

Staying awake on the job

Choosing the right type of fatigue management can save money – and lives – as the growing number of industry players demonstrates. Nadav Shemer investigates

“As far as human beings and evolution go, the concept of working in the night time hours is relatively new and not something our bodies have adapted to deal with”

In our jobs, every one of us experiences fatigue at one stage or another: our eyes struggle to stay open, we become distracted by other matters, and our work suffers as a result.

Now imagine you are suffering from fatigue while operating heavy equipment such as a haul truck, excavator or wheel loader. The consequences can be expensive – and even fatal.

NEED TO STAY ALERT

Industry statistics show that about two-thirds of traffic accidents in surface mines are caused by driver fatigue or exhaustion, according to Peter Stegmaier, Hexagon Mining’s chief marketing officer and co-founder of SAFEmine.

In some parts of the world, he points out, governments and regulatory bodies are already moving towards making safety precautions mandatory.

Erich Smidt, Guardvant-vice president of sales and marketing, refers to data from Caterpillar to demonstrate the importance of proactive fatigue management. Caterpillar has found that 93% of haulage-truck accidents in open-pit mines are due to human error and that 60-70% of human error-related accidents are fatigue-related, he says.

Jim Huemmer, a management consultant for Shiftwork Solutions, points to research from the US National Sleep Foundation, which has found that shift

workers average only 6.5 hours of sleep compared with the average 6.9 hours.

“Although many managers are aware that shift workers obtain less total sleep and quality of sleep than other employees, they may not be aware of correlations with absenteeism, short cuts, mistakes, lower productivity and other factors that also affect their costs,” Huemmer says.

Ian Thomas, managing director of Fatigue Management International, agrees that human beings were not designed for shift work and explains that in many cases they find it difficult to adapt to such a lifestyle.

Life can also stand in the way of getting the required amount of recuperative sleep at the right times, he explains. This causes sleep-debt to accumulate; like any other kind of debt, at some point there is payback.

“Now place that individual with that level of mental impairment into a low-stimulation, task-repetitive environment such as driving a haul truck round and around in circles for hours and hours at relatively low speeds and you will see just how easy it is to fall asleep behind the wheel, especially at the most vulnerable times of the day when your circadian body clock is at its lowest ebb,” he says referring to early mornings and mid-afternoons.

Although most of those who responded to *Mining Magazine* have



had more experience dealing with open-pit operations, they agree that underground operations are just as vulnerable to the effects of poor fatigue management.

Underground and surface operations typically use different rosters, but the emphasis on safety from both types of operations will ensure a similar standard of attention to mitigating risks associated with fatigue, Huemmer notes.

“Every mining operation is different, with a unique mix of equipment, capacities, maintenance schedules, logistics, and employee interests. Identifying and minimising fatigue-related risks requires careful consideration of these site-specific parameters,” he explains.

The advent of 24-hour mining means open-pit miners are deprived of sunlight in the same manner as their counterparts underground.

Anthony Fraser, business development manager for SmartCap, explains: “When we go for long periods without exposure to sunlight, it does have the potential to disrupt our natural rhythm. As far as human beings and evolution go, the concept of working in the night time hours is relatively new and

First Name	Last Name	Fatigue Risk	System Health	Details
Giuseppe	Gullizzoni	HIGH	✓	ⓘ
Alison	Bradford	MEDIUM	✓	ⓘ
Marco	Bottom	MEDIUM	✓	ⓘ
Manly	Macfarlanes	LOW	✗	ⓘ
Valerie	Liberty	LOW	✓	ⓘ
Nathan	Clark	LOW	?	ⓘ
Guido	Gullizzoni	LOW	✓	ⓘ
Jim	Jones	LOW	✓	ⓘ
Amanda	Jenkins	LOW	✓	ⓘ
Famela	Jefferson	LOW	✓	ⓘ
Jeff	Heiders	LOW	✓	ⓘ
Jim	Jones	LOW	✓	ⓘ
Amanda	Jenkins	LOW	✓	ⓘ
Famela	Jefferson	LOW	✓	ⓘ

A sample of the warning box displayed to supervisors as part of Hexagon Mining’s SAFEmine system



certainly not something our bodies have adapted to deal with.”

The commodities downturn has awakened some companies to the benefits of investing in technology, says Hexagon Mining’s Stegmaier.

Whether cost-cutting and shifting schedules, other by-products of the downturn, will have any effect on fatigue is yet to be proven.

