the federal *Bureau of Mines* to study mine safety

In 1968, a tremendous explosion at a nearby mine, Farmington Number Nine, killed 78. As the first TV-age mine tragedy it drew much attention, according to former coal miner, now West Virginia University History Professor, Paul Rakes.

> “This was the first time that a major disaster was seen by the nation as a community. People could actually see, not only the tearful families, but they could see smoke boiling out of the portal of the mine. And they're saying, this is 1968, "We're going to the moon and we can't make coal mining safer?" (Hochberg, 2006)

The Farmington accident led to the enactment of the 1969 Coal Mine Health and Safety Act and the eventual creation of the federal *Mine Safety and Health Administration* (MSHA). For the first time, the federal government had enforcement power over the mines. Mines did become safer. MSHA strengthened standards and increased federal mine inspections.

The last major changes to federal mining law occurred in 1977, several years after the 1972 fire at the Sunshine Mine, a silver mine, which killed 91 miners in Idaho. This Act was again amended June 15, 2006, under the title, “Mine Improvement and New Emergency Response (MINER) Act of 2006” by Congress in response to Sago, with post accident tracking of miners and communication requirements that must be in place by June 15, 2009.

Virginia has been more proactive in updating coal mine safety laws than federal regulations even at times required. As a mining state, Virginia has consistently endeavored to maintain the highest standards of mine safety, utilizing the most current resources and information available.

Overall, the creation and enforcement of regulations have made mining in the United States much safer over the years. Mine deaths in the United States, which neared 3,000 a year in the early 1900s and about 200 per year in 1969, dropped to 22 in the year 2005. In 2005 and to date in 2006, Virginia was without a coal mine fatality.

(*NOTE: On May 4, 2006, an off-site contractor was electrocuted near a mine site. MSHA has charged this as a "mine fatality" after initially ruling it as a non-industry related accident; however, the State investigation did not charge the fatality to the industry.)*

However, the 2006 disasters and the Pennsylvania QueCreek incident of 2002, have exhibited the need to complete the development of wireless miner tracking and communication systems. On July 24, 2002, coal miners at the Quecreek No. 1 Mine in Somerset County, Pennsylvania, accidentally mined into an inaccurately mapped abandoned flooded mine, inundating the room and pillar mine with an estimated 50 million gallons of water. A group of nine miners became trapped 240 feet underground. They used the mine phone system to notify another group of nine miners to evacuate immediately, completing the call before the flooding destroyed electrical and communication systems. In a dramatic rescue, emergency personnel drilled a hole 30 inches in diameter into the mine and lowered an escape capsule down to where the nine men had been trapped by water for 78 hours.

Rescuers made an educated guess about where the miners might be located underground based upon surveys, mapping, GPS instruments, and knowledge of underground mine areas at higher elevations. Once the mine electricity shorted out, rescuers had no furthur contact with the miners until the first drill hole allowed the miners to bang a responsive signal back to rescuers on the surface. Rescuers then sent an escape capsule through a larger hole drilled by a massive bit. However, most Appalachian mines do not have the flat access land available at this Pennsylvania mine. Communication would be key in determining the whereabouts and condition of trapped underground miners in any other situation.

FEDERAL MINER ACT AMENDMENTS OF 2006

Emergency Response Plans (ERPs) required by the federal MINER Act Amendment of 2006 are similar to those required by the Virginia statute that became effective June 15, 2006. The language of the federal bill provides a three-year window to test and evaluate wireless two-way mediums of communication and electronic tracking. If such testing does not lead to a reasonable adoption of technology, an adequate alternative means of compliance that approximates as closely as possible the degree of functional utility and safety protection will be set forth.

The plan also requires a redundant means of communication, with post accident tracking technology that is "consistent with commercially available technology and with the physical constraints, if any, of the mine", allowing above ground personnel to determine the current or immediately pre-accident location of all underground personnel. Any system utilized must be functional, reliable, and calculated to remain serviceable in a post-accident setting.

Virginia already requires two separate communication systems to be incorporated in each mine's emergency response plan; however, these systems do not currently have redundancy that allows the system to remain operable in the event of major catastrophes. HB1443 required each underground mine operator to amend the Emergency Response Plans (ERPs) of underground coal mines to include two separate means of communication, with one system being located outside of the belt entry, most likely in the intake entry, designated as the primary escapeway.

The federal MINER Act Amendment of 2006 will require new wireless technology for compliance. Further exploration of new technologies, available and prototyped, coupled with the research and knowledge of underground coal mines, will provide a clear picture of the strengths and shortcomings of such technology.

SOUTHWEST VIRGINIA TECHNOLOGY TRANSFER

On February 13, 2006, DMME and the Virginia Center for Coal and Energy Research (VCCER) held a special symposium at the Southwest Virginia Higher Education Center in Abingdon, Virginia, to address the capabilities and availability of wireless communication systems for use in underground coal mines. The symposium featured presentations from five companies that produce various wireless communication products for use in underground mines. Many of these products have not yet been certified by MSHA for use in underground coal mines.

Coal mine operators, safety directors, UMWA representatives, and miners were invited to the symposium to discuss the improvement of underground communication. MSHA and National Institute of Occupational Safety and Health (NIOSH) representatives were also on hand to present material and upcoming research opportunities, including Jurgen Brune who proposed that the best solution might be a combination of wired and wireless technologies. NIOSH researcher Bill Schiffbauer, who was also involved in earlier Bureau of Mines' research, stated there wasn't a single solution to all mines and that each system will more than likely be tailored to the mine's unique conditions.

