Use of New Technology for Improving Miner Health and Safety in Underground, Hard Rock Mining

Testimony to the
Subcommittee on Energy and Mineral Resources
Committee on Natural Resources

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May 25, 2016

Introduction

In this testimony, I would like to describe how new technology, often adapted from other industries, is being used in the underground hard rock mining industry to improve the health and safety of our workforce. I will also describe some new developments that I believe will result in fundamental changes to how underground mines will operate in the future.

What Are Some of the Challenges?

In all probability most of the near surface, high grade ore deposits in the U.S. have already been discovered and mined. So, there is a trend toward mining lower grade and deeper orebodies that can sometimes present additional technical challenges, both from an economics and safety and health standpoint. For example, some of these technical issues include:

- ***Ventilation and cooling of a large network of excavations*** – A typical mine consists of many miles of tunnels and excavations through which fresh air must be delivered. As the depth of the mine increases, the fan pressures required to push this air through the network of tunnels increases. Additionally, rock temperature increases with depth and, as a result, large refrigeration plants are often needed to keep air temperature within working limits.
- ***Control of air quality*** – The air quality must be controlled, meaning monitoring and control of gasses such as CO, SO_2, and NO_2 as well as diesel particulate matter and dust.
- ***Maintaining stable excavations*** - In situ ground stresses increase with depth and can result in localized instability and seismicity. Ground support is required to maintain safe working conditions and monitoring methods are often used to supplement knowledge of the ground conditions.
- ***Worker safety around large equipment in confined spaces*** - Large equipment operating in confined spaces along with mine personnel and mobile equipment require strict control of traffic and safe equipment operation.
- ***Communication and tracking of personnel and equipment*** **-** With many miles of excavation and potentially hundreds of personnel performing many different tasks, ease of communication for transmitting instructions, alarms and information exchange is essential.

New Technology

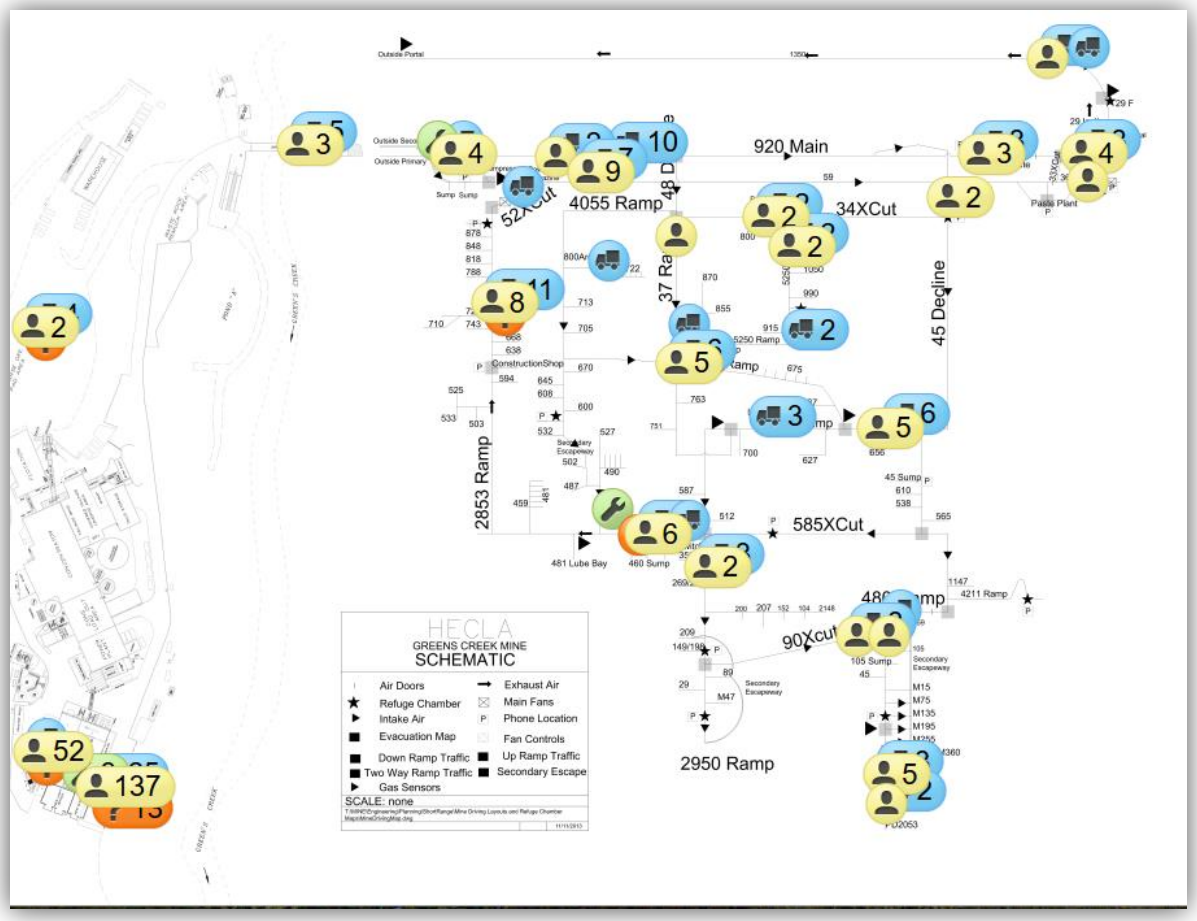
How is new technology assisting us in mitigating these challenges? Here, I review some examples of exciting recent technological innovations, often borrowed from the manufacturing, electronics and communications industries that are re-shaping the way that underground mines operate. In my approximately 40 years in the industry, I have not seen the "explosion" of the technological change that is occurring now. In these remarks, I center on three particular areas that are having a profound impact today: 1) high speed, wireless data transfer and its impact on communication, monitoring and data collection, 2) tele-remote and autonomous equipment operation, and, 3) battery technology.[1]

