The leap to Level 9

Development of collision avoidance technology is now very focused on so-called Level 9 technology where the vehicle can actually act itself to take evasive action where needed. While already embedded in the autonomous haulage industry, it is coming also in standard operations, led by South African legislation but likely coming to Australia and elsewhere soon. Paul Moore spoke to the major stakeholders

Collision avoidance as a topic in the mining industry is much more than just applying proximity detection sensors – the complication comes from there needing to be some kind of standardisation or protocol across the industry taking into account the innumerable potential types of interactions that can occur on a minesite, both surface and underground, between vehicles and between vehicles and workers; and from a technology standpoint trying to ensure the approach is consistent across technology suppliers, particularly when it comes to the point of what action is taken when a collision risk is detected. And on top of all this is being able to offer a system where the machine can take its own action to avoid a collision.

There are several lines of progress relating to collision avoidance technology – regulatory evolution from governments (still being led by South Africa), testing and research by institutions and groups such as Mining3 in Australia and the University of Pretoria's Vehicle Dynamics Group, and industry led work on establishing definitions, guidelines and protocols such as by the ICMM, ACARP, ISO and EMESRT.

South Africa has taken the lead in regulatory matters through Chapter 8 of its new Mine Health and Safety Act which laid out requirements for the whole mining industry in RSA to effectively have Level 9 compliant systems in place for trackless mobile machinery (TMM) – for which a deadline was initially set for June 2020, then extended to December 2020. However, this extended deadline has again been postponed with no new date announced as yet. However, it is still likely to be set for 2021, so is still far ahead of the ICMM stated target of 2025, which has meant that the industry in some cases has taken the view of focusing resources on South Africa for now and not necessarily applying that worldwide until it is mandated.

Testing to meet SA Chapter 8 has been focussed on the University of Pretoria's Vehicle Dynamics Group at the Armscor test site, though tests have also now also moved on to actual minesites and a few mines are now actually running Level 9 systems. The VDG has also been working with Mining3 in Australia in an effort to develop some kind of unified South Africa and Australia collision avoidance (or what it calls Collision Management System or CMS) technical strategy, For example, the two groups worked together on an online sensor technology capability tool providing users with unbiased information on Proximity Detection System sensors to assist in their decision making process.

Transport and mobile equipment accidents accounted for 30% of fatalities at ICMM operated mines in 2018, the highest cause of fatalities at ICMM member operations. ICMM's collaborative Innovation for Cleaner, Safer Vehicles (ICSV) programme aims to promote collision avoidance technology capable of eliminating fatalities from vehicle interactions, available to mining companies by 2025. To help companies start a conversation, a Maturity Framework was collaboratively developed by ICMM members, OEMs and other technology providers involved. The ICSV initiative is led by a CEO Advisory Group comprising leadership from BHP, Anglo American, Gold Fields, Caterpillar, Komatsu and Sandvik. Not much more has been said on the collision avoidance side of things to date, apart from

The University of Pretoria's VDG has now conducted about 35 tests with its test vehicles (Land Rovers) and tests on actual trackless mobile mining (TMM) equipment on mining sites: six with ADTs as pictured plus one with an LHD and one with a rigid haul truck

the organisation saying in 2021 "ICMM's company members will focus on integrating the initiative's goals into their corporate planning processes, allocating internal resources and effectively leveraging external resources such as synergies with other industry initiatives and collaboration between member companies."

EMESRT's Vehicle Interaction group

The Earth Moving Equipment Safety Round Table (EMESRT) is a well-known global initiative involving most of the major mining companies which engage with key mining industry OEMs to advance the design of the equipment to improve safe operability and maintainability and also issuing guidelines for the industry. Since 2013, EMESRT has led and participated in industry-level initiatives with the common goal of improving the reliability of what it calls Vehicle Interaction (VI) controls in mining.

The goals of the EMESRT Vehicle Interaction group are to clearly define the problem and risks associated with vehicle to vehicle and vehicle to person interactions; understand the scenarios where the risks are high; and build a set of performance criteria by which to evaluate proximity detection and collision avoidance technologies.

Central to this has been EMESRT taking the central role in developing a common interface protocol to allow PDS controls in mixed equipment fleets. This has led to the development of the international standard ISO21815 Collision Awareness and Avoidance – that formally defines the interface protocol. EMESRT's work has also included publishing definitions of VI levels of incident preventative controls (see box) of which there are nine, Level 9 being what everyone is currently interested in as it includes the vehicle actually taking action.

