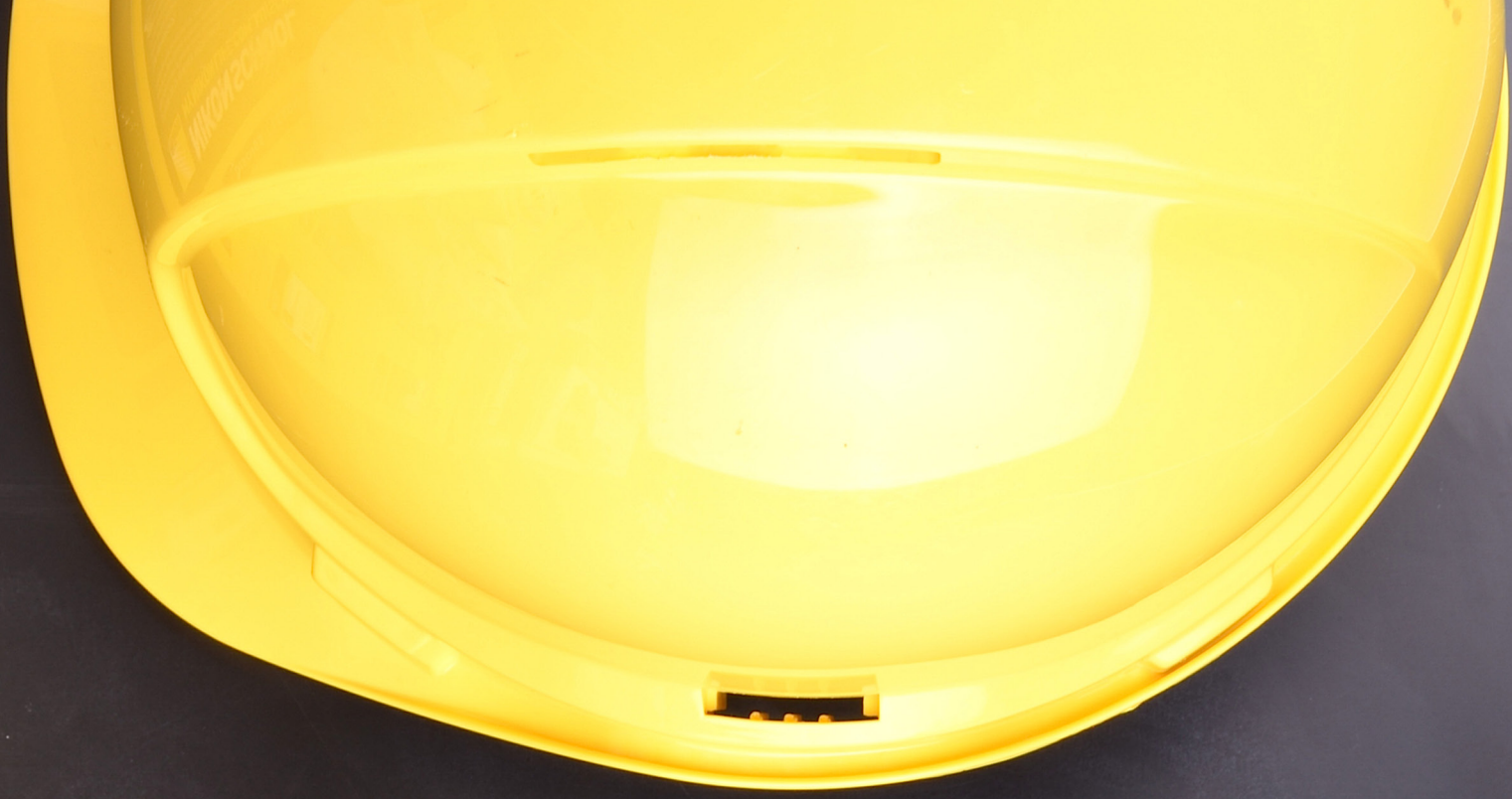


Neville Judd, Hexagon Mining, Canada,
explains how advances in mining software are helping to prevent industry accidents.

SERIOUS ABOUT SAFETY

Collisions involving equipment are a significant concern for all mining operations. Usually these incidents result in damage and downtime for repairs. However, severe incidents can involve injuries and even loss of life. New legislation reflects these concerns. Rules have been proposed in many countries that will require collision avoidance technology at mine sites.