DMME officials began the process of studying available communication technologies. Frank Linkous, Chief of the DMME Division of Mines, urged the crowd, "Don't let the urgent, crowd out the important." The symposium was well attended and furthered the quest for underground mine communication improvements in the Commonwealth of Virginia.

THE UNDERGROUND MINE ENVIRONMENT

The underground mine environment has more problematic barriers to technology deployment than most work environments. Thick overburdens, or sedimentary rock material overlying the coal seams, prevent the transmission of many electronic signals. The electrical properties of the coal and surrounding strata can affect the atmosphere. Every mine presents a unique environment, one in which open air signal propagation can be limited to line-of-sight and an inability to turn corners.

Miners often travel through extensive areas to compete their duties. The trip in and out of the mine can take thirty minutes to one hour due to the long descent into the mine. There are regular advances into new mine areas, which are followed by retreats of equipment and materials once a section of the mine is complete. This equipment and other materials, such as electrical lines, can cause magnetic interference with other technology. Disasters may also impede signals, such as mine fires causing ionized air.

An underground mine consists of two- or three-dimensional pathways with limited space. Wet conditions exist, with great extremes in relative humidity, corrosive water, and dust created by the extraction of coal and rock. Roof or entries may collapse due to many of these conditions.

There exists a limited line-of-sight in a coal mine due to coal pillars that support the roof, undulations, and multiple entries following the coal seam. The underground environment is typically gassy, with methane or other explosive or toxic gases present at some level. Mine ventilation systems use great air velocity and volume to remove dangerous gases and harmful contaminants from the mine environment, another factor that could affect communication.

Because of this environment, technology produced for the coal industry must fit very specific criteria. A simple spark from an electronic device in an explosive atmosphere could propagate an explosion with devastating effects. All communication devices that enter an underground mine in the United States must meet strict standards set by MSHA

MSHA APPROVAL PROCESS

MSHA approves electrical communication devices by providing official notification that the device under consideration has met the requirements of the applicable Part 23, *Telephones and Signal Devices*, of Title 30 of the *Code of Federal Regulations*. Technical experts evaluate and test equipment, instruments, and materials for compliance with federal regulations and approve or certify certain mining products for use in underground coal mines if they exhibit no probable explosion hazard under normal operations.

In U.S. underground coal mines, regulations require that MSHA approve all electrical communications devices as "permissible." Permissibility under Part 23 of Title 30 of the

Code of Federal Regulations requires the device to be explosion proof (XP) or intrinsically safe (IS) in the event of a loss of ventilation, complete with a back-up power supply in the event of a power outage.

Following the successful completion of evaluation and testing of a product, a license is issued authorizing a manufacturer to produce and distribute the product for use in mines. However, this is not an endorsement from the agency. Furthermore, the approval holder is responsible for producing products in accordance with approved drawings and specifications. After receiving equipment or products, the owner is responsible for maintaining them in accordance with MSHA requirements.

MSHA received over 120 requests for approval after the events of early 2006, with many still being reviewed. A complete listing of approved mine communication devices can be located at http://www.msha.gov/TECHSUPP/ACC/lists/23teleph.pdf .

CURRENT TECHNOLOGY IN USE

MSHA has approved for use in underground coal mines a limited range of communication devices, including leaky feeder systems, mine page phones, and hand held portable radios. Other communication devices, such as the PED cap lamp pager and TRACKER IV tag system, are being tested in mines by MSHA but have not fully received approval at this time.

These systems employ communication signaling from three basic options: through-the wire (TTW), through-the-air (TTA), and through-the-earth (TTE).

Through-the-wire (TTW) communication systems in a coal mine can travel over twisted pair, coax, CAT5, trolley, leaky feeders, and fiber optic cables. Each of these cable types have unique properties and limitations. Therefore, cables must be selected to suit the characteristics of the signals being conveyed.

Communication systems used today in underground coal mines generally employ a hard-wired system or a special cable called a "leaky feeder" in which a base station on the surface communicates with individual underground two-way radio units, such as walkie-talkie radios, via the cable. To allow radio frequencies to function underground, it is necessary to replace a standard surface antenna system with a cable network. The cable is designed to "leak" signal, which allows radio transmissions to both leak from the cable and also enter the cable.

Fiber optic cables are also used in some applications. Mine page phones and pager systems can also be used with these technologies. The systems are generally used for both data and voice communications. Capabilities are limited however, and the infrastructure is often disrupted during a disaster.

Mine page phones are self-contained, battery-powered communication units that provide loudspeaker paging and handset party line conversation over a two-conductor telephone line or the leaky feeder system. In general, they operate from 12-volt DC cap lamp 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 miles apart or as close together as a few feet. The system arrangement need not be on a loop basis, but can include branch circuits as required for convenience.

Through-the-air (TTA) signals are often limited to line-of-sight, unless tied in with hard-wired systems, such as the leaky feeder system. However, the electrical properties of coal attenuate certain frequencies more than other. The propagation of some frequencies is enhanced by a waveguide effect due to the sandwiching of radio signals between layers of strata with varying electrical properties. However, not all radio signals will propagate down a coal mine entry due to these same electrical properties of coal and the surrounding strata. Therefore, the viability of wireless radio transmissions using TTA signals in coal mines can only be determined through testing.

