PURE GENIUS

IN LIFE-THREATENING MINES, A HIGH-TECH SAFETY NET

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POSTING IN **CITIES**

IN THE DANGEROUS AND DIRTY WORLD OF MINING, TECHNOLOGY IS CREATING NEW WAYS TO DIG -- AND KEEP MINERS SAFE.

(http://www.smartplanet.com/features/the-safety-issue/6360729)

(http://i.bnet.com/blogs/elko-nevada-wiki-commons-nashville-620x348.jpg)

Elko, Nev., is cowboy country. Every pair of Wrangler jeans and Justin boots I saw when I visited the town earlier this year was a reminder that I was in the heartland. But 30 miles outside town, as I toured the Newmont gold mine, I had the strange sense of being in another country.

The tour bus entered the mine on cocoa powder-colored roads and immediately began driving on the left side, as did all the vehicles. It is a safety precaution created so that the cabs of trucks are farther away from each other. In the event of a head-on collision -- especially with the gargantuan Caterpillar trucks that stretch to two stories and haul 240 tons of ore around the mine -- drivers would be less likely to be injured.

Every vehicle had a flashing green light on its roof, and there were orange flags on the back of pick-up trucks and vans, like the ones you'd see on a child's bicycle. Signs declared five mile-per-hour speed limits and warnings about protective clothing. Everywhere I turned, there were messages about safety: "Danger: Entering Blast Area." "SAFETY: The measure of success."

Each afternoon at two o'clock, a blast occurs, fracturing thousands of tons of material, which is then carried away in haul trucks and processed. Thanks to the price of gold today, it's profitable for Newmont to mine a ton of earth even when it yields as little as two-hundredths of an ounce of gold.

On the tour, I peered into a gold quarry, about 1,500 feet deep and one-and-a-quarter miles across, and watched haul trucks snake down a path to the bottom. From my vantage point, everything looked orderly and harmless, like a giant Lego city. But even in surface mines like this, where the work happens above ground, there are countless ways that a poor decision, bad timing or relaxed standards could lead to fatalities.

On the evening news, we hear about big mining disasters, like the explosion at the Upper Big Branch Mine in West Virginia two years ago this month that killed 29 miners. But we are often unaware of the accidents and injuries that don't make headlines, not to mention the potential fatal occurrences, or PFOs in miner-speak.

There is an old adage that mining regulations are written in blood because so many come as a result of fatalities, like those at Upper Big

Branch. In that particular case, the Mine Safety and Health Administration report, released in March, found that the mine operator provided advance notice of mine inspections, hid minor injuries, kept two sets of books and intimidated employees into not reporting hazards to the agency, known as the watchdog for miners. The report also made recommendations for regulatory changes.

But while Upper Big Branch experienced a worst-case scenario, industry experts say that American mining as a whole is taking proactive steps to improve working conditions. Much of this progress can be attributed to technology.

“The driver is to try to get to zero fatalities,” said David Clardy, senior vice present of Matrix, which sells communications and tracking mining technology. “If you look at mine deaths in the last 10 years--besides Upper Big Branch -- they start to fall into [categories] like crushing machine death. And it seems like technology could help in these situations.”

Electronics in an extreme environment

The list of accidents that can occur in a mine is endless. The roof of a coal mine could collapse. Fires could start. Coal dust could explode. Large pieces of machinery could injure or kill a worker. Though automation is hardly a panacea, it has become a holy grail of sorts for mine owners. It can keep miners safer, increase productivity and open up new markets by reaching into areas of a mine that humans physically can’t access.

“Really, any machine that’s operating underground or on a surface mine is a candidate for automation,” said Tony Stentz, director of the National Robotics Engineering Center at Carnegie Mellon University, which is working on a number of mining-related projects. Stentz works with mines or equipment manufacturers that are seeking solutions to make their mines safer and more efficient.

Automation can move a conveyer belt, make a machine dig material or dump ore in trucks and direct a roof bolter to drill into the roof of the mine. Some machines are operated with a remote control, which addresses safety concerns by removing the person from the machine. The operator will often be above ground, sending commands down to the machine below and steering it remotely.

Other machines are partially or fully automated, so that it does the bulk of the work itself and merely reports back to a person monitoring progress on a screen. Cameras and sensors can be used to “see” the mine, decide where to mine coal and guide the cutter head to engage the coal.