EMESRT told ***IM*** that it was advised in November 2020 through the ISO21815 committee meeting minutes that the Part 2 (Interface Protocol) is currently being prepared for publication, which will be a big step forward adding to the general guidelines that have already been published. EMESRT for its part says it is continuing to work collaboratively with industry stakeholders on guidance material including development of an integrated package of information and support material including a draft Vehicle Interaction Self-Review tool for baselining current mining user site performance before considering the introduction of new technology and other innovations.

EMESRT work has also included the development of interoperability standards between third-party PDS suppliers and equipment supplied by OEMs – a

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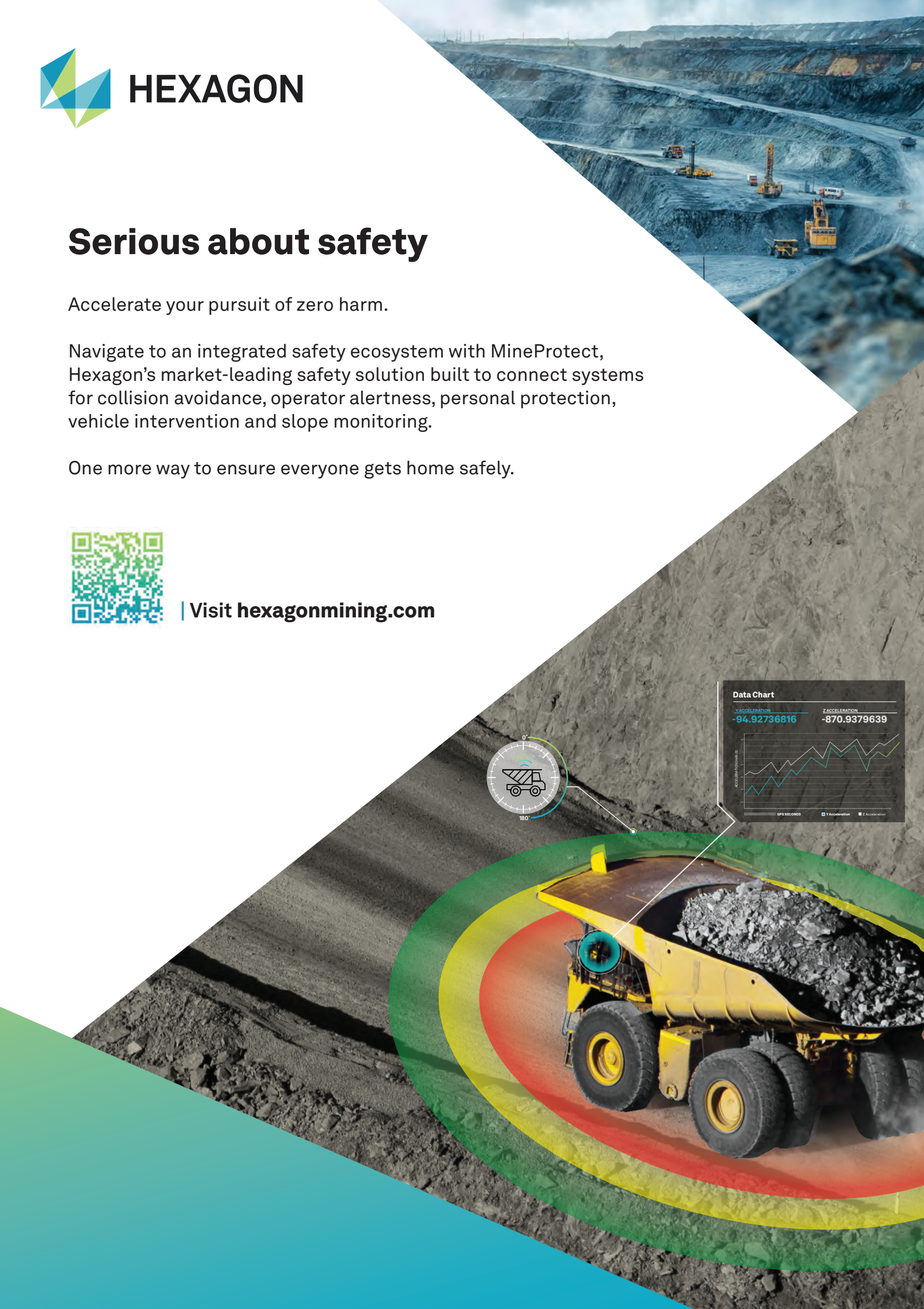


common interface protocol allows PDS controls in mixed equipment fleets. It also includes collaboration with the ICMM Risk Committee, ICMM Collaborative Technology Acceleration Summits and ongoing support for the mentioned ICMM Initiative for Cleaner Safer Vehicles (ICSV) programme. And it covers supporting and contributing to the industry review of the Australian Coal Industry's Research Program (ACARP) Proximity Detection System Validation Framework Project C26028, which also involves Mining3. EMESRT has also financially supported the development of the ICSV Knowledge Hub for Vehicle Interaction, with the understanding that the underlying platform would be used on future EMESRT topic specific Knowledge Hubs.