Through-the-earth (TTE) and truly wireless radio systems are less common, even though the technology that such systems are based on was discovered by former U.S. Bureau of Mine’s research in the 1970s. Some hand held two-way radios produced by Motorola that do not require a leaky feeder system to operate are used by MSHA, but none are currently commercially available. Walkie-talkies that may be used by miners in confined work areas are usually limited to line-of-sight usage.

The following table demonstrates the communication systems currently available and details their pros and cons.

APPROVED SYSTEM	PROS	CONS
“Leaky Feeder”	• These systems are currently available and are MSHA approved. • Leaky feeder systems have the capability of providing two-way voice communication.	• The main limitation is based on the VHF frequency band for two-way voice, data, and video. 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 of this problem 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. • The cables are subject to damage from everyday operations or accidents, which can disable the system. • Unlikely to withstand an explosion
Mine Page Phones	• These systems are currently available and are MSHA approved. • Paging telephones have the capability of providing two-way voice communication wherever telephone lines are installed. • Mature technology with simple and familiar operation. • The units are relatively immune to interference from other electrical systems. • Small portable units are available, which connect to telephone lines with alligator clips.	• The cables 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 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.
Hand Held Two-Way Radios	• These systems are currently available and are MSHA approved. • Hand-held walkie-talkies have the capability of providing two-way voice communication. • Flexibility can be provided for use (frequency range and number of channels).	• 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. • Limited range; typically about 500ft.

TECHNOLOGIES UNDER EVALUATION

Many “wireless” communication systems are available for use in underground coal mines; however, none are truly wireless. All depend on some sort of antenna or hard-wired network in order to provide either one-way or two-way communication. Transmissions frequencies can vary considerably, even with different models manufactured by the same company. Signal paths vary from coax, to twisted-pair cables, to Ethernet cables. Several different types of signal amplifiers are offered, and each company has proprietary software that must be used with their system.

In short, while the February 2006 technology symposium held in Southwest Virginia and the MSHA information sessions have created a greater understanding of the current state of the technology available, many questions remain to be answered before a coal company could choose which type of system they should install.

System Requirements

What criteria must be met to satisfy the requirements of the federal MINER Act Amendments of 2006? The ideal system would be small in size but rugged in construction, with ease of portability and individual accessibility. It must permissible and capable of complying with MSHA requirements. The system will have to be survivable in an explosion or fire. Precise tracking and two way voice or text capabilities are preferred. Most importantly, the system must be available and not merely conceptual.

Systems & Prototypes Available

While there are many different options available for communication systems in underground mines, generally, these systems can be divided into three basic groups: ***two-way communication systems, one-way paging systems, and personnel and equipment tracking systems.***

- I. Two Way Communication Systems
  - a. Medium Frequency Radios
  - b. Very Low Frequency Electromagnetic Field (Through The Earth)
  - c. Ultra-Wide Band Radio
  - d. Wireless Mesh Networks (Based on WiFi Technology)
- II. One Way Paging Systems
  - a. PED (integrated into cap lamp)
- III. Personnel and Equipment Tracking Systems
  - a. TRACKER Tagging System (Can be paired with PED system)

MSHA TESTING OF AVAILABLE TECHNOLOGIES

MSHA is currently studying several systems including broadband networks (Ethernet), radar technology, one-way paging cap lamps, electromagnetic antennas, and U.S. Army project sub-terrain wireless electronic communication system. Since January 2006, MSHA has received more than 120 system approval applications from various vendors, and they are attempting to expedite the review and approval of sufficient systems. MSHA is evaluating communication systems for capability in precise tracking, two-way communication, survivability in mine disasters, and MSHA safety compliance.

MSHA conducted an underground communication technology test at the McElroy Mine, a CONSOL Energy Inc. mine in Marshall County, West Virginia, from March 28 through April 27, 2006. MSHA evaluated and performed field-testing of six 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 resulted in the following observations. Please note that results are specific to this test area in this mine. Propagation distances may be longer or shorter at other sites depending on differences in entry geometry and mine infrastructure.

I. Two-Way Communication Systems

Two-way communication systems generally utilize a “leaky feeder” antenna network, as previously described. Thus miners with the appropriate device can receive a signal and transmit a signal. Miners carry a walkie-talkie, which operates the same as ones used on the surface. These systems generally operate on high frequency radio channels, which require “line-of-sight” for communication. The antenna system must be installed throughout the mine. Leaky feeder wires cannot be armored or buried.

Signal amplifiers are placed at specific intervals along the path of the antenna network (with spacing as close as 500 feet). The signal amplifiers require a source of electricity, which of course, is vulnerable to a power outage caused by a mine explosion, roof fall, or fire. As this type of system cannot be installed in isolated locations, such as bleeder entries, communication is not mine wide. Again, any mine emergency, which would interrupt normal communication channels, would in all likelihood interrupt this type of two-way communication system.

The following chart outlines the communication systems tested by MSHA and findings.

Two-Way Communication Systems Tested by MSHA

Medium Frequency Radio	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 using correct filtering and signal amplification could mitigate the effects. 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. The track entry length limited this range. The only conductors present in the last 300 feet 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 Radio (UWB)	1. In this test area, range was approximately 1,200 feet with uninterrupted reception and approximately 2,000 feet 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 20 feet or better accuracy and 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 2,000 feet. 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 (TTE)	1. Through-the-earth (TTE) voice communication signals could penetrate overburden of 270 feet 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 feet of overburden. 3. Based upon published literature and theoretical calculations, receiving signals at depths greater than 270 feet 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 558 feet and 631 feet. One-way text communication was received underground from the surface at a depth of 900 feet. At the 558 feet and 631 feet locations, reception speed was 20-30 characters per minute with some lost (~20%) characters. At the 900 feet 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 feet 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 feet 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 feet. 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.