Advent of High Speed, Wireless Data Collection

The advent of high-speed data transfer and wireless technology that is impacting every industry (and our own daily lives) is being utilized extensively to improve communication, monitoring and data collection in underground mines. Most mines have run fiber optic cable throughout the shafts, ramps and accesses underground and created Wifi "hotspots" at many locations. Hecla's Green's Creek mine in Alaska is a good example – we currently have fiber run through most of the working areas and have about 70 hotspots for wireless data collection. This high speed wireless system has allowed us to gather information which is transmitted to the ground surface and stored and displayed graphically to provide hard data for decision making - essentially in real-time and with rapid communication possible to the work force. What are we doing with the improved communication and information collected that impacts health and safety? Here are a few examples.

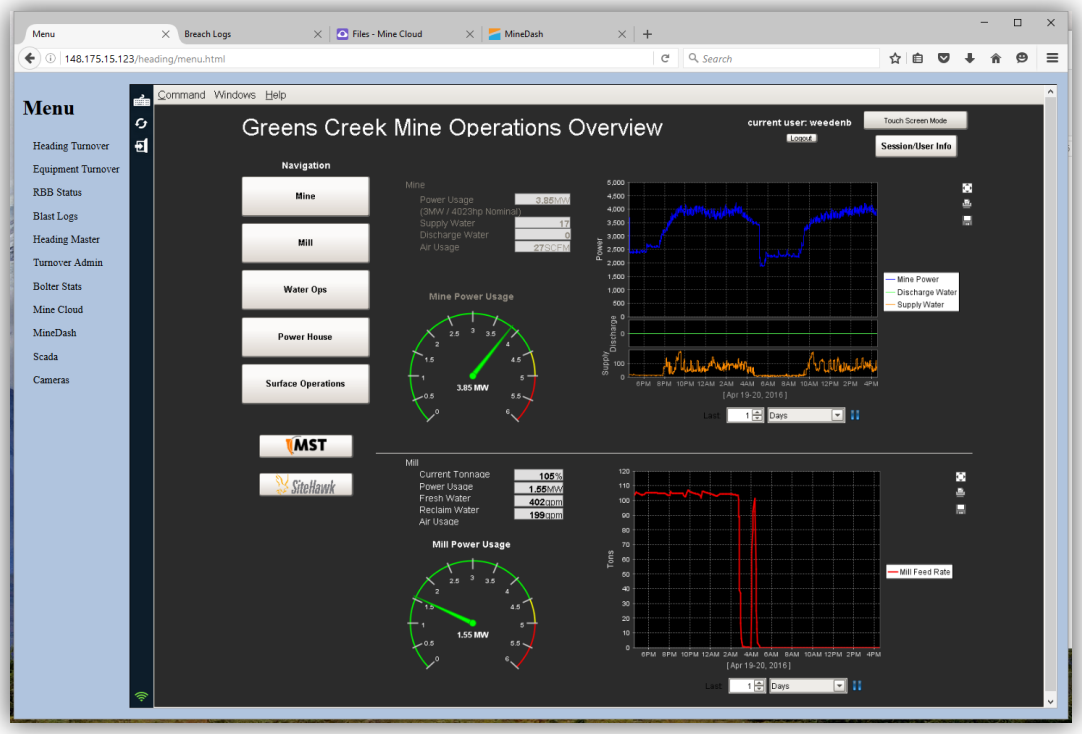