All of these factors occur against the backdrop of a highly competitive industry. Under increasing pressure to identify and exploit new reserves, reduce costs and boost productivity, mines must also improve safety. Are all these competing interests compatible?

The art of mining is to balance safety and productivity. Success today depends on improving both. Integrated solutions are helping to ensure that this is possible.

Technologies from Hexagon Mining are helping to prevent incidents, while improving efficiencies and increasing productivity. Studies undertaken by the company and feedback on its technology have determined the effectiveness of existing systems, the costs associated with implementation and the long-term benefits for mining operations.

This article will summarise that feedback and explain the latest advances in Hexagon Mining's safety solutions.

Bringing safety down to earth

Hexagon Mining's SAFEmine Collision Avoidance System (CAS) is used in more than 25 000 vehicles in over 55 mines.

The SAFEmine safety suite traces its origins to the Swiss Alps and avionics. A few skillful engineers and enthusiastic glider pilots designed a system to avoid collisions between glider planes. The system had to work in all three dimensions of space.

With little sight around the cockpit, glider pilots tend to fly in close proximity, chasing thermal upwinds. Collisions are rare but can end tragically. When the first collision avoidance system was built it became the standard for light aircraft in Swiss airspace and beyond.

When a mine manager from Anglo American approached the entrepreneurs about a collision-avoidance solution for his mine in South Africa, they responded by building the SAFEmine CAS. CAS tackles blind spots, one of the leading causes of incidents in the industry.

It gives vehicle operators 360° proximity detection at any speed, in all conditions via unobtrusive cabin display units. For operators, CAS represents peace of mind. It helps operators work more confidently and productively, especially in poor visibility caused by rain, snow and fog as well as at night, helping drivers to work more smoothly and efficiently.

"I was driving this truck where the collision-avoidance technology system was not activated, and I felt lost, because these haul trucks have large blind spots," said Leander Sloan, a haul truck operator at Barrick Gold's Cortez mine in Nevada.

41% of vehicular incidents at Barrick, including collisions, are due to a driver's lack of visibility. The company is currently trialing CAS on the haul truck and light vehicle fleet at Cortez.

Elsewhere, the benefits of CAS have proved to be even more significant.

"I was driving along in a light vehicle and came to an intersection, looked both ways, didn't see anything, so I started to accelerate," recalled Martin Leggat, a mine surveyor for New Hope Group's Acland mine in Queensland, Australia. "Then CAS went off and alerted me that a vehicle was coming and within a second there was a big 793 dump truck coming down on me. The system basically saved me."

Hexagon Mining SAFEmine collision avoidance system is used in more than 25 000 vehicles in over 55 mines.

Incidents of speeding have been reduced by mines using TRACK, real-time reporting functionality that is integrated with CAS.

Mines using CAS report a reduction in collisions. The Premier mine in Western Australia, for instance, reported a 53% reduction in metal-to-metal contacts within the year following implementation of CAS.

Another large mining company in Australia reported its results at the 2014 Queensland Mining Industry Health & Safety Conference. In the 12 months that preceded CAS implementation, the mine experienced 14 machine-to-machine incidents. After CAS was implemented, there were only two incidents during the next two years. The first involved a rented dozer that was not fitted with CAS, thus, the other vehicle was not able to detect this dozer. In the second incident, the system alerted the operator but he failed to take evasive action.

Hexagon Mining has since developed the Vehicle Intervention System to take control of the machine in certain situations, if the operator fails to respond to an alert.

Mines can use this data, and the improved safety record, to negotiate lower insurance premiums, further reducing cost. A major mine in South America showed that 98% of its 521 operators believed that CAS is a useful tool for keeping them and their colleagues safe. Further, 97% say that the information presented by CAS is sufficient and easy to interpret.

Incidents of speeding have been reduced by mines using TRACK, real-time reporting functionality that is integrated with CAS.

TRACK delivers real-time tracking and reporting functionality to help improve operator behaviour. It works via a web-based interface, customised reports and configurable text messages and email alerts. Mines have found TRACK to be effective in keeping vehicle speeds under required limits.