II. Paging Systems

Paging systems are strictly one-way forms of communication that generally utilize a "leaky feeder" antenna network. The transmitter can also use ultra-low frequency electromagnetic fields to send communications from the surface through hundreds of feet of rock and earth. The PED (Personal Emergency Device) system developed by Mine Site Technologies and advocated during the U.S. Senate hearings on the Sago explosion and the Alma mine fire is an example of one paging system. That system was available in 1987, commercially available in 1990, and approved by MSHA the following year.

The system was recently MSHA approved for use on Koehler, MSA, and Northern Lights cap lamps. These paging systems are similar to a surface pager in that the only available communications are one way from the surface to underground wearers. Messages can be sent to an individual, a selected group, or to all wearers. In an emergency, a paging system can be used to send evacuation instructions to miners located underground.

The miner wears a liquid-crystal display unit, which is integrated into the belt-mounted battery packs for their cap lights. Paging systems are designed to utilize the battery power on the existing mine light. When a message is received, the battery power to the miner's cap light is interrupted, causing the cap light to flash and alert the miner that a message has been received. Battery life normally averages 8 to 12 hours, but if the cap lamp is turned off, this time could be extended to days.

While the antenna system is normally installed underground, the Mine Site Technologies system can be deployed on the surface or underground. The CSE Corporation, the United States representative of Mine Site Technologies, claims the PED antenna has a range of 5,000 to 6,000 feet if located underground and 2,500 feet if located on the surface. Placing the antenna underground exposes it to the dangers of a mine explosion or fire and could compromise the system in such an emergency. Surface installations require the coal mine operator to own access rights to specific areas above the mine, and terrain can cause further complications.

However, because communications are only one-way, the sender has no idea whether the underground coal miners receive messages. While the system certainly has potential for warning miners about an emergency situation, in most cases it is the underground miners who initially discover the situations that require evacuation.

According to MSHA, as well as DMME's own investigation into the system in Virginia, there are serious reliability issues with the PED system. Each time a representative of the DMME has contacted the Laurel Mountain Mine, the only Virginia user of the PED system, concerning the PED system, problems with the system have been reported. The PED system is not explosion proof or intrinsically safe, which are MSHA requirements for a communication system with the mine ventilation interrupted. Therefore the system cannot be used after mine explosion or fire. MSHA is currently planning to test the PED system at five underground coal mines.

In spite of these problems, the units have had successes. PED technology first gained attention in the United States after the 1998 mine fire at Cyprus Plateau Mining Corporation's Willow Creek Mine, which is located near Price, Utah. In this incident a fire began in the gob that quickly grew and began filling the mine with noxious fumes. Willow Creek had installed PED six months earlier; hence a mine-wide evacuation message was immediately transmitted to personnel. The result was that all 45 miners underground at the time were able to get out of the mine before it filled with smoke and fumes. Both mine management and MSHA have acknowledged PED as potentially saving a number of lives.

The PED system is not inexpensive. The system would cost over $100,000 to install in a mine the size of Sago.

PED Systems	
PROS	**CONS**
• System enables communication of text messages from a central control center on the surface to miners underground. • 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 and uses a through–the-earth transmission system. • 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. • System has the potential of providing messages to miners during the early stages of a mine fire including evaluation instructions. • Can be retrofitted with existing cap lamp manufacturers lamps, Koehler, NLT, and MSA. • System can be deployed in an emergency by stringing antenna cable	• Installations incorporating underground antenna loops may be compromised in the event of a fire or explosion, preventing communications. • Systems employing underground antenna loops are not intrinsically safe and power must be removed in the event of a fan outage or other incidents such as mine fires and explosions, thus disrupting communication capability. • 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. • Reports of some areas in mines where signal cannot be received (shadow zones). • Can interfere with existing mine systems. • Surface access for antenna in the event of a mine emergency would be a problem for most Appalachian

on the surface thus enabling one-way communication from the surface in some cases. This deployment may take time, however.	underground coal mines.

MSHA Preliminary Evaluation Results

MSHA Technical Support engineers, with the participation and full cooperation of both the mine operators and miners using the system, recently investigated the operation of the PED system at several U. S. underground coal mines. The issues reported in the evaluation regarding signal loss or "shadow" zones will be further investigated by MSHA at a later date to accurately determine the nature of these anomalies.