- ***Tracking of workers and equipment*** – all mobile equipment and miner's cap lamps are/can be equipped with personalized RFID tags so we now can see, in real-time, where people and equipment are within the mine. Below is screen "grab" of real-time tracking of mine personnel and equipment superimposed on a schematic of the mine workings at our Green's Creek Mine. This figure also shows where all of the mine fans, gas sensors and refuge chambers are located.

[1] Although the purpose of my testimony is to discuss how technological innovation is being used to improve health and safety in the mining industry, there is, of course, our baseline safety program carried out by our company safety professionals, workers and management. Hecla was an early implementer of the **CORE**Safety program, developed by the National Mining Association, as the baseline safety program at our operations. Although I do not plan to discuss this program in my oral remarks, some additional discussion in this area is provided the end of this written document.



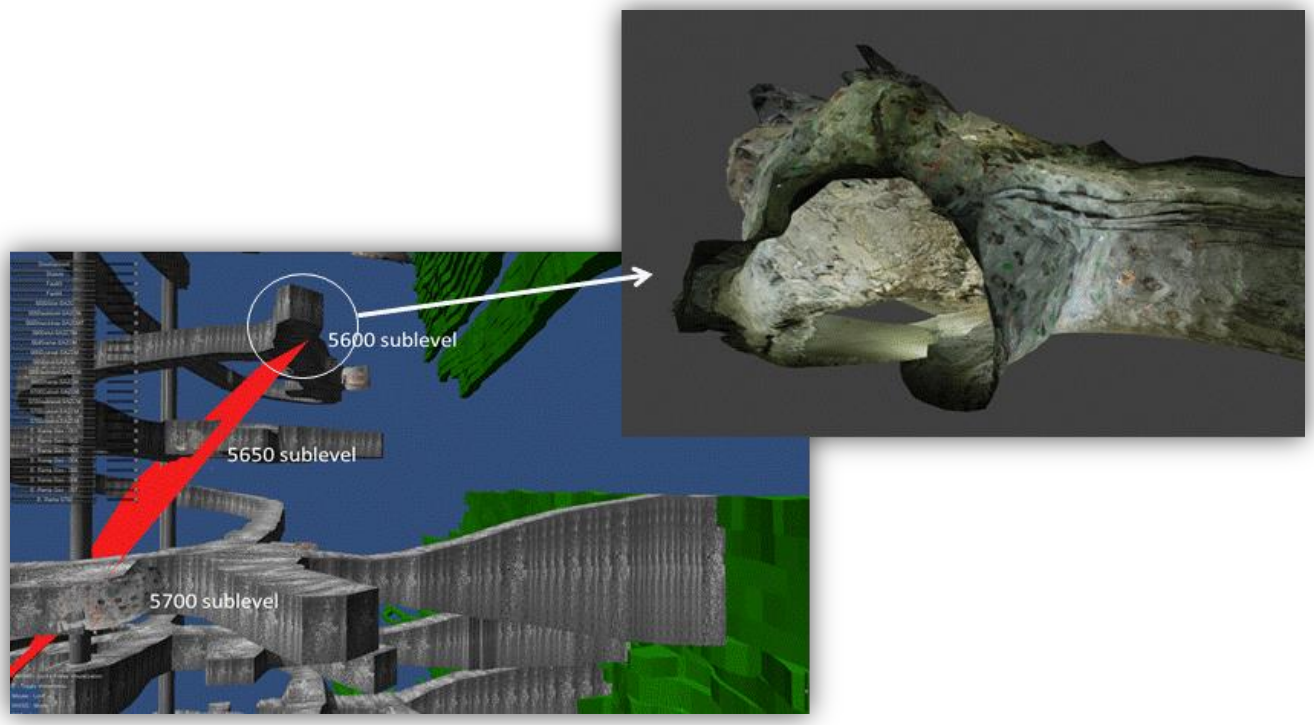
Screen "grab" of underground tunnel system at Green's Creek Mine showing real-time location of workers and equipment with location of fans and refuge chambers.