“The idea is that these are imaging sensors that provide data, which is automatically understood by a computer,” Stentz said. “There’s a lot of work in robotics in interpreting data from image sensors and understanding the environment around the machine so it can do what it needs to do, whether it’s driving safely or scooping material.”

Many machines are already being operated remotely and steered autonomously (relying on reflective devices to navigate), but Stentz said there are a number of innovations currently in the prototype

stage, and the next five years will be critical for implementing technology.

Due to the extreme environment, and the tendency for things to break in a mine -- an oft-repeated phrase is that a miner can find a way to break an anvil -- Stentz said there is a lot of work going into developing electronics that are ruggedized. “We’re talking about environments that experience 100 Gs of shock,” he said. “Thermal extremes from –20 to 80 degrees Celsius. So if you know those specifications in advance, you can engineer something that can survive extreme environments.” The electronics must be housed in a way so that they’re protected but also so that they’re what Stentz calls “intrinsically safe” -- they won’t ignite coal dust in the air or cause an explosion.

For all the good it does, automaton also means “there’s more stuff that needs to go through the process of ensuring it’s safe,” Stentz said. “Just because we’re adding automation doesn’t let us off the hook in that regard.” Nor is automation a cure-all. In fact, in some cases, it’s created deadly problems.

Unintended consequences

A continuous miner is a giant machine that boasts a large rotating drum with teeth and scrapes coal from the seam. It moves so quickly and efficiently that it can reach tons of coal a minute. Automating these machines years ago made sense -- not only did they remove the miner from the open cab, where there is a high concentration of dust, but they put him in a position where he could see better, resulting in

fewer movements for the machine and, ultimately, increased efficiency. Still, between 1984 and 2001, 33 people were crushed or pinned to death by their own remote control continuous miner machines, according to the MSHA.

"Getting the guy out of the cab put him in a safer area, but then it caused some unintended consequences," said Kenny Murray, vice president of operations for Alliance Coal, which owns 10 mines. Murray began his career in 1974 as a continuous miner operator in Pennsylvania and later became a mine supervisor and eventually an inspector for MSHA, before he began to oversee health and safety at Alliance. "These are big pieces of equipment being moved in a loud, very confined area with limited visibility," he said. "They move quickly and pivot quickly."

In response to the large number of fatalities, developers came up with a proximity detection technology that is installed on the machine to detect the presence of a person or piece of machinery within a certain distance of the continuous miner. They can be programmed to send warning signals and stop the machine altogether if the worker gets too close. MSHA has approved three of these systems and has proposed a rule for using proximity detection in underground coal mines that could be finalized this summer.

Matrix Design Group, a subsidiary of Alliance, developed a system that is being used by Joy Mining, one of the largest manufacturers of continuous miners. The SmartZone Proximity System uses triangulation formulas to determine where the remote control

operator and other laborers are in relation to the machine -- in a similar way that the Xbox Kinect uses motion sensors to gauge a user's position.

The operator carries a remote control, and everyone working in the area wears a cell-phone-sized transmitter, which communicates information about that person's location. Receivers are located on each corner of the vehicle and, by using some complex algorithms, they can figure out how close the person is to the defined warning zone or stop zone.

Matrix tested the system in 2009 and starting deploying units last year. Currently, half of Alliance's 10 mines have installed proximity detection systems on about 40 machines.

"It's not the technology that's difficult," said Matrixs's Clardy. "It's the interaction. What you're doing is training the operator to not get too close. The hardest part is always changing people's behavior and getting a culture of safety." The trick, he said, is making sure the technology works well enough that the miners use it.

The safety culture

No matter how many bells and whistles are introduced to promote safety, those in the industry said that none of it matters if the culture doesn't change. A miner could decide not to wear the proximity detection transmitter, or a mine owner could skip a safety check. According to the Upper Big Branch report, in the 18 months before the explosion, there were 684 violations at the mine, and 56 of them

were the result of the mine operator's failure to comply with mandatory safety and health standards.

Newmont, whose mine I toured, has an employee workbook with 16 pages of questions such as, "What have we done right when we are injury or incident free for a day?" The book addresses the Newmont Safety Journey, using words such as "awareness" and "ownership" of the safety culture.