“It is very difficult to say as fatigue is not something that is typically measured on a daily basis,” states Fraser.

“Most research indicates that increasing from an eight-hour shift to 12-hour shift will increase the risk of fatigue incidents... Fatigue in itself is very subjective and only recently have we had the tools to practically quantify and measure it. What we can say is that stress plays a large part in the quality of our sleep and the commodities downturn certainly isn’t doing anything to alleviate people’s stress levels.”

Huemmer of Shiftwork Solutions agrees that it is too early to tell whether there will be any noticeable impact on worker fatigue. He says higher operating costs and lower commodity prices will put pressure on most mining managers to do more with less – and

that identifying fatigue-related risks helps companies to quantify what gains are possible before making a final decision on the optimal solution.

“Getting it right the first time is more important than ever,” he declares.

CHOOSING THE RIGHT SOLUTION

Fatigue-management technology can be roughly categorised into those that pre-empt or predict and those that react or detect.

Or, as Carol Setters, VP sales for PRISM Fatigue Management, divides it:

- Pre-emptive (i.e. education or training);
- Predictive (i.e. PRISM’s own fatigue-risk indices);
- Performance (i.e. alertness testing); and
- Detection (i.e. smart caps, eye monitoring).

All of these technologies are essential in keeping fatigue risk at bay, but the majority of companies still focus on technologies that only catch fatigue at the point of failure – after it has been in play for two to three hours, Setters argues.

“The key here is focusing on a

comprehensive approach that includes prediction. Fatigue management, ideally, is self-managed and provides the type of real-time data that keeps employees and supervisors in front of risks, and gives workers the kind of immediate feedback that actually influences the culture of the environment,” she says.

A robust, sustainable, fatigue-risk management system should be a blend of training, education and awareness, and a flexible and practical policy actively supported by senior management, adds Thomas.

At the operational coal-face it should include a set of customised fatigue-monitoring and fatigue-management technologies and tools that are aligned to each other, he suggests.

“Nice in theory, not so easy in practice as expectations on ROI [return on investment] tend to be immediate but the shift change in attitudes and processes required to make it all work is not always quite as immediate – so you can find yourself caught up in conflicts of interest,” he says.

Mines should consider ease of use, ease of installation and the ability to integrate with existing safety technology when choosing a fatigue-monitoring system, adds Stegmaier.

And it should also be unobtrusive and avoid disturbances such as unnecessary alarms, he recommends.

Huemmer says mining companies need to understand that fatigue-monitoring systems vary and they will need to develop policies to address different levels of fatigue found in the workplace.

Some systems are very conservative and find fatigue with almost all hours of work, especially if night-shift hours are worked as part of the roster cycle, he explains.

“Evaluating fatigue-related risks and options for mitigating these risks require an understanding of site operations, logistics, work requirements, opportunities for sleep, sleep quality and other factors,” he says.

“For example, we obtain feedback from shift workers that show on average that a worker achieves 1.3 hours less sleep per shift when working night shift compared with working day shift, and 1.9 hours less sleep when compared with a day off. This information is useful for evaluating how well an existing workforce is coping with their hours of work and designing optimal solutions, but does not make it unsafe to work night-shift hours.

“Identifying fatigue does not automatically make an activity unsafe.” ►

Fatigue can be a critical problem for operators of heavy equipment such as haul trucks

“Most research indicates that increasing from an eight-hour shift to 12-hour shift will increase the risk of fatigue incidents”

Solutions providers

Mining Magazine spoke to several providers of fatigue-monitoring solutions. Their products are detailed below.

Guardvant OpWeb sample report for fatigue-event distribution over the 24 hours of the day during a set period

FATIGUE MANAGEMENT INTERNATIONAL

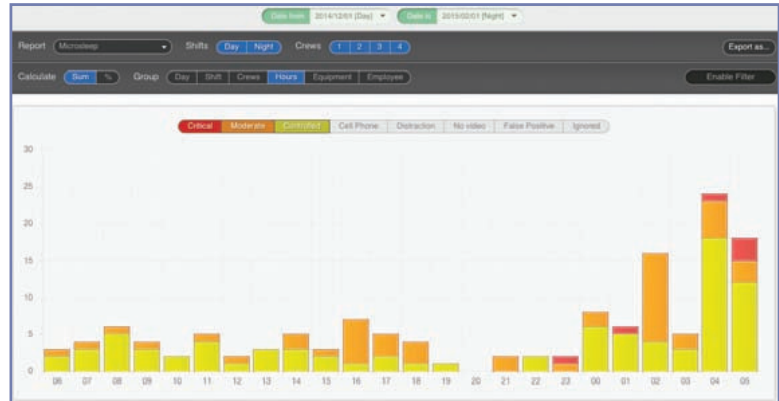
FMI offers consultation services, mobile apps and technology to the mining, oil-and-gas and transportation industries.

