

Justin Fisher (USA) and Marcos Bayuelo (Switzerland), Hexagon Mining, discuss the importance of balancing safety and productivity in mining operations, and outline how technology can be used to tackle the daily hazards faced by coal miners.

SERIOUS ABOUT SAFETY

Particle pollution, poor visibility, distraction, noise and fatigue are daily hazards for anyone working in a coal mine. Visible or otherwise, particle pollution endangers humans and animals if inhaled. Collisions involving equipment can result in damage and downtime for repairs. Severe incidents can involve injuries and even loss of life.

Under increasing pressure to identify and exploit new reserves, reduce costs and boost productivity, mines must also address these concerns and improve safety. Are all of these competing interests compatible?

The art of mining is to balance safety and productivity. Integrated solutions are helping to ensure that this is possible. This article will discuss the importance of monitoring and tracking potentially dangerous particles in the atmosphere. It will also examine the latest advances in collision avoidance

technology, fatigue and distraction monitoring, personal protection and vehicle intervention.

Monitoring air quality at opencast coal mines

The daily operations of opencast coal mining, including blasting, grinding and hauling materials, create dust and cause particulate matter (PM) to enter the atmosphere. This particle pollution may be visible as haze or smog, or it may be so small that it cannot be seen with the naked eye. This microscopic PM, defined as less than or equal to 10 μm dia. poses a health risk to humans and animals if inhaled and can lead to asthma, lung damage and other complications. The smaller the particles, the more dangerous they are. High levels of PM can also affect the climate and cause damage to ecosystems by contaminating water and soil.




Figure 1. Dust and potentially harmful particulate matter in the atmosphere are perennial hazards around coal mines amid blasting, grinding and hauling.



Figure 2. Taking up minimal room on the dashboard, the size of Hexagon's collision avoidance system belies its importance to the protection of both the operator and vehicle.

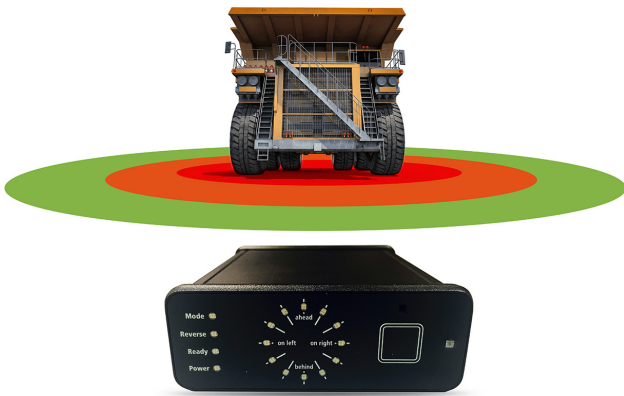


Figure 3. CAS protects more than 30 000 vehicles worldwide, providing equipment operators with information about the location of nearby vehicles.

Compliance with air quality standards

The US Environmental Protection Agency (EPA) sets air quality standards to minimise adverse effects on population centres and the ecosystems surrounding mines. Non-compliance with these regulations can lead to production stoppages and financial penalties.

To avoid violating dust emission limits, mining companies install open path boundary monitoring systems to measure and track aerosols in the air. The placement of these sensors is determined by customary wind direction and the proximity of sensitive areas, such as towns, reservoirs or wildlife refuges. Although these systems are strategically located, instances of air quality violations continue to plague the industry, and a more robust solution is needed.

Another tool in the toolbox

Boundary fence line monitors that record PM levels in the atmosphere have been employed for decades. Although highly sensitive, the existing technology captures only a narrow range of activity and struggles with accuracy in the varied terrain often found near mining operations. A sensor that continuously collects

detailed PM data over a broad swath of uneven topography would help address these data gaps.

Micro-pulse LiDAR technology from Hexagon AB is based on laser pulses that reflect off particles in the atmosphere, which are recorded by a highly sensitive receiver. These returns provide a snapshot of conditions over the area of interest and are the basis for vertical aerosol profiles and time sequence plots. The vertical profile identifies the type and quantity of aerosols in the atmosphere, as well as the direction particles are moving.

This type of system is capable of scanning a vertical range of 15 km and a horizontal range of 6 km, with 360° coverage. To allow for an uneven landscape, the scanning angle can be adjusted down to capture more of the ground. After set-up, the unit operates autonomously and gathers real time data at a selected time interval. By operating multiple units, an overlapping scan of a large area may be created to avoid data gaps.

Integrate information for complete picture

The collection of atmospheric data over a broad vertical range allows for accurate calculations of the planetary boundary layer (PBL) – the highest point above the surface of the Earth where a range of aerosols, from pollen to industrial emissions, are collected, trapped by the temperature inversion layer.