Evaluation notes from that study include:

- The PED system was installed at four mines surveyed in February 2006 to enable the mine to contact key personnel in the mine. Although mines did consider that this system may be useful in the event of an emergency at the mine, the primary reason they reported that the system was installed was to contact personnel so that they could assist with a malfunction in the mine affecting production.
- Antennas were installed to provide coverage in pre-determined areas. In one U.S. mine surveyed, the antennas provide coverage to virtually the complete mine. In three other mines, coverage was limited to the active working area of the mine.
- All four mines visited reported experiencing "shadow zones" in the areas where the system was intended to provide coverage. "Shadow zones" are areas, within the antenna radius coverage, where a miner wearing the PED receiver may not receive a message sent. MSHA engineers verified this in one particular mine.
- The PED receiver is attached to the miner's cap lamp battery. This ensures the receiver is always with the miner. It increases the size and weight of the cap lamp battery. The increased size simply requires a larger cap lamp pouch and miners seem to get used to the increased weight (one pound).
- The PED System only provides one-way communication from a person sending a message at the PEDCall computer to a person receiving a message via a BeltPED. The person sending the message receives no confirmation that the message was received. If the receiving BeltPED does not receive the message at the time it is sent, the message is lost. For this reason, a typical message is for the person receiving a message to call the person sending the message. This is to ensure that the receiver received the message.
- All four mines visited installed an underground antenna. This approach was taken because mine owners did not have the right of way on the surface and because they felt the antenna in the mine would be easier to maintain.
- Mine personnel reported the PED System to interfere with other mine communication systems such as pager phones, trolley phones, and mine phones. Each mine has developed methods to reduce this interference to a tolerable level.

- The transmission of messages is not instantaneous and it depends on the length of the message. The longer the message, the longer the transmission. A 32-character message may take almost 3 minutes to be received.

III. Radio Frequency Identification (RFID) Tracking Systems

Another system advocated during the Senate Sago hearings is the radio frequency identification tracking systems (RFID). This is a mature technology that is just recently being introduced into underground United States mines. In Australia, the system has successfully been used for personnel and vehicle monitoring in a number of metal mines, and it was recently installed in one underground coal mine. The system was approved for use by MSHA in 2003.

These systems use tags worn by a miner or mounted on a piece of equipment that send out unique radio frequency signals that track the location of the wearer. When a miner wearing a tag passes by beacons installed at strategic locations throughout the mine, the location of the miner is recorded. The beacons are essentially radio receivers, which pick up a unique signal sent by each tag. The beacons have a total range of approximately 300 feet (150 feet each way) and are operated by electric power.

These systems require an infrastructure of hard wire data and power connections. The tracking system is also subject to power outages as a result of a mine explosion or fire; however, the last location of miners would be known.

According to DMME research, the tags cost approximately $200 and the beacons cost approximately $5,000 each. Beacons must be placed at regular intervals along main lines and at other strategic locations in order to effectively denote the location of miners. The number of tags and beacons required will vary considerably with the size of the mine and the number of miners employed.

Many of the tracking systems available offer the option to monitor many other aspects of underground coal mining such as belt conveyors, pumps, and power distribution centers.

The number of installed readers limits the tracking accuracy. The range of the readers is typically limited to approximately 150 feet. Therefore, if the readers are spaced (as commonly done) at 3,000 feet intervals, a signal is received when the transmitter passes within 150 feet of reader A, but then not again until it passes within 150 feet of reader B. If the system is disrupted in an emergency and personnel need to be located, this limitation would create a potential search window of approximately ½ mile, assuming the miners do not change their location in the mine.

Several tracking transmitters have been approved by MSHA. However, the readers are not MSHA approved, and therefore not intrinsically safe, but could be placed in explosion proof boxes.

Mine Site Technologies developed the TRACKER IV system. The Model TAG IV Transmitter has been approved by MSHA. Marco, another company, has received MSHA approval for their transmitter, named the Model PRIM Model PTT-1.

RFID Tracking Systems	
PROS	**CONS**
• If the system is disrupted, it still could provide the last recorded location of all personnel and equipment underground.	• System is subject to damage from fire and explosion, which could compromise the ability to track personnel or vehicles. • The tracking accuracy is limited by the number of installed readers; this limitation would create a potential search window of approximately ½ mile. • Cannot provide precise location of personnel.

<u>Other Systems Under Evaluation by MSHA</u>

There are several systems that are undergoing evaluation and testing. These include:

- **Rajant Breadcrumb System** (representative of 802.11 systems)

  The Rajant Breadcrumb System is a fully wireless LAN network based on Wi-Fi technology (802.11b at 2.4 GHz). It is a self-configuring and self-healing node-based system intended for rapid deployment of a wireless network. The system has both communicating and tracking capabilities and is used by police, military, HAZMAT, and other emergency response agencies.

- **Time Domain Ultra-wide Band Communications and Tracking**
  Time Domain ultra-wide band communications and tracking (representative of UWB systems) utilizes pulsed ultra wide band RF energy spanning 3.1-5.5 GHz instead of narrow band signals. It is a self-figuring, self-healing wireless node-based system. Hand-Helds will act as tags or specific RFID tags can be used. The system provides both communications and precision tracking with about one-foot accuracy capabilities. It is well suited for high multi-path environments and has the ability to penetrate walls or concrete stoppings. It operates below the noise floor, thereby reducing interference issues.

- **Kutta Consulting Subterranean Wireless Electronic Communications System**
  The Kutta Consulting Subterranean Wireless Electronic Communications System (SWECS) is under development for the U.S. Army. It is a self-configuring, self-healing wireless node-based system, is fully portable, and can be used without a network for through-the-earth communication. It has tested so far to over 800 feet through the earth. Relative location of a specific SWEC radio to a node can be determined and radio location of an SWEC underground from the surface is possible. Node-to-node communication can be low frequency, allowing a network link to be established through geological barriers or roof falls. It can be used with existing mine communications infrastructure such as leaky feeder systems.