Its Fatigue Radar system is a business-intelligence platform that turns real-time data into information on practical steps to manage workplace fatigue. Users can integrate multiple data streams such as risk assessments, self-assessments, supervisor assessments and fatigue-risk management action plans into easy to use, click-and-view dashboards that are accessible on any device.

The Advisory System for Tired Drivers (ASTID) can be fully integrated into any GPS or Wi-Fi based fleet-management system to help develop operator self-awareness through real-time data management. It can feed into the Fatigue Radar backend-reporting system to interact with other data inputs such as production and asset tracking. It is non-invasive: there is no technology for drivers to wear and there is no intrusive filming during driving.

FMI's main R&D focus is a multi-sensory fatigue-assessment technology, under the working name of 'Project Bodyguard'. It will target anyone who is seated and operates something that requires alertness and vigilance.

Mining companies that have used a



blend of FMI's services include: Rio Tinto, Anglo American and Debswana.

GUARDVANT

The Guardvant OpGuard system provides miners with a tool to keep operators safe and to realise the financial benefits of mitigating fatigue and distraction risk, according to Smidt.

The system comprises a passive



optical sensor that tracks percentage eyelid closure, micro-sleeps and 3-D head positions. This in turn feeds an algorithm that processes and alerts for operator fatigue, and for distraction events such as phone-use or reading, as they occur. Driver behaviour can also be monitored for braking, hard steering and violent truck movements.

OpGuard can be integrated with Guardvant's ProxGuard collision-avoidance system to provide situational awareness for operators and management. The ProxGuard system issues collision warnings based on inputs from radar, camera and GPS.

The Guardvant OpWeb Office Server offers comprehensive system configuration, diagnostics and reporting. This intuitive tool allows the supervisors and dispatchers to configure and monitor operational performance through a real-time dashboard and reporting-tool interface. Standard and customised reports for fatigue, distraction, hard braking and speeding can be organised by operator, truck, shift, time-range and location and then be linked with other operational data.

On the R&D side, Guardvant is developing integrated solutions that add value in the areas of mine safety, operations and engineering. This includes work on improving safety, reducing costs and improving the haul-truck operator's user experience.

The next-generation Guardvant Mobile Server is enabling this through on-board integration, allowing the hosting of multiple applications in a single on-board platform, Smidt explains. This includes fatigue monitoring, collision avoidance, fleet management, biometric access and other third-party applications. ▶

This computer hub unit is the nerve centre of Guardvant's OpGuard system

Staying awake in the Arctic

Mining Magazine was reminded of the importance of fatigue management during a recent visit to EuroChem's Kovdorskiy open-pit mine in Russia's Arctic north-west, a 24/7 operation where workers must cope with complete or near-complete darkness for several months a year.

EuroChem is about to adopt Esmo, a Russian system already in use by Uralkali, Polyus Gold and Gazprom.

This fully automated software can be easily integrated into databases such as Oracle, 1C and SAP to assess the readiness of each employee to conduct their work.

Before each shift, employees sit down at an Esmo terminal equipped with a camera, thermometer, breathalyser and a tonometer to measure eye pressure. Any employee deemed to be under the influence of drugs or alcohol or otherwise unfit for work undergoes a series of tests and examination by a private health worker. Employees that do not meet the necessary

medical standards are prohibited from entering the danger zone.

The system maintains a record of all data, including video and photographs, and sends the statistical reports to all relevant units of the company. All disputes are resolved by utilising archived data.

Traditionally, companies would employ three health workers, each of whom would spend three-and-a-half minutes examining one employee. The Esmo examination takes one minute and 10 seconds, meaning it can check 52 employees in one hour – one employee more than the three workers would treat in the same period.

According to Esmo, it takes four months on average to implement the system: one month for research and development of the technical assignment, two months for construction, and one month for installation, training and commissioning.

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Vehicle-tracking functionality within Hexagon Mining's SAFEmine software

Guardvant solutions have been deployed around the world by mining companies including Gold Fields, Goldcorp, Codelco, Anglo American Platinum, DeBeers and Cloud Peak Energy.

