Hitachi's Aerial Angle® technology enhances the visibility for operators of mining equipment by alerting them to obstacles when driving, stopping or starting their dump trucks

Peace of mind

Predicting and where possible eliminating fatigue in mining operations; as well as introducing new collision avoidance and object detection systems, remain top priorities for today's safety conscious mining industry, reports Paul Moore

Equipment-related accidents throughout the history of the mining industry have driven an ever-increasing focus on operator safety. Today, as regulatory agencies and mine organisations continue to strive for a zero-incident workplace, mines everywhere are placing even more emphasis on both standalone and fleet management system (FMS)-integrated safety solutions. So while mines are evaluating the many various collision awareness technologies available to the market today, each having their own strengths and weaknesses, how do mine managers know which is best?

Modular Mining Systems Global Sales Manager, Ed Bardo, told ***IM***: "Vehicle-to-vehicle collisions are among the top five causes of high-risk incidents in mines, resulting in equipment downtime, productivity losses, equipment- and personnel-related costs, injuries, and fatalities. These factors have generated a global motivation to focus on vehicle safety within mines, including increased regulation and legislation that will soon require mining organisations to have and use a safety system that can detect and minimise vehicle collisions."

He adds on regional drivers: "In South Africa, for example, legislation states that any open-pit mine in which a collision risk is significant must include a means for any 'diesel-powered trackless mobile machine' to automatically detect the presence of any other such machine within its vicinity, and upon detecting the presence of another machine, the operators in both vehicles shall be alerted to each other's presence by means of an effective warning, such as an audible and/or visual cue. Australia does not yet have legislation in place, but New South Wales has pre-specified basic capabilities that will have to be adhered to when their legislation is enacted in order to meet specific safety requirements. For example, a mine that requires Proximity Awareness Technology will be required to utilise a system that alerts the operator to a potential collision; this alert could include an audible alarm, a visual cue, or both."

Bardo says that the common weakness that the existing proximity and collision awareness approaches on the market today have is the inability to filter out events that are not actually a potential vehicle collision risk. "Modular Mining Systems' approach to collision awareness focuses on minimising false alarms while providing real time information about high-risk potential incidents. Modular's MineAlert™ Collision Awareness System (CAS) utilises intelligent path prediction and scenario-based pattern recognition algorithms to filter out the potential non-risk based nuisance and proximity alarms, which can dramatically reduce the false alarm rate. This gives the operators of mining vehicles increased situational awareness by providing critical decision-making safety information only when it matters."

One of the major challenges for a collision awareness system is the ability to predict the actual direction a driver is going in the near term (one to five seconds out). "Many systems on the market today use range and proximity sensors that alert operators when two vehicles are approaching each other; as mentioned previously, proximity, speed, and bearing alone will often alarm in normal operating conditions, even though no collision risk is imminent. A common example of this is when two haul trucks on the haul route are passing each other on a curved road going in opposite directions and in different lanes. This appears to be a collision due to the fact that the

vehicles will, at some point, be in close proximity to each other and with what appears to be intersecting paths. If proximity, speed and general bearing are used alone in classifying the risk, the normal passing manoeuvre will trigger an alarm when no danger exists. To make matters worse, operators will learn to ignore the system since they receive these alarms with regularity in normal, safe operations."

Modular's path prediction capability enables the system to accurately differentiate vehicles travelling in different lanes and also determine that their paths are not likely to intersect. This acts as another filter against false alarms and provides a more trustworthy warning when an alert is issued. The path prediction algorithm works with collision scenario recognition to provide a strong filtering mechanism that alerts operators only when a true risk exists.