ISO21815 progress so far

Currently the ISO lists three parts of the 21815 protocol – Part 1: General requirements, Part 2: On-board J1939 communication interface and Part 3: General risk area and risk level. Part 1 was released as a draft for comment in March 2020 and subsequently published. As stated, publication of Part 2 is imminent which will be followed by Part 3. Adhering to the ISO21815 protocols even though only the general requirements have yet been formally established has become the global standard which PDS technology suppliers and the mines themselves have sought to meet.

Companies currently claiming to have systems that meet ISO21815 and EMESRT Level 9 standards include Strata Worldwide and its HazardAvert system, Schauenburg Systems' CMS, and Booyco Electronics' CXS, all mainly focused on underground, plus in surface mining Hexagon's Vehicle Intervention System (VIS), part of its HxGN MineProtect portfolio and Wabtec's Collision Awareness System, part of its Wabtec Digital Mine suite of solutions. In Germany, Becker Mining Systems is set to launch a Level 9 system for underground in 2021, while numerous other players are also at various stages of testing and rollout.

The University of Pretoria has also developed a test to check compliance of both OEMs and CAS vendors to the latest draft of ISO/DTS21815-2 (the CAN protocol).

Mining3 to release testing methodology

Mining3 described its role to ***IM*** relative to collision avoidance technology as one of assisting the industry to develop a standardised testing methodology of the industry's various PDS systems as it points out that CAS Level 9 really requires proof that the fully autonomous element of vehicles taking their own action to avoid hazards really work. Susan Grandone, Mining3 COO told ***IM***: "They require peer to peer communication and 'sight' of each other as well as AI to assess and make decisions on the fly. This capability is simply not realised yet. However, because lives continue to be at risk, it is necessary to provide interim and transitional solutions. ACARP, EMESRT and Mining3 support and are working on a single, unified industry testing methodology with minimum baseline tests that are reliable and measurable for end users to acquire scientific facts and data quickly and cost effectively to understand which systems are best suited to their needs, operations, and environment. The added benefit of the framework is that suppliers can also employ the testing methodology to provide end users confidence but also to improve their products from the information acquired."

Grandone says that the test methodology is not meant to compare one system against another or to determine whether a particular system works or doesn't work per se. "It is meant to provide knowledge about the various sensors and sensor suites used in said systems - what they are, how they work together, the types of applications/environments they can be used most effectively, where they cannot be used effectively, the different levels of granularity provided by said sensors (such as high-precision GPS versus standard GPS) and so on."

Mining3 also has been developing and "testing" a test methodology using a Cat 777 haul truck, a light vehicle and other objects at its testing proving ground site in Pinjarra Hills, Queensland, to provide knowledge to end users on what sort of testing they should require and what sort of results they should look for and what those results mean. "We've also identified and specified a design of experiments (DOE) for said tests, a roadmap and 'blueprint' relative to a data acquisition system (how to connect it and calibrate it), that would be required to collect the test data, scripts that should be used to compile the raw data acquired and analyse data, fully understand what your data tells you, and perhaps most importantly, what cannot be safety tested and should be tested in a simulation environment."

Mining3 refers to this suite of elements as a PDS toolkit. "End users need tools that help them to make

PROVIX's proven underground camera tech

Cameras are also playing a crucial role in collision avoidance. **PROVIX** LHD camera systems have been implemented this year at Volcan's lead-zinc-silver mining operations in Peru to prevent collisions between personnel and equipment. Volcon completed a fleetwide project to analyse the effectiveness of the PROVIX camera system.. The intuitive LHD camera systems were successfully tested and implemented at Glencore's Kidd Creek mine in Canada back in 2012 and have been deployed at many other mines since including in Canada alone at Pure Gold's Madsen, Newmont's Borden, Diavik Diamond Mines, Evolution Mining's Red Lake plus Barrick Gold and Kirkland Lake Gold sites.

