SmartCap Life relies on EEG, or reading electrical brain activity

SAFETY

Blink of an eye

Operator fatigue and distraction represent the single biggest accident risk to mobile fleet. New fatigue-monitoring technologies now offer mine owners an unprecedented opportunity to address what was once an invisible and hard-to-tackle problem. Jayne Flannery reports

Fatigue at the wheel is something that most honest drivers would confess to having experienced. Under the pressure of a long and tedious shift, the sensation can take on catastrophic implications for the operator of a haul truck loaded with hundreds of tonnes of rock traversing steep, narrow roads with a view obscured by dust and darkness. And it can all go wrong in the blink of an eye.

Human safety has always been the over-riding concern in addressing fatigue and distraction. But mine owners are well aware of the other costs that manifest in lower productivity and absenteeism as well as damage to physical assets, the potential for mine downtime,

legal and compensation expenses and regulatory problems. A poor safety record is also anathema to investors.

Ryan Hawes, vice-president for business development with Guard-Vant, is keen to draw attention to the fact that purchasing decisions are also driven by volatile commodity prices.

"Recent pressure on commodity prices means there is more focus than ever on the cost savings that can be achieved by increased productivity from operatives and a tighter headcount. Fatigue monitoring is an important facet of this," he comments.

Technology Investment Priorities, a report published last year on

investment trends in Australian mining by Reportstack, identified that 80% of mines had already invested in collision-avoidance systems.

Australia possesses one of the world's strictest regulatory environments with regards to safety, but across all geographical regions the regulatory space is becoming tighter.

"On the compliance side, the trend is undoubtedly towards increasing government regulation, but there is also growing awareness among progressive companies that safety is a good investment both morally and financially," says Barbara Hirtz, product manager of FatigueMonitor, the industry solution of Hexagon Mining. ▶

"Safety is a good investment both morally and financially"
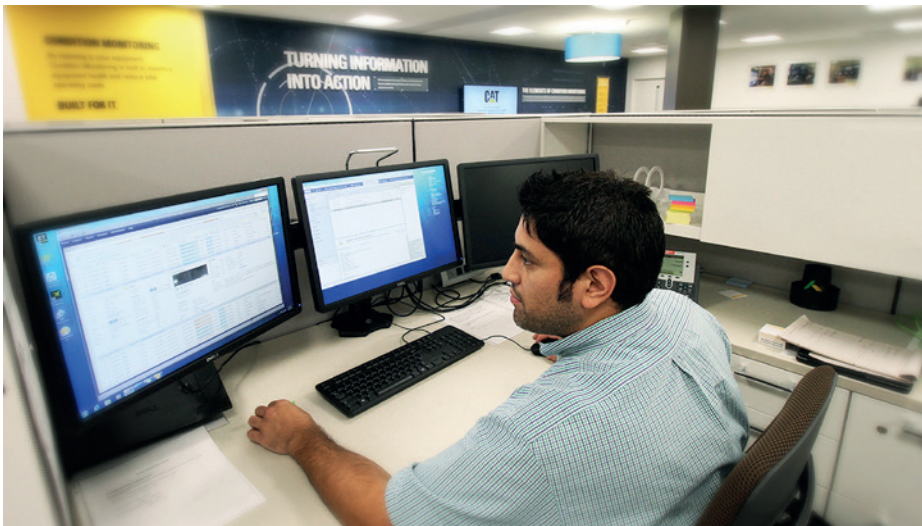
A Caterpillar safety advisor in a fatigue-monitoring centre

To date, mining has been dominated by cab-mounted imaging systems used for tracking percentage of eye closure (PERCLOS) in drivers, along with a range of other computer vision technologies that can analyse factors such as facial features and head pose.

The other key means of monitoring fatigue is wearable technologies, such as headbands or watches, that rely on EEG, or measuring the electrical activity of the brain.

DUAL APPROACH

Caterpillar has taken on both segments of the market. It offers the Cat Driver Safety System (DSS) for fatigue monitoring in vehicles. Additionally, Cat Smartband wearable technology is available to ena-

ble workers to monitor their own sleep and fatigue levels, says Silvano Angelone, fatigue solutions consultant at Caterpillar. "With the technology available today, invisible risks can be exposed and made completely visible and we want to facilitate this process at each level."