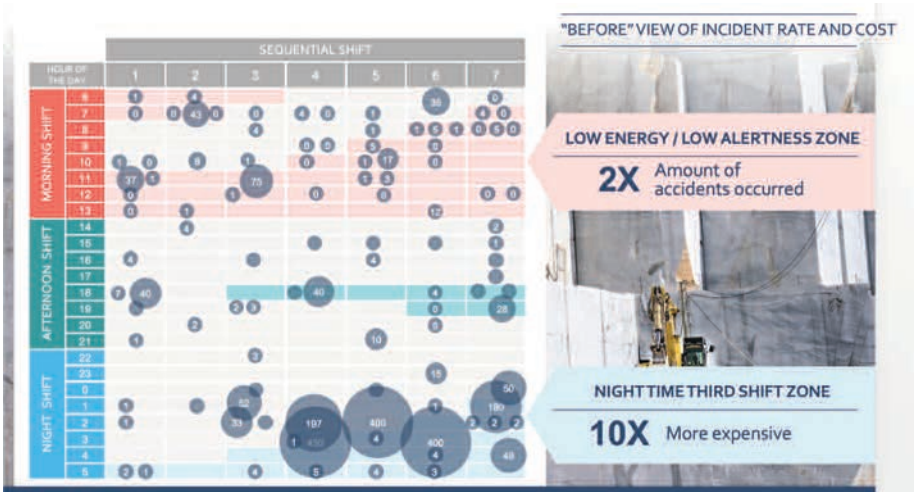
Communication is the fundamental component of any safety system, as this defines how quickly and reliably information will be passed to the end user. The MineAlert system utilises Direct Short-Range Communications (DSRC), a high-speed, low-latency peer-to-peer communications standard developed specifically for safety applications in the automotive industry. This communications technology allows timely alarms and informative warnings to reach operators without delay. DSRC is a peer-to-peer communications system, so it operates in an environment with no wireless network infrastructure, allowing for full functionality on routes in and between mines, as well as for drivers commuting to a mine site in system-equipped light vehicles. It also virtually guarantees long-term compatibility with future vehicle standards and regulations. DSRC is a standards-based safety protocol that helps ensure forward adaptability as vehicle technology progresses.

"One of the most effective ways to eliminate false alerts is by implementing a system that recognises dangerous situations or scenarios and differentiates those from safe situations. For example, vehicles may be moving towards each other or are in close proximity, but are not actually a collision risk. Modular's system addresses many of the most common vehicle-collision scenarios as identified by mining safety groups and the automotive and commercial transportation industries. These include such common vehicle accident scenarios as forward collision warning (FCW), head-on collision (HOC), blind spot warning (BSP), intersection movement assist (IMA), and do not pass warning (DNPW). Multiple levels of alarms notify operators of potential hazards; if an operator doesn't take corrective action after the first notification, more urgent, audible warnings will sound. One of the key differences in the Modular approach to informing and alarming the operator of the vehicle is the quick end to any alarm that is no longer necessary. This means that if an operator has taken an action to prevent a potential incident after receiving a warning, both the visual and audible alarms will end automatically without requiring operator intervention. Modular's CAS dynamically recognises changing situations and scenarios in real time, triggering and removing alarms based on real-time actions. This provides immediate operator feedback about dangerous actions and truly provides information to improve situational awareness."

Predictive fatigue management

While many systems looking at operator fatigue in mining are real-time and reactive, **Predictive Safety's** new FMS solution both monitors and predicts worker fatigue, which it says helps workers get in front of and manage their fatigue. "The conversation for starting the process at a new site often begins with a Fatigue Risk Assessment. The attached chart displays several key data insights demonstrating FMS's strong prediction abilities. On this new site, FMS has shown a distinct ability to not only accurately predict worker fatigue zones, but also the relationship between elevated fatigue zones and increased incident rates. Establishing a baseline like this is key to FMS's process and allows our clients the insight needed to reduce the presence of fatigue at a work site."

In the chart shown, FMS reveals the highest



Predictive Safety's new FMS solution both monitors and predicts worker fatigue, here showing the highest fatigue risk time zones

fatigue risk zones near the end of the morning (5am to 2pm) and night (10pm to 5am) shifts, especially as workers increase their consecutive shifts. The bubble graphics represent each incident and their damage rates. The graph shows that the large majority of incidents are occurring within high or severe fatigue zones.