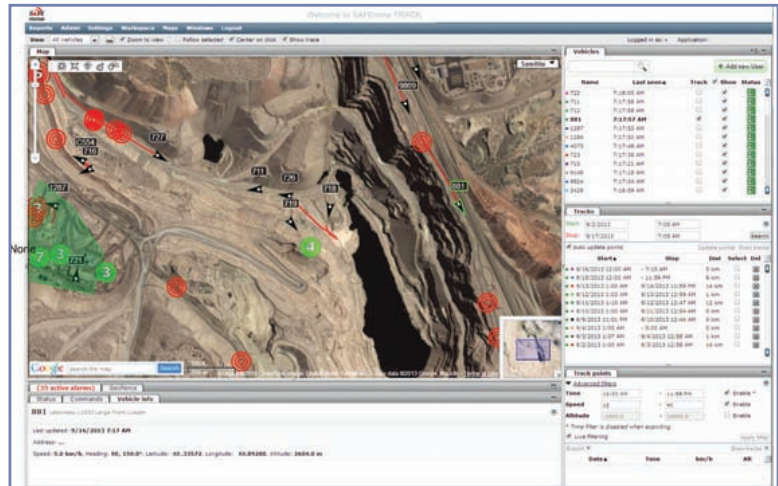
Gold Fields is one of several customers to have conducted a cost-benefit analysis of Guardvant equipment. It studied the use of the OpGuard system in a Cat 785 haul truck at its Tarkwa mine in Ghana, and presented the findings at the SME conference in Denver in February.

Between January 2011 and December 2012, before installing the system, Gold Fields recorded 19 potentially fatal fatigue-related incidents and recorded US\$691,000 in direct damages and repairs from fatigue-related incidents. In 2013, with the OpGuard system, it recorded just one fatigue-related incident that could have led to a fatality, and US\$150,600 in costs that could be directly marked down to fatigue-related damages or repairs.

HEXAGON MINING

SAFEmine, Hexagon Mining's safety arm, is the developer of FatigueMonitor, a solution that combines data from fatigue-detection and collision-avoidance systems to minimise accidents involving mining vehicles.

Developed in partnership with the University Hospital of Berne and the University of Zurich, Hexagon Mining says FatigueMonitor is the industry's first



multi-technology fatigue-detection system for monitoring driver alertness.

The solution is integrated with another SAFEmine product, Collision Avoidance System, which uses audio and visual indications to warn of possible collisions and supports operators by improving traffic awareness in blind spots around the vehicle.

FatigueSupervisor is a web-based application that provides dispatchers and supervisors in the control room with all fatigue-related data – historical and real-time – of all haul trucks, personnel carriers and fuel, water and service trucks equipped with the system. A black-box recording technology allows supervisors to analyse incidents. The application does not require drivers to wear additional equipment, such as glasses or caps.

The Premier coal mine in Western Australia reported a 53% reduction in metal-to-metal contacts within a year of fully implementing SAFEmine technology, according to Hexagon Mining. Likewise, the general manager of another Australian operation reported to the 2014 Queensland Mining Industry Health & Safety Conference that his mine had reported just two machine incidents in the two years after implementing the SAFEmine system, as opposed to 14 incidents in the 12 months that preceded its installation.

PRISM SAFETY SYSTEMS

PRISM is a predictive model that can alert workers and supervisors about fatigue risk before serious safety concerns arise, sales chief Carol Setters says.

Hexagon Mining calculates ROI

Hexagon Mining provided MM with three case studies to demonstrate the potential return on investment of having the SAFEmine Collision Avoidance and Traffic Awareness System avert just one major incident. The analyses assume similar fleet size and implementation costs for the SAFEmine system at each mine, plus ongoing cost of ownership.

Case 1

At a surface gold -mine parking area, a haul truck backs into another haul truck (dump body strikes cab). No one is injured. One truck is down for repair for five days (10 shifts). This mine averages one incident per year.

- Cost of repair: US\$200,000
- Lost production: US\$660,000
- Total per incident: US\$860,000
- Total over five years: US\$4,300,000

The total investment for SAFEmine technology over five years is US\$1.8 million. Because the technology potentially eliminates these types of accidents, the total savings to the mine is potentially US\$2.5 million over this period.

Case 2

One person dies when a haul truck backs over a light vehicle at a large surface coal mine. Mining operations stop for two days for an investigation. This happens once in five years.