"Mining has been around for a long time, and it's been done a certain way for a long time," said Wes Leavitt, Newmont's director of Health Safety and Loss Prevention. "We've evolved, but we still like to get our hands on things and get dirty. That will be one of our biggest hurdles to overcome." Leavitt said mining will attract a different type of worker in the future -- a good video gamer, he noted, would probably make a good remote control operator.

Much of the new technology aims to influence behavior. There's the Seeing Eye Machine, for instance, which Newmont is testing at its Phoenix mine. The device sits on the dashboard of the haul truck and can detect when a driver is starting to feel sleepy. "Not fatigue where you just fall asleep, but just micro sleeps where your mind's not completely engaged," Leavitt said. The machine looks into the driver's eye, and if it determines the driver is sleepy, the seat will vibrate. If it happens multiple times, the driver has to get out and talk to a supervisor. Leavitt said the Phoenix mine has seen a 90 percent reduction in fatigue-related events during the pilot.

Another technology that can affect miner behavior is the Personal

Dust Monitor, which was designed by Thermo Fisher Scientific to measure what is called respirable coal dust, which causes black lung and is one of the biggest hazards in the industry. According to Mike Nemergut at Thermo Fisher, the dust breathed by miners is "orders of magnitudes" higher than what he sees in the worst cities in China.

Thermo Fisher essentially miniaturized a technology that it uses in instruments to monitor urban air quality around the world, and put it on a miner's belt. The device draws a continuous sample of air from the miner's breathing zone, then removes the larger particles and measures the dust collected on a filter. The monitor stores exposure information and updates the display every five seconds, which means miners can react in real time and move to a better area to lower their exposure. The monitor won't prevent someone from getting black lung, but it provides the information so a miner can take a couple steps toward a better ventilated area.

"Compared to what was on the market before [when dust samples were collected manually], it's a game-changer," Nemergut said. "Can you imagine collecting a sample on the filter and then waiting two to three weeks for results?" The $13,000 unit also provides cumulative readings throughout the shift and the week so a miner's exposure can be tracked by a safety officer. There are currently 400 units in operation, but Nemergut said 4,000 to 7,000 monitors will be deployed in the next three years, because MSHA is expected to finalize a rule requiring their use.

The bottom line

A "potential fatal occurrence" means that nobody was hurt, but these types of events are still reviewed as though they were disasters. “We apply the same rigor and process to the high potential events as we do the actual event,” Leavitt said. “We put together an investigation team, which drills down into system failures and the behavior component. If something occurred, you ask five times why it occurred.”

Leavitt said 75 to 90 percent of events have at least one basic cause associated with a behavioral aspect, such as someone choosing not to follow a procedure.

He said at Newmont, it’s also customary to review events even when something happens at another mine. In 2010, two men were killed at a Barrick gold mine, also outside Elko, when a pipe broke and the miners fell down a shaft. “So we would have looked at whether we had a similar system set up and was there a mention of a safety system being bypassed,” Leavitt said. “We talked to our guys. There’s a reason these systems are in place.”

Murray said there’s no obligation to report what he calls near-misses -- where an inch to the left or an additional second could have resulted in a serious accident or fatality. “But there’s so much information to gain from these,” he said. “We investigate them as seriously as we do an accident.” Before Alliance miners go underground, at the coffee station, they check out a 42-inch plasma TV that updates them on news about accidents or potential events.

Naturally, some miners resist change, whether it’s in the form of electronics or engines. But Murray said when it comes to efficiency,

miners often embrace the new technology. “Coal miners want the biggest, fastest and strongest,” he said. “Coal miners love to produce coal, and everyone wants to be the most productive. But they also want to be safe. A safe mine is a productive mine.”

A productive mine also makes mine owners happy. Automation and technology help protect workers, but also increase efficiency and reduce the down-time associated with any accident.

“These are big machines, and they can make hundreds of dollars of revenue per minute,” said Carnegie Mellon’s Stentz. “So even if you just add some kind of technology to the machine to make it five or 10 percent faster, even if there’s still a person there operating it, it has a tremendous impact on the bottom line.”

Safety is a huge driver behind innovation, Stentz said. “But it’s just one of many reasons that mining companies are pursuing automation.”

Photo based on the original by Jaroslaw Binczarowski (http://en.wikipedia.org/wiki/File:Elko2.jpg).

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