"Now that we have a solid measurement for these fatigue damages we can begin to manage the risk. Another interesting insight that emerged from our data involves incident damage rates. While the morning shift saw the largest number of incidents, the night shift saw damage rates nearly ten times greater than the other shifts. When incidents occurred at night, the problems are clearly more serious."

Hexagon Mining VIS and FatigueMonitor

Hexagon Mining previewed new and improved safety technology at MINExpo 2016, including a first look at the company's Vehicle Intervention System (VIS), which adds a powerful layer of protection to its highly popular Collision Avoidance System (CAS). Also in the spotlight was the next generation of FatigueMonitor, a computer vision technology that monitors operators while they drive to prevent fatigue-related incidents.

"Our safety solutions minimise two major causes of accidents in a mine – blind spots and fatigue," said Hexagon Mining President, Hélio Samora. "This integrated technology is essential to our mission of helping companies run safer, more productive mines."

VIS assists the operator and takes control of a machine in certain situations when the operator does not react appropriately to a CAS alert. FatigueMonitor prevents incidents by alerting drivers for distractions and fatigue so as to keep their attention focused on the road. Both solutions are significant additions to SAFEmine CAS, which is installed in more than 25,000 vehicles in over 55 mines worldwide. "FatigueMonitor helps protect operators and assets in several ways," explains Barbara Hirtz, Product Manager at Hexagon Mining.

Computer vision algorithms are only activated when the operator is actually driving and thus, when there is a potential risk for an accident. Furthermore, FatigueMonitor presents rolling fatigue risk estimations for each operator which includes factors such as the time of day, shift counts, shift changes, driving hours, and computer vision alerts generated by the system. "The tool shows the operator with highest fatigue risk always on top which makes it really easy to use" says Hirtz.

Operators are continuously and transparently informed via the dashboard-mounted display in the truck and so are the supervisors via a control room application showing all active operators at a glance. Once a fatigue or distraction event is identified, the operator hears a unique alert. Simultaneously, the recorded 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.

Fabien Kritter, VIS Product Manager at Hexagon Mining says that VIS is known in the mining industry as a level 9 system according to EMESRT guidelines. "Level 7 covers proximity detection using cameras, radar etc, and the ability to see what is around you," explains Kritter. "A level 8 system is one that allows you to predict the future and provide a collision avoidance alarm to the operator. A level 9 system builds on this by intervening in a hazard situation. On the truck, VIS allows for different actions from cutting propulsion up to activating the service brake."

Kritter describes VIS as the next level up from the SAFEmine CAS. "VIS is doing what is also being developed for high-end automobile systems in that it assists the driver when appropriate. A typical example is forgetting to apply the brakes of the truck when queuing which may have dramatic consequences depending on the situation if you are on an incline."

VIS is an additional layer of safety to guard against human error. It will further mitigate the consequences of incidents that impede safe production in operations. There are many situations where this system can be applied to assist operators in their daily tasks, lowering the risk of an accident and allowing for smoother and more productive operations.

In terms of industry use and testing, Hexagon Mining was approached over two years ago by

VIS testing at the Anglo Kumba Iron Ore Sishen mine

Entering data directly into Pitram Mobile tablets provides the control room with real time information regarding the location of equipment

Anglo American's Kumba Iron Ore, which was also one of its first CAS customers, and told Hexagon, "we need a solution to make our operations safer and go further." Hexagon's VIS was subsequently piloted at the Kumba Iron Ore Sishen mine in South Africa as part of its Operator Assist Project, which assists haul truck operators to prevent imminent collisions.

"VIS has now been tested over 10,000 hours in a production environment. A project of this magnitude has never been done before. But the return we got from operators was very positive; they really like the system and see the benefit of it. The mine management also liked it because it makes their operation safer but most importantly it didn't disrupt production or cause any downtime, and they also got the good feedback from the operators," said Kritter.

"Anglo American – Kumba Iron Ore has always believed that good technologies can be a game changer for their operations, to reduce safety risks and improve safety efficiencies and most importantly, save people's lives," said Kritter. After the successful field trial, Kumba Iron Ore has decided to roll out Hexagon Mining's VIS solution across its operations.