- Loss of vehicle: US\$40,000
- Lost production: US\$9,120,000
- Cost of truck repair: US\$120,000
- Fines: US\$240,000
- Cost of fatality: US\$9,500,000
- Total per incident: US\$19,020,000

Because this results in a fatality, it is the most drastic of the case studies with potential costs approaching US\$20 million. The benefits of eliminating a fatal collision are obvious, but this illustrates that investing in a collision-avoidance system makes financial as well as moral sense.

Case 3

A surface coal mine in a hot climate experiences premature tyre wear and tyre failures on haul trucks. Several trucks are travelling faster than recommended, causing tyres to overheat and delaminate. This occurs about four times a year and results in two non-injury collisions between haul trucks in 10 years.

- Tyre replacement: US\$50,000
- Lost tyre life: US\$20,000
- Lost production: US\$10,500
- Total per tyre incident: US\$80,500
- Cost of truck repairs: US\$400,000
- Total over five years: US\$2,010,000

Hexagon Mining says the CAS speed-monitoring and alarming functions reduce speeding events by 90% in this example. This cuts costs by US\$1.85 million over five years, including two avoided collisions.

PRISM provides all aspects of fatigue management, including bio-mathematical shift schedule evaluations to ensure fatigue-safe scheduling, compliance reporting and fatigue risk assessments.

In five stages, the system captures and analyses real-time fatigue data from every employee, predicting when their condition will downgrade and offering helpful countermeasures to head off the effects of fatigue.

When a fatigue warning level has been reached, the worker and supervisor are notified immediately. The fatigued worker selects, completes and documents the chosen countermeasure, usually without disruption to their shift. Management can then review real-time and historical fatigue analysis by employee and department.

Through various partnerships around the safety industry, PRISM can also incorporate drug- and alcohol-detection systems into its solution at the request of clients.

PRISM has been partnered with Anglo American's South African mines for four years and has tested its product at the Kolomela iron-ore operation – where it has seen a 35% reduction in high-potential and lost-time incidents per tonne of ore hauled. It has also noted a 3% increase in worker attendance and a 38% reduction in hours worked in severe- and high-fatigue zones. And 72% of all workers surveyed agreed that monitoring fatigue improved safety.

PRISM will roll out its product globally in 2015. It is also working with several safety experts to expand its predictive safety model to include many data points in occupational environments. One example is the emergence of wearable technology, which can help to identify and analyse fatigue-risk factors 24/7.

SHIFTWORK SOLUTIONS

Shiftwork Solutions is an Australian provider of customised roster solutions. It evaluates the performance and fatigue-related risks associated with rostering practices and hours of work for the mining industry. It has developed a consultative process that works directly with managers, employees and unions to design and implement optimal solutions to address site-specific business requirements, employee requirements and health-and-safety requirements.

It is continuing to develop additional functionality and capabilities for its roster-management software, ROSTERkey. This software is designed to assist managers and employees working in shiftwork operations.



Shiftwork Solutions' services have been used by more than 100 mines and mining operations



Vale, BHP Billiton Iron Ore, Barrick Gold, Anglo American, Peabody Energy, Thiess and Xstrata.

SMARTCAP

SmartCap is a baseball cap with sensors concealed in the lining. It uses electroencephalography to measure an operator's brainwaves for risk of micro-sleep. It allows operators to proactively manage their own fatigue by providing alerts as the risk of micro-sleep is identified.

With the look and feel of a typical baseball cap, SmartCap is intended to overcome any reservations operators might usually have in regards to camera- or response-based technologies.

SmartCap is used by about 20 companies in five countries. Rio Tinto Coal Australia uses the system at several mines in eastern Australia and Assmang uses it at mines in South Africa.

According to SmartCap, operations that use its product have seen a greater than 50% reduction in 'alarm events', have effectively eliminated fatigue incidents, and see an average 16% increase in alertness in the first 12 months. ♥

Fatigue management is crucial in industries that use shift work

Photo: Shiftwork Solutions

SmartCap produces a baseball cap that monitors the wearer's brainwaves, pictured here with the associated display unit

ROSTERkey provides time-critical information for decision-making and allows mining operations to:

- Better visualise workload, employee availability and options;
- Optimise the allocation of both labour and capital resources;
- Manage changes in workload, shift assignments, relief coverage, training, etc.;
- Provide valuable information and alerts for managing operations and health and safety; and
- Monitor the performance of allocations, rosters and hours of work.

Shiftwork Solutions' services have been used by more than 100 mines and mining operations, including: Rio Tinto,