- **Vital Alert Canary 2 Mine Messenger**
  The Vital Alert Canary 2 is a real time two-way digital voice and data communications system that works through-the-earth. It uses a wire wound ferrite rod with a semi-conductor amplifier as an antenna and hand-held radios or phones to talk to the surface through underground base units. Preliminary tests suggest the signal can penetrate depths to around 100 feet and one surface unit can communicate with several underground base units.

- **Transtek Partnership**
  The Transtek Telemag Prototype Communication System is a real time, two-way digital voice communications system through-the-earth. It uses a loop antenna and signal processing on the surface and underground to communicate. Calculations suggest the signal can penetrate depths up to 1,000 feet. It can be used with a hand-held radio option within about a 600-foot radius of the Telemag underground unit and needs an identical unit on the surface to transmit and receive underground.

- **Geosteering Mining services, LLC MinerTrack System**
  The GeoSteering Mining Services MinerTracker System utilizes the MinerTracker unit consisting of a modified electromagnetic field generator designed for the TramGuard™ Proximity Protection System with a battery backup. MinerTracker units transmit the I.D. of any Personal Alarm Devices (PAD) within signal range to the surface via a cable. During an emergency each MinerTracker unit operates as a signal beacon that transmits a location pulse through-the-earth every five seconds. During an emergency the MinerTracker unit will transmit the I.D. of any PEDs passing within its range during the previous five minutes. Miners can enter different command modes for the MinerTracker unit via the PAD. The MinerTracker unit can receive voice signals through-the-earth and miners can respond to voice signals with single digital data pulses using the PAD (i.e., yes, no).

These systems provide a cross selection of various technologies. Because there is no supporting data to give adequate pros and cons of each system, DMME has no information to convey regarding these systems. However, highlights of each system are available in a report presented by Dave Chirdon of MSHA entitled, *Emergency Communication and Tracking Systems: MSHA Technology Evaluation,* which is located on the Internet at http://www.nrcce.wvu.edu/energyforum/docs/Chirdon.pdf .

Frequency Selection

Frequency selection has a great impact on signal propagation. Some frequencies utilize the coal mine entry as a waveguide, enhancing signal propagation, while other frequencies will not travel more than 50 feet. However, not all radio signals will propagate down a coal mine entry due to the electrical properties of the coal and the surrounding strata. Unaided radio signals in a certain frequency range may propagate line-of-sight up to about 1,000 feet but typically will not turn corners for more than a single crosscut. Parasitic propagation in the proximity of wires, conductors, pipes, and rails can enhance the propagation of signals at certain frequencies, specifically medium frequencies.

With regard to frequency selection, 600-3000 Hertz has been found best for through-the-earth voice frequency band. Signal frequency of 300 to 600 kilohertz is excellent for parasitic propagation in medium frequency band. A signal of 27 MHz has very poor propagation in high frequency band. Signal frequencies of 150, 500, and 900 MHz to 2.5 GHz are better for line-of-sight and can turn one or two crosscuts.

Maintenance

Maintenance with each of the communication systems discussed above is unknown. As discussed earlier, underground coal mines constitute a harsh environment for delicate electronic devices. Technical skills are in short supply now in Virginia, as well as the nation. It must be considered how mines will be able to install and maintain these high technology communication systems. The cost of such maintenance is another area that has not been fully addressed.

Other Options

Though not generally thought of as a communication system, a seismic location system can locate a miner with an accuracy of 100 feet and can tell a miner his signal has been located. As a miner moves, the path of these signals can track movement during an escape. Research performed in the 1970's by the USBM produced a system and a method that could provide locations of miners to a depth of 2,000 feet. Many advances have been made in seismic equipment with current systems operating off a laptop computer. Miners generate seismic signals by pounding on mine surfaces such as the roof, floor, and ribs, but preferably roof bolts. The system can monitor approximately 1 square mile over most mines.

NIOSH AND U.S. BUREAU OF MINES TESTING

Low frequency electromagnetic fields have been promising since the 1970s and have been tested to go through 2,000 feet of rock. However, surface access may be a significant limitation.

In the mid 70s to the early 80s, the U.S. Bureau of Mines conducted extensive electronic communications research over a broad spectrum of frequencies and system types. Frequencies investigated ranged from extremely low frequencies (ELF) to a few GHz. Most significant was their TTE research at frequencies between 600 Hz to 3000 Hz.

The research resulted in the development of several communications devices. The above-the-mine part of the system consisted of a transmitter and long wire loop antenna, and a hand-held locator receiver with a 15-inch loop antenna. The miner-carried part of the system was a compact belt-worn device with a voice receiver and a wire-loop antenna that would be unfolded during an emergency to provide a beacon signal to the surface. The concept was validated through the resulting tests at 94 coal mines at depths up to 1,000 feet. A statistical analysis of the data concluded that, at 750 feet depth, there was a 68% probability of signal detection. Despite promising tests the device failed to gain commercial success.

NIOSH researched these early tests again in 1992. NIOSH indicated the technology could be improved, especially since the Australian company Mine Site Technologies had been using similar technology for its PED paging system since 1987. In 1990, the system had been demonstrated at the NIOSH Lake Lynn Laboratory successfully. However, the research efforts of 1992 did not result in new marketable products but did produce a 1997 NIOSH report.

Current NIOSH Action

The U.S. Bureau of Mines (USBM) carried out considerable research on underground communications in the late 1980s until Congress disbanded the agency in 1996. Until 2006, no agency had assumed full responsibility for furthering those research initiatives.