VIS and FatigueMonitor are the next levels addressing safety in mining, and represent a significant building block in the zero-harm goal.

Avoiding collisions with mining software

MICROMINE says its leading fleet management and mine control solution, Pitram, provides the capability to monitor equipment usage and prevent potential collisions in both underground and surface mining operations. "Pitram allows the transfer of data from equipment, directly inputted by operators via the Pitram Mobile device in each cabin, to the control room via the wireless network on site. Direct data entry provides a higher level of data integrity and reliability that cannot be guaranteed when radioed to the control room. Utilising Pitram Mobile reduces the likelihood of human error by accurately collecting and transferring data

directly to the Pitram server without the need for manual input. This avoids incorrect figures being entered, therefore providing the control room with a more accurate representation of current equipment allocation."

An underground operation utilises proximity detection warnings that alert equipment operators and the control room when a potential collision is likely to occur. Pitram warnings assist in the prevention of such instances, warning operators ahead of time to ensure the safety of workers is maintained.

Pitram's collision avoidance capability is furthered by the machine guidance module. "The module has been designed to improve the productivity, utilisation and accuracy of machines by utilising high precision software to provide accurate measurements and reduce the need for rework." MICROMINE partnered with North American company, **Carlson Software**, to further enhance tracking of the mining operation through the use of high precision capabilities. The benefit of high precision software is that the control room has accurate, real-time GPS precise locations of equipment.

"The addition of high precision GPS to a mine site increases safety standards by reducing the possibility of a mine collision through real-time data. The alarm system tracks and alerts the equipment operator, if necessary, when a machine breaches the exclusion radius, or if the machine leaves a safe work boundary. The GPS locations in Pitram have the additional benefit of assisting with maintaining a safe working environment by providing warnings to operators in regards to machine speed, proximity to a dangerous situation or if materials are dumped in the wrong location."

MICROMINE states that implementing a mine collision avoidance system like Pitram assists in raising the standard of safety on site and helping to prevent injury or death due to vehicle interaction. "Solutions that identify the likelihood of risk and assist with mitigation before they pose a problem are invaluable to mining operations. Implemented correctly, these solutions have the capability to greatly reduce the chance of an accident while maintaining operational capability and productivity."

SmartCap introduces "Life"

SmartCap Technologies, a leader in driver fatigue monitoring, has introduced 'Life by SmartCap'. The new product Life was launched at MINExpo 2016 in Las Vegas. The company states: "SmartCap has always focused on producing unique alertness wearables that are comfortable, accurate and protect the user's privacy. With the new product taking SmartCap to the next level, customers are expected to experience even more satisfaction with the new design features."

SmartCap Life users can monitor fatigue levels anywhere, anytime via Bluetooth. The LifeBand connects to the Life App, which allows users to have their personal fatigue data at their fingertips, so they can be their own fatigue manager

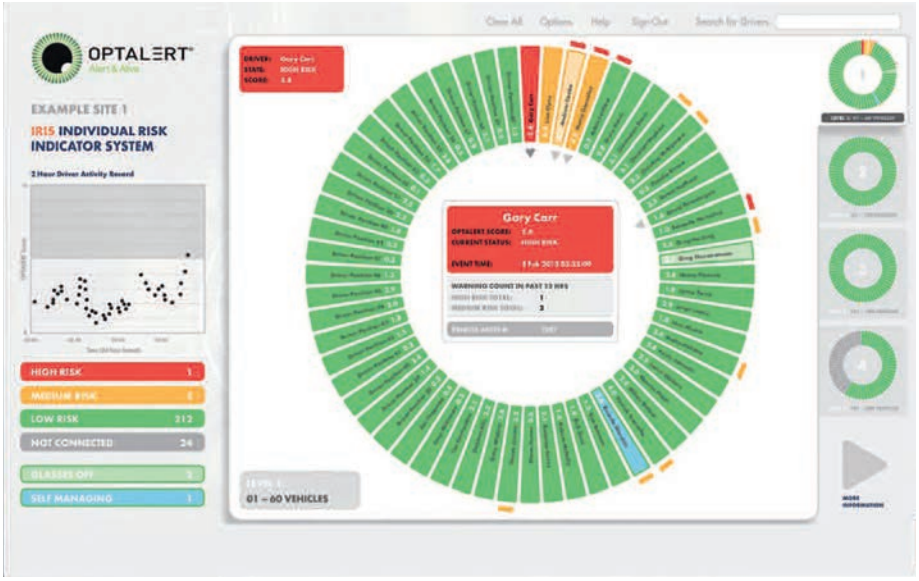
SmartCap says that what sets Life apart from the previous product offering is the focus on the end user, with a strong focus on creating a community of users. SmartCap Technologies CEO, Dush Wimal states: "SmartCap has already taken a market leading position in the mining market over the last 12 months. With the launch of Life we will be able to help more people manage their fatigue and alertness anywhere, anytime. Life is the world's most effective fatigue monitoring solution that provides real-time feedback. Our early warning alarms, combined with real-time monitoring, enable proactive intervention to better manage fatigue risk."