DSS is a non-intrusive, in-cab fatigue-detection technology that instantly alerts operators the moment fatigue or distraction is identified. Fatigue-detection technology works by monitoring PERCLOS, eye-closure duration and head pose. If the DSS detects a fatigue or distraction event, the operator is immediately alerted through configurable vehicle seat vibration and/or audio alarm.

The fatigue or distraction event is sent to a 24-hour monitoring centre to classify and confirm the event. Caterpillar experts analyse the data and provide customised reporting with site-level recommendations. Fatigue data can be cross-referenced with equipment and scheduling data to support a robust fatigue-management system.

Additionally, Cat Smartband

wearable technology is available to enable workers and managers to monitor sleep and fatigue levels.

The Cat Smartband is an actigraphy watch that can help workers understand the connection between sleep, fatigue and accident risk on and off the site. The technology monitors the worker's sleep and wake periods and converts the data into an effectiveness score, which can be viewed by employees at any time. This provides managers with data that can drive continuous improvement.

SYSTEMS INTEGRATION

On the technological side, there is a clear trend towards increased integration of fatigue-monitoring systems with complementary solutions, such as collision-avoidance and fleet-management systems.

Hexagon Mining's SAFEmine Collision Avoidance System (CAS) is a well-established industry solution installed in more than 25,000 vehicles in 55 mines. CAS has recently been enhanced with the integration of additional layers of protection, including FatigueMonitor, a fatigue-detection, alerting and reporting solution.

"It is the fact that it uses a whole range of technologies to address fatigue and can be integrated with other accident-prevention systems that makes it such a powerful solution," says Hirtz.

The system provides a rolling fatigue risk estimation for each operator by weighing all available data, including factors such as the time of day, shift counts, shift changes, driving hours and computer vision alerts generated by the system.

Based on these factors, it computes a fatigue risk, which is displayed on the dashboard as low, medium, or high and is simultaneously available in a control room application.

Should an operator fail to respond to a CAS warning, an automatic Vehicle Intervention System (VIS) has been developed that will take over. "It's a natural evolution of CAS and has been successfully implemented at the Sishen mine operated by Anglo American Kumba Iron Ore in South Africa," says VIS product manager Fabien Kritter.

Hawes of GuardVant agrees that the market is currently seeing refinements to existing hardware and integration with other systems, rather than new breakthroughs in technology.

"But we are definitely getting smarter in differentiating genuine fatigue events from false ones, which still remains a challenge in fatigue monitoring," he says.

GuardVant's OpGuard uses non-intrusive imaging technology to monitor haul-truck operators for a combination of 3-D head and facial movements, PERCLOS and micro-sleep events that indicate signs of fatigue or distraction. When the OpGuard algorithm detects fatigue or distracted driving events, the system provides an alert to the operator and designated supervisors and managers.

Critically, OpGuard can be interfaced with the mine's fleet-management system and can also be combined with ProxGuard, a collision-avoidance system ▶

> ## "We are getting smarter in differentiating genuine fatigue events from false ones"

designed to improve the operator's situational awareness.

Last year, GuardVant announced the official opening of its 24/7 monitoring centre for OpGuard customers, offering managers access to real-time fatigue and distraction data. "While we offered this service in the past on a case-by-case basis, it is now available to all our customers," he explains.

QUANTIFYING IMPROVEMENTS

Quantifying the comparative success of engineering safety systems and initiatives is challenging. Mines are usually reticent about disclosing such data. "FatigueMonitor and VIS are new technologies just beginning to realise benefits at operations such as Norsk Hydro's Paragominas bauxite mine in Brazil and Anglo American's Sishen iron-ore mine in South Africa," says Kritter of Hexagon Mining.

However, a recent study conducted by Hexagon Mining in a major South American mine showed that 98% of its 521 operators believed that CAS was a useful tool for enhancing site safety. Another bonus is better driving behaviour. For example, a small mine in Canada reported a 54% reduction in all overspeed events and a 100% reduction in events where vehicle speed was 10km/h over the limit after implementing CAS.

Last year, Newmont Ghana selected GuardVant's suite of fatigue-monitoring, proximity-detection and collision-avoidance systems for its Akyem and Ahafo gold mines to target both operator fatigue and to reduce close-proximity accidents caused by blind spots.

"By combining fatigue monitoring, close proximity detection and collision avoidance, we are combating two very common safety issues at mines. These systems prevent accidents and the data generated also enables managers to implement operational changes and develop employee programmes that further reduce the number of accidents," says Emmanuel Kwame Attifu, IT country manager for Newmont Ghana.