- ***Communication and data transfer via tablets, VOIP phones and cap lamps*** – we can now have immediate digital communication between workers, managers and engineers, including things like daily pre-shift workplace inspection records, warning messages and emergency and work instructions. Additionally, information such as mine maps, drawings, equipment manuals, etc., can be instantly transferred from the mine cloud storage to tablets. It is possible to communicate anywhere on the planet from deep underground.
- ***Collision avoidance*** – vehicles and workers can now detect one another at a distance, warn of proximity and automatically stop equipment if necessary.
- ***Monitoring the environment*** – Instrumentation can continuously monitor, record and alarm for hazards such as mine gasses (e.g., CO, NO_2, O_2, SO_2 and, diesel particulates), air temperature and humidity, air flow rates, water levels, locks on explosives storage, etc. The figures below are screen "grabs" from our real-time monitoring system at Green's Creek showing, in this case, power consumption (top figure) and status of the mine ventilation system and air control doors (bottom figure).



Screen "grabs" from the mine monitoring system showing things like power consumption (top) and ventilation performance (below). Many other standard parameters such as mine gasses, water levels, etc., can be displayed in real-time at any location worldwide.

- ***Monitoring Equipment Diagnostics and Performance*** – We can monitor the performance of equipment configured with the required electronics to ensuring proper equipment performance and operation as well as alarm for in case of emergency. Real-time graphical display on ground surface is available.
- ***Video observation of hazardous areas*** – Cameras are commonplace for monitoring areas of potential hazard, including the shaft, ore dumps, rock breakers, conveyors, explosives magazines, etc.
- ***Electronic blasting*** – Computer controlled blasting from ground surface or areas remote from the mine increases safety by fully removing miners from the mine during blasting.
- ***Geotechnical Monitoring*** – One of the leading causes of injury in underground mines are ground falls. New techniques in ground support, include spray-on epoxy linings and deformable rock bolts are being introduced to supplement long-time, standard support methods. Monitoring techniques (see Figure below) including 3D photogrammetry, laser scanning of excavations and digitizing, real-time seismic monitoring systems are used to detect regions of instability as they develop.



New and evolving techniques in ground control monitoring, including 3D photogrammetry (top), laser scanning and digitizing seismic monitoring (bottom left) help to detect regions of potentially-unstable ground. NIOSH, Spokane Mining Research Center is an active partner with western US mining companies in pioneering new ground control and ground support research. Large-scale compression testing of new ground support methods at NIOSH is shown (bottom right).