Users can monitor fatigue levels via Bluetooth. The Life system consists of the LifeBand, which connects to the Life App, available from the Apple Store and Google Play. The band has a long-life battery that lasts seven times longer compared to the previous model. No calibration is required and unlike other fatigue monitoring products, the LifeBand doesn't require set up before every use so mining users can get on their way quicker. It is also one complete unit so parts can never go missing, and the replaceable sensor components mean users can self-service their own device with ease. The LifeZone feature of the App allows users to have their personal fatigue data at their fingertips, so they can be their own fatigue manager. Having the access to regular reports reinforces personal responsibility. Like the predecessor SmartCap products, Life "utilises the gold standard in sleep science – EEG [electroencephalogram] technology. You and your family can experience peace of mind knowing that Life measures, not guesses your fatigue level so you can get home safe, every day." Mining users can choose the headwear that suits them, whether a hardhat or cap or other to attach the LifeBand. Life utilises state of the art brainwave technology to determine alertness, to eliminate microsleeps with accurate fatigue measurements. They can then download the App for Bluetooth connectivity and to allow progress tracking to support wellness initiatives. A fatigue level 'speedometer' view provides real time alerts to prevent microsleeps before they happen. The screen also adjusts for night and day time settings and alerts you when the cap is fitted incorrectly. It also protects user privacy by making the recorded data personal, while also being available in different languages.

Combining collision avoidance and drowsiness detection

Optalert, one of the leading drowsiness detection providers, recently agreed with **GE Mining**, the global mining solutions provider, to work together on the integration of Optalert's early-warning drowsiness detection technology with GE Mining's Collision Avoidance System.

Collision Avoidance Systems (CAS) protect miners above and underground by providing 360° proximity protection for vehicles, equipment and



Optalert's products continuously provide real-time objective, scientifically-validated alertness information to both drivers (in cab) and supervisors

personnel. By integrating Optalert's algorithm into the CAS, this would expand those parameters to include driver performance, improving the safety paradigm for heavy vehicle drivers.

"Effectively, that means our quantifiable drowsiness score can help regulate the tolerance of collision avoidance, so if a driver is less alert, the distance allowed for collision avoidance would be increased," Optalert CEO Scott Coles said.

"This means a greater layer of safety and protection for heavy vehicle drivers and it also highlights a significant industry change, with scientifically-proven drowsiness detection now considered an important component of safety monitoring in mining. Optalert's technology concentrates on the driver, not just their behaviour, and can detect when a person is more at risk of becoming a drowsy driver, rather than wake a person who has fallen asleep. No other technology working in this space is able to measure drowsiness with any objective accuracy. Every mine has a goal of zero-harm. Together, Optalert and GE will work together to help bring the industry closer."