Using area definitions, speed limits can be adjusted for different areas of the mine. For instance, haul roads can differ from access roads. A demonstration at a

Canadian coal mine revealed a 54% reduction in all over-speed events in the mine, and a 100% reduction in events where vehicle speed was 10 k/hr over the speed limit.

Reduction in costs and downtime associated with collisions is an added benefit to the safety improvements realised through these systems. A single accident with no injuries can limit machine availability and put mining operations on hold for days. The resulting repair costs, equipment downtime, administrative requirements and lost productivity all impact profit. Quantifying the comparative success of safety technology is difficult because mining operators are notoriously reluctant to disclose such data. Safety is a sound investment, but sometimes decision-makers are unaware of accidents prevented by such technology.

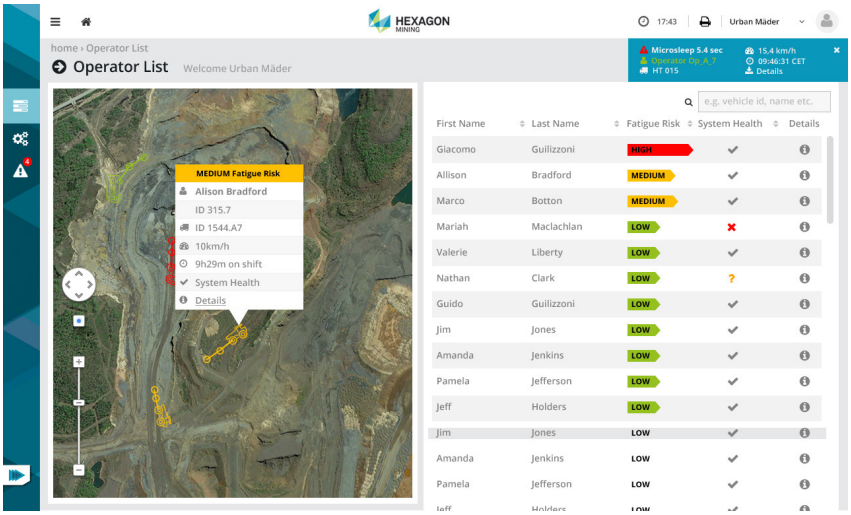
ROI analysis makes a compelling case for investment in collision avoidance. Hexagon Mining researched three potential scenarios, which are summarised here.

If a medium-sized mine averages one non-injury backing accident per year involving two haul trucks, the total cost could be US$4.3 million over five years. The total investment for CAS technology over five years is US$1.8 million. The technology potentially eliminates these types of accidents so the total savings to the mine is potentially US$2.5 million over the same period. The ROI is calculated as (US$4.3 million – US$1.8 million)/1.8 million = 1.4 or 140%.

A second scenario documents an accident resulting in a fatality. With potential costs approaching US$20 million, the benefits of eliminating a collision that relates to a fatality are obvious. However, this serves to illustrate that investment in collision avoidance or a fatigue monitoring system makes financial, as well as moral, sense.

In the final example, CAS's speed monitoring and alarming functions reduce over-speed events by 90%. This results in a cost savings of US$1.85 million over five years, including two avoided collisions. With the investment in CAS, the mine breaks even in approximately five years (ROI=0.03), or less if other incidents are avoided.

Fully integrated with CAS, FatigueMonitor uses a proven computer vision technology to monitor operators unobtrusively while they drive.



In the control room, supervisors can monitor the fatigue risk for each operator via FatigueMonitor.

Eyes on the road: fatigue matters

Operator fatigue is another leading cause of incidents in the mine. Heavy machinery, monotonous work and long hours heighten the dangers of fatigue. Operators are often unaware of critical situations, so help detecting fatigue levels is essential to mitigate the associated risks.

To that end, Hexagon Mining developed the FatigueMonitor. Fully integrated with CAS, FatigueMonitor uses proven computer vision technology to monitor operators unobtrusively while driving.

While alcohol in the human body can be measured with handheld devices and subject to legal limits, measuring human fatigue scientifically and in real-world conditions is less straightforward.

The market tries to solve this dilemma with different approaches, loosely segmented as predictive and reactive methods.

Predictive

Operators are evaluated for their tiredness and the system issues notifications of potential fatigue risks. Currently, all known predictive methods are slow to measure variations of a person's fatigue status. They update information in the order of several minutes, hours, or even shifts.