Remote Control and Automation of the Mining Process

High-speed fiber and wireless communication now allow both tele-remote and autonomous equipment operation. Developers of remote equipment include manufacturers like Caterpillar, Atlas Copco and Sandvik. This technology allows equipment operators to be moved from the mining face to secured locations either underground or on the ground surface (in fact, anywhere on the planet), thus removing them from potentially-hazardous conditions. Autonomous truck operation has been commonplace for some time in the open pit mining industry, but is now becoming commonplace in underground mines worldwide. Some of the leading examples of autonomous and tele-remote control can be found today in mines in Sweden, Australia and Chile. Some examples of this technology include:

- ***Fully autonomous trucking (open pit and underground)*** - Vehicle tracking and software traffic control is used for loading and haulage of ore. Laser "gates" are used to shut down trucks or other vehicles automatically if someone enters the traffic zone. The Williams Mine in Canada has used autonomous trucking since 2007.
- ***Tele-remote front-end loaders and drills that can be operated in a semi-autonomous fashion*** - Laser guidance is used for loaders that allow them to travel through the tunnel network without drivers and without collision. Typically, a miner will load ore into the loader bucket using joystick control and cameras from the ground surface, then place the unit in automated mode for hauling and dumping. As an example, the Northparkes Mine in Australia uses tele-remote loaders for its production. Intelligent drills can use on-board computers to drill the tunnel blast holes to patterns designed by engineering. All of this activity is monitored from remote locations, minimizing worker exposure to possible hazards.
- ***Remote control*** – Remote control of equipment such as fans and pumps, rock breakers, conveyors, shafts, etc., can be applied from ground surface if, for example, monitoring sensors indicate malfunction or gas accumulation.
- ***Mechanical mining equipment*** – Under development and testing now are flexible mechanical boring machines (see below) that can mine hard rock orebodies under tele-remote or autonomous control, install ground support, and perform conveyance functions. Someday, this technology may result in reduction in need for drill and blast in many mining situations. Hecla is working at present with an equipment manufacturer to develop a mechanical miner for deep vein mining that will allow us to move workers from the mining face to secured locations.

Atlas-Copco "mobile miner"

Battery Technology

Battery technology is rapidly advancing and now battery operated loaders and trucks are available that produce no diesel particulates, much reduced heat output to the atmosphere and significantly reduced noise levels. Many miners, including Hecla, are now testing battery powered equipment underground and the results thus far are promising. Eventually, diesel will largely be replaced by battery equipment.

Battery-powered front end loader at Hecla's Lucky Friday Mine in Idaho

Summary

Recent technological advances developed in many industries are rapidly being adapted to the underground, hard rock mining industry. In particular, the advent of high-speed, wireless data transfer, its use in monitoring, communication and data assessment as well as remote control of equipment is changing the manner in which mines are being monitored and operated. Additionally, battery technology is now allowing operation of large, mobile equipment fleets without diesel. All of these developments are now having significant impacts on the underground mining industry. Measurable

impacts on health and safety improvements will undoubtedly be seen as these new technologies are implemented at more operations in the near future.