Mining operations typically involve a lot of movement, so there are higher dust plumes, which tend to travel further away from the source. By combining data from multiple kinds of instruments, the results of all of these monitoring systems can be enhanced. For example, integrating the PBL calculation with wind direction and temperature readings is helpful in predicting how fast and how far dust emissions will travel.

Australian field trials with micro-pulse LiDAR

Pacific Environment, an environmental consulting firm based in Sydney (Australia) used a research grant from the Australian Coal Association Research Program (ACARP) to evaluate the effectiveness of using a micro-pulse LiDAR system to monitor emissions at coal mines. The group collected field data at three locations in Australia: Hunter Valley Operations (HVO), a multi-pit opencast coal mine operated 24 hr/d, seven days a week; the Mount Thorley Warkworth area, comprising two adjacent opencast mines; and Fort Scratchley at the Port of Newcastle, the largest bulk shipping port on the east coast of Australia and the world's leading coal export port.

Analysis of the data, including comparisons to returns provided by conventional particulate monitors, shows the system is effective for identifying PM emission sources and PM movements across critical site boundaries, such as fence lines and open pits. The scanner's ability to

measure along a path length of hundreds of metres is an advantage over single-site monitoring.

Real time information about the quantity and movement of dust emissions at opencast coal mines is desirable to mitigate negative impacts on nearby populations and to improve compliance monitoring and early warning systems. Integrating micro-pulse LiDAR with other sensors facilitates the identification and tracking of potentially harmful airborne particles. This allows mine operators to better manage onsite dust emissions, reduce unnecessary production stoppages and improve general air quality in the area.

The case for collision avoidance

Collisions involving mining equipment are a significant concern for all mines, especially coal operations where traffic density combined with poor visibility create heightened risks.

In recent years, the industry has focused on developing technology that can protect drivers and operators from collisions in busy opencast coal mines, particularly where large haul trucks interact with smaller vehicles. Solutions are typically based on radio, radar or camera technology, or a combination of these.

Operating costs, safety and stricter regulations

The following cases illustrate the potential costs associated with collision incidents. The specific incidents are hypothetical, but costs are derived from actual incidents reported to industry or governmental agencies in various countries.

Table 1. The ROI case for collision avoidance	
Cost of repair	US\$200 000
Lost production	US\$660 000
Total per incident	US\$860 000
Total over five years	US\$4 300 0000

For example, an opencast gold mine has an incident in which a haul truck backs into another haul truck in a parking area (dump body strikes cab).

There are no injuries. One truck is down for repair for five days (10 shifts). This mine averages one incident per year.

Technology is proven to improve the awareness of operators and to reduce the number of incidents involving heavy traffic. In another example, a large mining company in Australia reported results at the 2014 Queensland Mining Industry Health & Safety Conference. In the 12 months that preceded the installation of traffic awareness technology, the mine experienced 14 machine-to-machine incidents. After technology was implemented, only two incidents occurred at the mine during the next two years.

The impact of a serious injury or fatality at a mine is widespread. Long after the formal investigation is complete, the workers, families, surrounding communities and the mining company continue to feel the effects. Thus, not all direct and indirect costs associated with an incident can be accurately quantified in this kind of analysis.

Technologies have been developed to help prevent these incidents and studies have been conducted to determine the effectiveness of existing systems, the costs associated with implementation, and the long-term benefits for mining operations.

New legislation also reflects these concerns, as rules are proposed in many countries that will require collision avoidance technology at mine sites. In 2017, South Africa's Department of Mineral Resources introduced regulations compelling opencast mines to enhance safety for all trackless mobile machinery, such as haul trucks.

Helping drivers in operation

Collision avoidance and traffic awareness technology from Hexagon increases situational awareness and reduces accidents by actively alerting the vehicle operator of imminent threats. The MineProtect portfolio includes: a collision avoidance system (CAS) with various driver interface options; fatigue monitoring; advanced radar for detecting unprotected objects; personal alert for pedestrian awareness; an automatic vehicle intervention system to stop vehicles when operators are unable to respond; and a suite of analytics tools to visualise and manage data and extract the required information for preventive decisions.