Reactive

The system reacts when the operator falls asleep. A wake-up alarm is issued in the case of a microsleep to avoid immediate danger. To do so, reactive systems must identify and alert within seconds or fraction of seconds.

The ideal fatigue system is as predictive as it is reactive, and combines the best of both worlds.

Reducing fatigue

Humans naturally close their eyes when they fall asleep. It is an immediate bodily

reaction to microsleeps and is measurable. Consequently, eye-lid closure is the indicator of choice for identifying fatigue events.

Highly-versatile computer vision technology is at the core of Hexagon Mining's FatigueMonitor. While most preventive systems and wearables are limited to fatigue, computer vision also identifies operator distraction and can therefore help to keep attention on the road.

Part of the fatigue prevention strategy lies in the provision of individual fatigue risk for every operator. This challenging task is approached by using as many available parameters as possible. To estimate fatigue risk levels, the output of the computer vision is, of course, one factor. But it also accounts for individual driving hours on the truck, breaks, number of consecutive shifts, preceding shift changes or time of day, etc. This is what is called a multi-factorial approach.

Camera systems are truck-based and need not be customised for each operator, which is a major advantage considering spare part management and administration. All computer vision-based systems work in the near-infrared range, regardless of lighting conditions (day/night). This wavelength penetrates many standard sunglasses that are otherwise completely dark in the visual range.

Once an incident is identified, the system issues a unique in-cabin alert. A blinking warning sign on the FatigueMonitor status display informs the potentially disoriented driver in parallel. Simultaneously, the corresponding image sequence is sent to the control room for review. Video review not only helps to trigger the mine's fatigue procedures but it can also be used for training and prevention by reviewing the videos with the operator after the shift.

The combination of a fatigue and distraction monitoring system with the collision avoidance system is unique and powerful. Highest loss accidents typically involve two heavy vehicles or one heavy and one light vehicle. The dangers are even more imminent in surrounding traffic, which is exactly when CAS takes care of the vehicle-to-vehicle interaction and alarms accordingly while FatigueMonitor looks inside the cabin. Both risks are mitigated with the same system – two layers of safety in one display on a single unit, meaning less hardware in the cabin.

In the control room, supervisors can monitor the fatigue risk for each operator via FatigueMonitor.

Vehicle intervention: a first and last resort

Previewed at MINExpo in 2016, Hexagon Mining's Vehicle Intervention System (VIS) adds a further layer of protection to CAS.

VIS takes control of a machine in certain situations if the operator does not react appropriately to a CAS warning. This further mitigates the costly consequences of accidents. Depending on the situation, VIS can automatically cut the propulsion, apply the retarder or even activate the service brakes.

Sishen mine operated by Anglo American Kumba Iron Ore contacted Hexagon Mining about a system in 2014. The mine had conducted an extensive risk assessment of its operation to understand major risks. Together with the customer, a step-by-step approach was created to develop a solution.

VIS is integrated with CAS and uses the same sensors and user interface thus protecting the customer's initial investment. It is one more step in the trend towards human-assist products.

As a result, heavy machine equipment operators will have more combined safety and operational context than ever before. The safety portfolio will soon be extended towards personal protection systems, actively warning pedestrians in the mines.

Safety

Safety is also at the heart of Hexagon Mining's integration of planning, operations, geodetic slope monitoring, surveying, UAV, (unmanned aerial vehicle) and radar-based monitoring systems. Automated motorised total stations and GNSS technology are pivotal to risk management in mining highwalls, tailings dams, and other critical structures. Leica GeoMos can combine any geotechnical, meteorological, hydrological or other sensors into its analysis and dashboard platform, correlating all pertinent data into one location. Complementing GeoMos is the IBIS radar from IDS's GeoRadar division, which was recently acquired by Hexagon.

The IBIS radar is an interferometric mine slope radar that addresses the need for critical safety and long-term slope monitoring. It is used in more than 170 locations worldwide and has warned before slope failure in many prominent mining groups.

Hexagon Mining believes that the integration of its wide technology portfolio can deliver a holistic view of a mine, bringing with it benefits for both safety and productivity. WC

VIS takes control of a machine in certain situations if an operator does not react appropriately to a CAS warning.