NIOSH has formed a ***Mine Emergency Communication Systems Partnership*** with the United Mine Workers of America, United Steel Workers of America, Mine Safety and Health Administration, state government mining agencies in Pennsylvania and West Virginia, coal operators, the Bituminous Coal Operators' Association, the Industrial Minerals Association of North America, and the National Stone, Sand, and Gravel Association.

The partnership is developing a series of testing protocols for underground mine communication systems. The participants are currently testing a variety of mostly new communication technology of the types previously discussed. Some of the results are very promising. Details about these tests and other useful information can be found at http://www.msha.gov/techsupp/pedlocatingdevices.asp .

SYSTEM TESTING IN VIRGINIA COAL MINES

Laurel Mountain Mines

Laurel Mountain Mines, operated by Dickenson-Russell Coal Company LLC in Russell County, an operating subsidiary of Alpha Natural Resources, began using the PED system underground after installation in 2000. Barry Compton, Superintendent, purchased 25 PED units that fit on the mine light, a transmitter, antenna wire, and accessories for approximately $30,000 at that time. The PEDs are distributed by CSE Products in Pennsylvania.

The transmitter is located approximately 1.5 to 2 miles underground and operates off mine electrical power, placing the system in non-operational status if the power is disrupted. The antenna is looped up a neutral intake entry back through an adjacent entry. The antenna cannot be used in a return entry. One button pushed can alert the miners wearing units to evacuate the mine; however, it has been found that the miners must be located behind the loop. If a miner is in a metal man trip jeep or ahead of the antenna, the signal encounters interference. The signal has been tested to project 3 to 4 miles in the right conditions.

CONSOL Energy Mine

CONSOL's Buchanan No. 1 mine complex is a large, longwall shaft mine that extracts Pocohontas #3 coal reserves, approximately 1,300-1,800 feet in vertical depth from local terrain. Mike Horne, CONSOL representative, reported results of PED testing at the Buchanan No. 1 mine.

The test had no success with a surface antenna. The mine was too deep for the signals to penetrate the overburden. Once the antenna system was moved to an interior location, the signal was receivable with some lapses in signal propagation. However, the signal also interfered with the mine's automated monitoring system (AMS), the phone system, and the electronic drives of some equipment.

According to a CONSOL representative, Buchanan No. 1 is no longer using the PED system because the antenna could not be installed at the surface where it would be most beneficial in a mine emergency.

VIRGINIA COMMUNICATION COMPANIES

There are several Virginia communication companies who have participated in the ongoing dialogue about underground mine communication and tracking systems.

Pyott-Boone Electronics (Tazewell, VA) www.pyottboone.com
Pyott-Boone Electronics was established in 1972 to supply the coal mining industry with the most technologically advanced communication and monitoring systems available. Pyott-Boone is a U.S. representative for MineCom Australia, a manufacturer of leaky feeder systems for nearly 20 years. Also offered are VHF and UHF frequency systems

with options such as personnel and vehicle tracking, train automation, skip and hoist controls, telephone and page interfaces, data monitoring, and more. Pyott-Boone's customer base includes Northrop Grumman and Lockheed Martin.

Innovative Wireless Technologies (Lynchburg, VA) www.iwtwireless.com
The main office and headquarters for Innovative Wireless Technologies (IWT) is located in Forest, Virginia, just outside Lynchburg. Formed in 1997, IWT has expanded to include additional offices in Northern Virginia just outside the Washington D.C. area and in Reading, Pennsylvania IWT offers broad expertise in radio frequency (RF) design, hardware design, systems design, and software design for wireless products. The client list of IWT includes Tyco Electronics, RF Micro Devices, Agilent Technologies, and a host of other Fortune 500 companies.

SYColeman (Arlington, VA) www.sycoleman.com
SYColeman is a defense intelligence and security firm that develops wireless mesh systems, communication, and 3D surveillance technologies. SYColeman is a wholly owned subsidiary of L-3 Communications (NYSE: LLL). In 2002, SYColeman was formed through the integration of two separate businesses: SYTechnology, Inc., and Coleman Research Corporation. SYColeman's customer base includes the Department of Energy, the Department of Defense, the Corp of Engineers, multiple military divisions and private entities.

It is theorized that development options for underground communication and tracking have been held back primarily by the size of the market. Traditionally, the federal government has supported the development of critical technologies in areas where there is a public need and the free market cannot respond. With the reductions in funding and eventual termination of the U.S. Bureau of Mines, many efforts to advance mine technology ended in the United States when left to the free market.

Due to the recent events and the responding legislation, the market for underground communication has become enlivened. While many companies are interested in solving the communication problems faced by the underground mining industry today, without adequate funding or initiatives, that interest might be short lived. The goal of the ***Mine Emergency Communication Systems Partnership*** formed by NIOSH is to establish general performance expectations for mine emergency communications systems, establish uniform and fair criteria for testing and evaluating systems, and to conduct in-mine tests on systems. At this time they have not outlined goals to spur development of new technologies.

The Commonwealth should work with MSHA to define a federal and state partnership that will strive for continuous development of mining technologies. The Small Business Innovative Research (SBIR) model should be used to seek partners for these needs. This process has well defined phases, provisions for cost sharing, and commercialization goals that could enhance and accelerate development of technologies.