Addendum
CORESafety Program

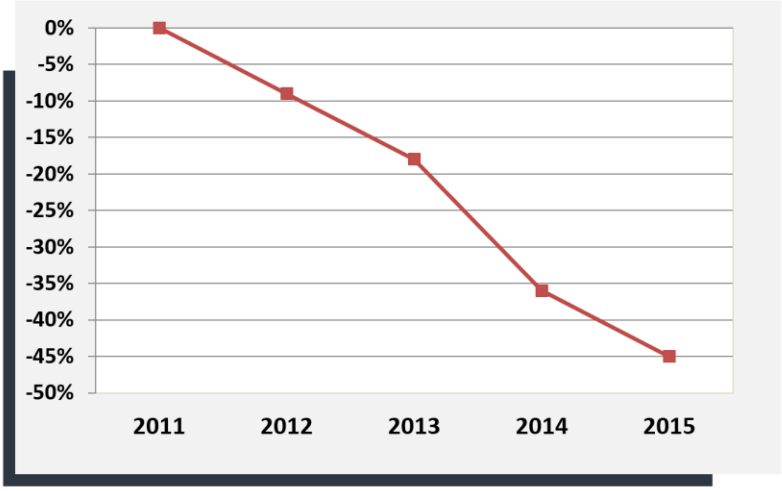
The discussion above has centered on the introduction of new, advanced technology to enhance the industry's health and safety performance. However, every mining company relies on its safety and health professionals to provide day-to-day training and oversight of the workforce. National Mining Association, in 2011, endorsed a first-of-its-kind safety and health management system to drive continuous performance improvement in U.S. mining. **CORE**Safety®, as its' known, is a common safety and health framework that relies on a management system approach to improve safety and health performance. The goal of **CORE**Safety is to achieve zero fatalities and a 50 percent reduction in the rate of injuries in U.S. mining within five years—0:50:5.

CORESafety is built on the Plan-Do-Check-Act model, which has been successfully deployed in other industries to drive continuous improvement in safety and health performance. It includes 20 modules designed specifically for U.S. mining by mine safety and health professionals. The modules are adaptable to the operations of all mining companies and intended to complement existing safety programs and practices. The system stresses continual improvement and demonstrates the determination and commitment of U.S. mining leaders to remain a model for the world.

While still relatively new we're beginning to see the positive results of this initiative. As reflected in the two charts below (provided by the NMA), the number of fatalities in the participating companies has decreased by almost 50 percent in the 4 years since **CORE**Safety was introduced. Of equal importance is that the relationship between implementation and improvement in injury rates continues to strengthen. Hecla was an earlier supporter of **CORE**Safety and I can attest to our leadership's belief in and support of this.

PROGRESS

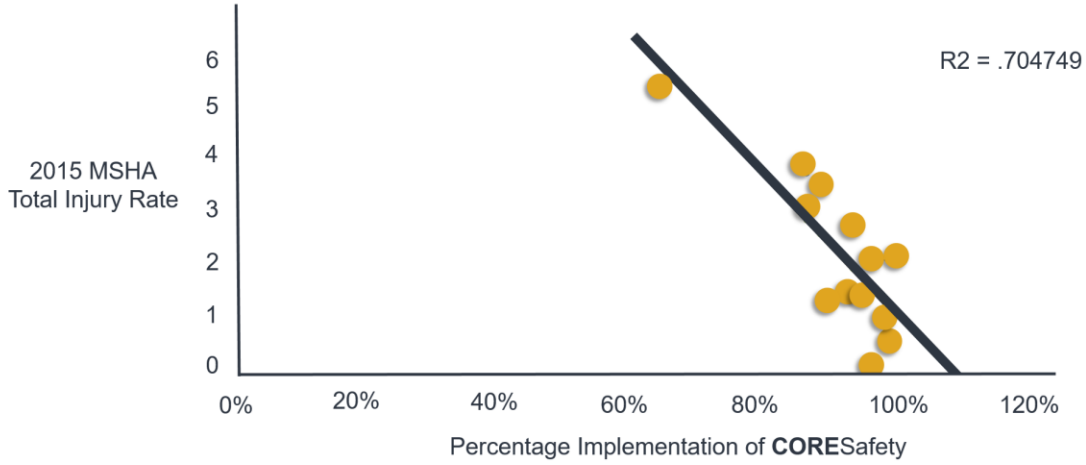
CORESafety: FATALITY REDUCTION



NMA 1

THE JOURNEY

CORRELATION BETWEEN IMPLEMENTATION OF **CORE**Safety & TOTAL INJURY RATES (2015)



NMA 2

Slides provided by the National Mining Association showing fatality and total injury rates for mines participating in the CORESafety program.