GuardVant mining orders in Africa and Latin America

Operator fatigue and close proximity areas of reduced operator visibility — or blind spots — are widely recognised as two of the leading causes of mining accidents involving mining equipment. Turning to a more advanced way of monitoring fatigue and distraction, Southern Copper Company (an indirect subsidiary of Grupo Mexico) has installed **GuardVant** OpGuard systems on its mine fleet at La Caridad mine in Mexico. "With the installation of the OpGuard system, Southern Copper Company expects a decrease in safety incidents and operating costs as well as an increase in equipment availability." The OpGuard Operator Fatigue and Alertness Monitoring System uses a non-intrusive infrared camera to monitor the operator's eye closure and head movements for signs of fatigue and distraction. When a fatigue or distracted-driving event is detected the operator is immediately alerted by in-cab audio alerts and seat vibration. OpGuard automatically turns on when a haul truck is in operation, which helps operators easily and consistently adopt the technology.

Located 23 km southeast of Nacozari de Garcia, Mexico, the open-pit mining operation produces copper, molybdenum, gold and silver. Initially mined back in the 1800s, La Caridad reopened in 1979 and had an annual production of over 126,000 t of copper in 2014, contributing to Grupo Mexico's ranking as one of the top 10 largest copper producers in the world. La Caridad currently employs over 1,000 people at its mine site. Grupo Mexico has 14 mines and exploration projects across Mexico, Peru, the US, Chile, Ecuador and Argentina. GuardVant solutions are currently used at three other Southern Copper Company mines: Buenavista, Toquepala, and Cuajone.

The Guardvant OpGuard Operator Fatigue and Alertness Monitoring System uses a non-intrusive infrared camera to monitor the operator's eye closure and head movements for signs of fatigue and distraction

Newmont Ghana has also selected GuardVant's fatigue monitoring, proximity detection and collision avoidance systems for its operating gold mines Akyem and Ahafo. "By combining fatigue monitoring, close proximity detection and collision avoidance, Newmont Ghana is combatting 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 programs that further reduce the number of accidents. The reduction in accidents also positively impacts equipment availability and productivity," said Emmanuel Kwame Attifu, IT Country Manager for Newmont Ghana.

Kwame also added: "After an intensive evaluation of solutions, GuardVant was selected as the most desirable solution for the African region based on the maturity of the system in terms of its functionalities, scalability, reliability and reporting structure."

Newmont Ghana selected both ProxGuard and CollisionGuard to reduce close-proximity accidents caused by blind spots. ProxGuard uses long- and short-range radars and video to detect objects in close proximity. The in-cab video screen immediately displays the view when a sensor detects an object within its range. CollisionGuard uses GPS and peer-to-peer communication to display the relative position of any equipment outfitted with CollisionGuard on the in-cab monitor. "As a result of implementing these safety solutions, the operator's situational awareness of other heavy equipment, light vehicles, and pedestrians will improve and increase."

Peripheral vision

Hitachi Construction Machinery introduced a peripheral vision display system with object detection technology called Aerial Angle® at MINExpo 2016. The technology enhances the visibility for operators of mining equipment by alerting them to obstacles when driving, stopping or starting their dump trucks.

"Customers around the world are striving to enhance efficiency of the entire mining supply chain," said Craig Lamarque, Division Manager, Hitachi Construction Machinery. "As a result, there is an increasing demand for machinery manufacturers to incorporate information communications technology (ICT) into mining machinery and management systems, and to provide solutions that integrate these technologies. This technology addresses the important customer issues of enhancing operator awareness, improving productivity and reducing life cycle costs."

Hitachi Construction Machinery previously provided full-perimeter display systems for dump trucks and hydraulic excavators used in mining. The new object detect assist technology features two operating modes – Stationary Mode, which incorporates camera image processing technology used in the Around View Monitor® with Moving Object Detection System developed jointly by Nissan and Clarion; and Forward Mode, which incorporates millimetre wave radar technology developed by Hitachi.

In Stationary Mode, a warning is provided to the dump truck operator when the vehicle is stopped or starting to move, if any moving objects such as other vehicles are detected nearby. The warning is displayed in the driver's seat monitor with accompanying sound. Moving objects are recognised through images captured by cameras mounted on the front, rear, left and right sides of the dump truck. By quickly notifying the operator of any

changes to the surrounding environment, the system contributes to improved operator awareness.