DMME ACTIONS

DMME has taken many actions since the enactment of HB 1443. Because of new requirements, DMME required that Emergency Response Plans (ERPs) be updated for each coal mine, and that these be submitted to DMME for review and approval by May 15, 2006. All plans were received by the deadline and have been reviewed and approved by DMME. Comprehensive audits have been conducted on all underground mining operations to measure and evaluate compliance with Emergency Response Plan provisions and the new standards required by HB 1443.

DMME and the Virginia Center for Coal and Energy Research at Virginia Tech jointly sponsored a symposium on February 13, 2006, entitled, “The Capabilities and Availability of Wireless Communication and Underground Mine Tracking Systems.” Over 100 representatives of the mining industry and mine regulatory agencies attended where vendors, both national and international, gave presentations on technologies available or in development for the mining industry.

A DMME representative attended a public meeting held on mine rescue equipment and technology held by MSHA on March 13, 2006, in Washington DC. Speakers here also provided current information on communication and tracking systems available or under development.

DMME’s Division of Mines Safety Engineer is in regular contact with MSHA and operators testing wireless systems. DMME intends to monitor their testing progress and identify systems that might be best suited for further testing in Virginia mines.

Findings

No “true wireless” system with two-way communication is available at this time. Most currently available systems used in mining employ the “leaky feeder” system or a “distributed antenna” system with a network of amplifiers, all located underground. However, underground distributed antenna systems are subject to the same disruption by an underground mine fire or explosion as the existing wire-based communication systems.

Due to mining conditions and the mining environment, criteria for any wireless communication and tracking system will be stringent. The system must be capable of precise tracking, and two-way voice is preferred. The system must have survivability in a fire or explosion. The system must be capable of complying with MSHA requirements for approval and usage. Communication and tracking systems must also be designed to avoid interference with other mine monitoring and control systems.

The focus of improving communication and tracking is on a wireless system. However, research and development of a truly robust wireless communication and tracking system could be years ahead in completion.

Research and experience has shown that communication systems may not work equally well in every mine. Each mine requires a customized solution that caters to the individual requirements of the mine environment. Since communication systems may not cover the entire underground working area of the mine, the area of coverage is an important planning aspect in mine design.

Even with current technology, the physical limits of signal propagation remain unchanged. Computerized digital technology can create smaller and smarter systems and improve features. However, technology cannot change the underground mining environment, and these physical limits must be addressed in creative and mine-specific ways.

AGENCY RECOMMENDATIONS

We must question, what do we really want? Secondary "wireless" communication? The ability to track the location of miners? The ability to page miners? The ability for miners to communicate with the surface? DMME believes that what would be best is a means for miners to communicate with the surface without interruption in a mine emergency.

The communication system should be built to survive exposure to water, fire, or explosion. However, redundancy will be needed, with learning and self-healing capabilities, due to the ever-changing environment of the mine. The system must function properly without disruptions of service in extreme temperatures that are the result of mine fires, mine roof collapses, explosions, and power failures.

In the process of federal review of wireless technologies, Virginia will continue to closely monitor the MSHA review and certification of wireless systems and become involved, whenever possible, in the decisionmaking regarding the types of technology that will be required. We will continue to communicate with vendors, and if a system becomes available, will move to quickly evaluate and make recommendations.

In completing the charge given by the Virginia General Assembly to evaluate the availability, functional, and operational capabilities of communication and tracking devices, the Department of Mines, Minerals, and Energy has concluded that no single product exists to meet the requirements of HB 1443.

However, protecting miners can be achieved in underground coal mines by employing systems that function in the unique atmosphere of each mine. The best approach would combine several available technologies to create a communication system that utilized the strengths of the systems and minimized the weaknesses. Reliability improvements are possible with these systems. Through utilizing multiple products and procedures, a system could be placed in each mine that would protect miners in an emergency until new systems and technologies are available and effective.

A lack of information during a mine emergency severely inhibits decisionmaking both for those underground trying to escape and those on the surface trying to respond. Therefore, mine-specific integrated communication or tracking systems should be evaluated by each mining facility and become part of mine communication planning.

DMME is currently working to audit the mine communications of all underground mines and expects to have all audits complete by January of 2007.

CONCLUSION

There exists a prospect to protect our miners and also facilitate Virginia small business innovation. However, such progress will require vigilance, investment of time and monies, and the exploration of available technology. As discussed, there are several Virginia-owned or based companies that have technologies that may be well suited for the future needs of the mining industry. Support and funding of these research and development ventures will not only provide a much needed resource for the mining industry, but may generate economic development through the creation of jobs in the communication industry.

DMME believes that the coal industry, labor, and the regulatory agencies in Virginia have formed a unique relationship whereby each of the parties operates with a sense of trust and respect for each other. This relationship has allowed Virginia to set new standards in limiting coal mine fatalities and reducing serious personal injury rates.

Several major incidents in Virginia within this decade could have led to fatalities or serious injuries, such as the VP 8 Mine fire, the Buchanan No. 1 Mine fire, the Band Mill Mine ignition, and an American Energy No 1 Mine accidental hole-through into abandoned mine workings. However, quick and prudent actions allowed our miners to escape unharmed. Prudent communication planning may aid in continuing this excellent record of mine safety.

DMME believes that Virginia mines are doing a lot of things right; however, we can still learn from recent incidents. DMME believes that Virginia's coal industry will be willing to implement proposed changes that may spare our miners any similar fate. DMME will strive to keep Virginia underground coal mines on the cutting edge of developing communication technology.

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