CAS protects more than 30 000 vehicles worldwide, providing equipment operators with information about the location of nearby vehicles. It sounds an audible alarm if an approaching vehicle is on a collision course. The system monitors 360° around the vehicle, and vehicle locations are

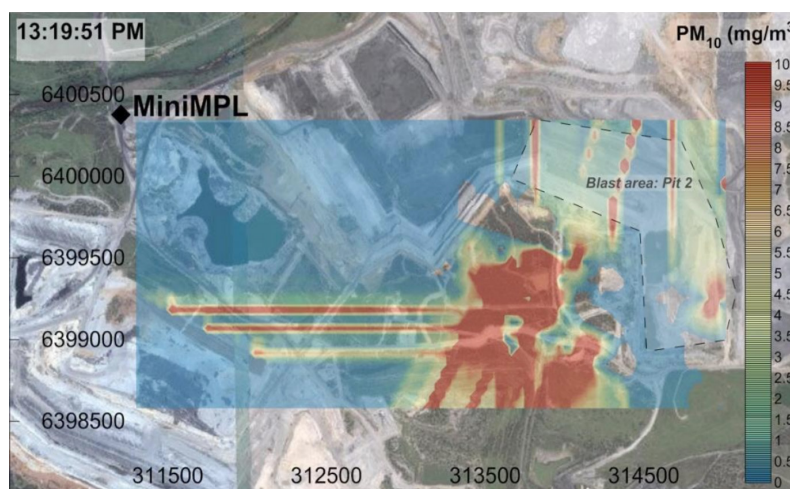


Figure 4. PM10 concentrations over Cheshunt Pit at HVO during a blast event on 15 July 2016, mapped onto satellite imagery of the coal mine.

indicated on an LED display for intuitive manoeuvres on its visual line of sight. The operator sees required information within seconds and a top-view screen offers enhanced awareness in specific situations, such as low speed.

Using GNSS satellite positioning technology, CAS determines the location, speed and heading of the vehicle, together with machinery-specific details, such as braking distances for a specific haul truck type. The technology transmits this information to nearby vehicles, along with the vehicle's ID, using a V2V radio network with enhanced data traffic management.

Sophisticated algorithms continuously monitor vehicle traffic to determine if a collision is likely. An audible alarm is generated only if two or more vehicles are at high risk of collision. Smart trajectory prediction algorithms proven in aviation minimise nuisance alarms. No radio or IT infrastructure is required, which eliminates the latency on communications. This, combined with proprietary hardware and the operating system, ensures operators are notified the moment a risk is detected, ensuring accidents are avoided.

CAS comprises minimal components and is scalable to cover most controls for Level 7, 8 and 9 on the unwanted scenarios identified by the earthmoving equipment safety round table (EMESRT). It includes black box recordings of all relevant traffic events and routine data, plus an obstacle map containing stop signs, multiple speed limits, overhead power lines and blast areas. All of this can be tailored to a mine's requirements and operational parameters to reduce overhead and increase safety controls.

Serving the management

Accessing the right data at the right time is the key to operational safety. Hexagon's MineEnterprise platform comprises dashboards for monitoring and minimising accidents, together with a specialised design framework and services to support the technology across the mine value chain.

MineEnterprise CAS Analytics connects multiple data sources, empowering users to connect and visualise all traffic information, such as near-misses per shift. Live dashboards simplify information, providing the right information to the right stakeholder.

These include a real time critical risks dashboard and a month-to-day dashboard measuring safety progress and performance indicators for fleet-speeding analysis. This allows supervisors to discuss traffic violations with operators and light vehicle drivers.

Business tools include an alarm analysis module for location management, helping to clearly identify dangerous locations. Situational context quickly reveals the cause of unwanted events and close interactions.

MineEnterprise CAS Analytics empowers engineers to see if numerous unwanted events occur at a specific intersection and which intersections could be changed to reduce blind spots. It delivers all of the tools to build



Figure 5. A mini micro-pulse LiDAR instrument in an all-weather enclosure deployed at HVO in New South Wales.



Figure 6. CAS monitors 360° around the vehicle and vehicle locations are indicated on an LED display for intuitive manoeuvres on its visual line of sight.

and manage customised dashboards, as well as the reports required for short interval, and daily and monthly safety management activities.

Dashboard and data inputs can be combined according to specific performance indicators, such as productivity per operator, combined with unwanted close interactions and microsleep events. CAS Analytics' measurement and visualisation capabilities provide holistic insight into operators' performance, productivity and safety. This can be scaled to a corporate level, allowing mines to visualise and compare different site performances on a standardised data format across the organisation.

Beyond data visualisation and reporting, MineEnterprise delivers data sets for fleet management, fatigue monitoring, personal protection and vehicle intervention. These sets blend data for enhanced operational safety management.

Mines now have more solutions at their disposal to ensure that everyone gets home safely. The implementation of such technologies, with their long-term benefits for personnel and operations, might be the smartest investment a mine can make. ^WC