In Forward Mode, a warning is provided to the operator while driving, when approaching another vehicle on the road ahead. The approach warning is displayed in the driver's seat monitor with accompanying sound. This mode uses millimetre wave radar, which is effective in poor visibility conditions such as rain, snow, fog or dust.

Two types of warnings are provided to the operator based on the radar data, according to factors such as the approach distance and relative speed of the object. Through these warnings, the system contributes to the operator's awareness of the surroundings.

In addition to its use in the Aerial Angle system, the object detect assist technology is also being integrated into Hitachi's driverless autonomous dump trucks that are currently in development.

"Hitachi Construction Machinery Group embraces the 'One Hitachi' concept of using the construction machinery technology that it has accumulated over many years in combination with its strengths in ICT, control and Internet of Things technology," said Lamarque. "Moving forward, we will continue to serve as a familiar and trusted partner by providing reliable solutions that resolve customer issues through collaborative creation."

Proximity awareness

Caterpillar is introducing a new collision avoidance system, Proximity Awareness, for surface vehicles. Part of the Cat® MineStar™ Detect capability set, the new system uses the latest peer-to-peer communications leveraged by the automotive industry. The system "delivers fast and reliable communications between vehicles and presents collision avoidance information to operators without the need for a robust radio network covering the site."

The onboard hardware can be fitted to light vehicles and to any brand of surface mining equipment. Fewer components are required compared to the previous Cat Proximity Awareness system, which uses a WiFi network. The result "is reduced space required onboard vehicles, fast installation and lower cost."

The onboard display can store up to 24 hours of incident data. This data is sent to the office for storage and analysis by using strategically located communications hot spots on site. Incident capture, playback and reporting are independent of MineStar Fleet.

Cat MineStar Fleet, Proximity Awareness and Object Detection can run on a single, in-cab display. The new Proximity Awareness system also features alarm tones that operators can easily distinguish from alerts delivered by other systems. "When combined with Fleet in the office, enhanced reporting includes operator performance as related to the number of safety incidents. The new system retains the many features provided by the previous system, such as avoidance zones, speed zones, highly configurable machine envelopes and projected paths, operator notifications, incident capture and playback for training or incident reconstruction. Like the previous system, the new system is easy for operators to use. The Proximity Awareness system presents information to the operator via an intuitive graphic display in the cab."

Caterpillar now offers object detection systems for all brands of mobile surface mining equipment

The system provides three onboard alarming levels. The zones, which define alarming, are customer configurable. Alarming priority ranges from low to critical. Low priority indicates the projected path of a machine is on course to collide with another machine, or it's following another machine too closely. Critical alarms occur when two or more machines have their closest zones intersect. If machines routinely are in close proximity, such as loading and hauling vehicles, alarm filters can be implemented between machines classes to silence non-critical warnings.

Caterpillar has also announced the availability of Cat® MineStar™ Detect Object Detection systems for additional Cat machines and virtually all brands of mobile surface mining equipment. Previously unsupported Cat machines as well as other brands of machines can now be equipped with the cameras, radars and in-cab displays that deliver increased site awareness to mobile equipment operators.

Object Detection kits are available with one to four cameras and as many as eight radars for applications ranging from small auxiliary equipment to ultra-class mining trucks. "Functionality remains the same as the proven Object Detection system equipping Cat mining trucks from the factory and available as a factory option on several Cat wheel loaders and wheel dozers."

The expanded line of retrofit kits enables enhancement of safety and standardising of mixed fleets for the benefit of operators and maintenance technicians. Object Detection is wholly contained on the machine and does not require the installation or operation of any off-board infrastructure. The system is also fully supported by Cat dealers.

Detect Object Detection is designed to work during machine startup and when a machine is travelling at low speeds. The system employs radar capabilities to automatically detect hazards such as other equipment or vehicles within critical zones around the machine – in front, at the rear and each side. The system also presents specific camera views to show the operator where potential hazards are detected. A proximity bar on the in-cab display flashes yellow or red, depending on the distance of the detected object. *IM*