Southern Copper Co (an indirect subsidiary of Grupo Mexico) has installed OpGuard systems on its mine fleet at La Caridad mine in Mexico. Similarly, the company is confident of a decrease in safety incidents and operating costs as well as an increase in equipment availability. GuardVant solutions are

already in use at three other Southern Copper Co mines: Buenavista, Toquepala and Cuajone.

In partnership with Potash Corp, Caterpillar undertook a Fatigue Risk Assessment (FRA) at the Aurora, North Carolina, mine. The study, presented in October 2016, was conducted to understand the feasibility of implementing DSS and showed the potential for an overall reduction in fatigue-related events of 89%. Potash has since moved forward to implement a full installation.

BOOST FOR WEARABLE KIT

The Australian company SmartCap was developed within CRCMining, a cooperative research centre established by the Australian government and supported by four universities and 13 industry partners. It has been working with wearable technology for the past eight years. It believes that its new SmartCap Life product is a breakthrough in proactive, rather than reactive, warning systems.

Fitted easily into any headwear, SmartCap Life relies on EEG, or reading electrical brain activity. "We're not talking about detecting micro-sleeps, we're in the business of eliminating them," declares Dush Wimal, SmartCap CEO. "Physiological signs are a lagging indicator. We can intervene early, and stop you from having a micro-sleep altogether."

Using the Bluetooth-enabled Life app, users can get real-time voice-and-vibration alerts on impending micro-sleeps, track their alertness levels throughout a timeline and even get a warning if the headwear is fitted incorrectly.

The five sensors on the rechargeable Life Band can be easily replaced, and, unlike earlier gener-

"We're not talking about detecting micro-sleeps, we're in the business of eliminating them"

A GuardVant fatigue camera

ations of wearable technology, it requires no set-up before wear and is washable and unaffected by sweat. It also features exceptionally long battery life.

Life gathers a broad spectrum of fatigue data providing everything from company-wide holistic trends to individual profiling. Cloud-hosted analytics give insight and decision support to the fatigue risk management system.

Wimal says the cost typically is around US$2 per person per day for mining applications – making it an attractive entry-level prospect. However, critics point out that, although cheap and relatively simple to implement, it is a one-dimensional approach that cannot readily be integrated with other safety features and imposes a high degree of intrusion upon wearers.

HOLISTIC APPROACH

All safety experts are eager to stress that investment in technology alone – irrespective of the number of layers – is not sufficient to decrease accidents caused by fatigue. There is no silver bullet or stand-alone solution.

Accident prevention begins with an understanding of the complex causes of fatigue. These include physiological reasons and circadian rhythms, along with behavioural issues such as late nights and the effects of alcohol; and operational sources such as shift length, scheduling and the type of task being undertaken.

Employee engagement and understanding is vital. Operators may fear an underlying agenda of 'you're tired, you're fired'. Others, especially experienced operators, will display the 'super-hero' complex and will resist change because they believe they can effectively manage their own fatigue.

Then, there may be serious privacy and oversight concerns, particularly with wearable technologies that rely on tight skin contact for good conductivity.

In all scenarios, there is likely to be resistance to the 'Big Brother' syndrome unless the value of the technology can be clearly communicated.

There is also a need for fatigue-monitoring to become embedded in a broad, holistic approach to safety. "A comprehensive and holistic approach to fatigue management within a broad risk-management framework with multiple layers of protection that embraces culture, policies and training as well as new technology will always be more effective. Organisational change has to take place, so often the progressive roll-out of one technology at a time is easier for cultural adaptation and integration into new working practices," says Hirtz of Hexagon Mining.

There is also a clear need to convert the vast quantities of data generated by fatigue monitors into a usable predictive planning tool via integration with other systems in order to leverage the maximum benefits from continuous improvement.

Looking to the future, Angelone of Caterpillar is optimistic about the growth potential of the marketplace. "We see mining companies continuing to implement additional safety measures for the workforce and the continued growth of comprehensive Fatigue Risk Management Plans," he says.

However, he sounds an important note of caution. "We also expect to witness continued growth in the use of autonomous vehicles and in the remote operation of vehicles from a safe area. These systems obviously change the need for operator fatigue monitoring," he concludes. ♥

There is a clear trend towards increased integration of fatigue-monitoring systems with complementary solutions, such as collision avoidance