PROVIX comments: "Canadian mines have reduced interactions between heavy equipment and personnel due to the advent of collision avoidance systems. The LHD camera system project involved designing, testing and deploying a robust video camera system that does not require or allow any operator input. PROVIX integrated the camera system into the electrical control system of the LHD to ensure that all mobile equipment operation and maintenance standards were met. Kidd Creek worked with PROVIX to design the camera system and once the prototype was ready to deploy, Laurentian University analysed the effectiveness of the camera system through established Line of Sight [LOS] testing methods. Although the first systems were deployed on Sandvik loaders, the PROVIX interface panel was adapted to standardise connection to any type of underground equipment."

The cameras are positioned on underground trucks and LHDs in particular to eliminate blind spots, minimise equipment damage and maximise the operator's field of view. Opposite to the operator, two far side cameras are positioned to maximise visual awareness of the entire blind side which cannot be seen from the driver's seating position. The front camera is positioned on a light bar or the cab roof to achieve maximum forward visibility over a loaded bucket. The rear camera provides a full field of view behind the equipment. Each of the cameras provides part of a 360° view around the equipment.

LOS to ground level has been improved from values of 40 m to ⟵4 m around the perimeter of the machine when the LHD bucket is down. LOS to a standing operator in front of the machine when operating with a full bucket has been reduced from more than 60 m to ⟵20 m. LOS to a standing operator height is excellent for the entire 1 m which is the established testing boundary around the machine. They provide operators with more situational awareness and enhanced vision through expanded sightlines and "operators who have expanded vision and heightened situational awareness do not have to reduce speed as often. Decreased travel and trip times are the results."

There are additional benefits for remote LHD operation, as the camera system is enabled for wireless video transmission to a safe operator station locally or over the network for surface operation. Remote operation requires an additional camera(s) deployed on the operator's cab side. An integrated camera system that is suitable for both remote and manned operation reduces lost time when changing between the two operating modes and the cost associated is reduced.

informed decisions about how to select and use these technologies. They are not researchers or professional 'testers.' What we've done is try to provide knowledge and information, facts and data, and an 'instruction manual' of sorts to help them through the assessment process. An added benefit of what we've been developing is that the suppliers/developers of these technologies benefit by understanding how the system can/will be used and how they themselves should be validating/testing their systems."

All of this work is the culmination of almost five years of research and testing by Mining3 under the funding & auspices of ACARP and with funding & support from EMESRT. Mining3 says it has brought intellectual power to the table internally but has also collaborated and engaged with CSIRO, the University of Pretoria, and the University of Queensland Australia for substantive contributions. The project will finish in the next few months and there will be a dedicated website through Mining3 where all of the information will be made available to the industry.

While Mining3 is not developing independent CAS or PDS it is worth remembering that it did do the R&D on its own system called AcuMine back around 2005. It was a joint R&D series of projects with University of Sydney and it was a true peer to peer collision avoidance and awareness system – a SMART system. It was state of the art but the industry wasn't ready to take it on-board seriously at the time and it hasn't been brought back to the table due to IP and legal complexities plus today many OEMs and suppliers are developing these systems commercially anyway.

Grandone said that one of the significant findings of testing so far is that it cannot successfully and safely test CAS or PDS relative to any of the more complex, dynamic PUEs (potentially unwanted events) that are the most commonly occurring near misses or incidents in the surface mining industry and so cannot field test Level 9 controls for the same.

EMESRT VI Control Classification Level Definitions 7 to 9

Level 7 – Operator Awareness

Technologies that provide information to enhance the operator ability to observe and understand potential hazards in the vicinity of the equipment

- Ability to provide enhanced situational awareness
- Alerts the operator to a potential abnormal situation
- Provides context of the situation to the operator: Where is it? What is it? How far away is it? What is its heading? How fast is it going?
- Supports visual confirmation for the operator

Level 8 – Advisory Controls

Technologies that provide alarms and/or instruction to enhance the operator ability to predict a potential unsafe interaction and the corrective action required

- Determines an imminent threat of collision
- Provides a specific instruction to the operator to intervene (act)
- Operator assesses the instruction in relation to other contributing factors then intervenes (acts)

Level 9 –Intervention Controls

Technologies that automatically intervene and take some form of equipment control to prevent or mitigate an unsafe interaction

- Provides a specific instruction to the Machine to intervene (act)
- Machine assesses the instruction in relation to other contributing factors then intervenes (acts)
- Relinquish intervention control to the operator should they take evasive action
- Provides a manual over-ride to recover after a collision intervention scenario has occurred

"Mining3 is of the opinion that any and all such scenarios and Level 9 controls should be fully testing in a dynamic simulation environment. There are no such simulations designed for a mining environment and mining equipment today – R&D needs to done and partnerships established with the software simulation industry to leverage their current capability and frameworks and modify them with mining experts who have the mining knowledge, expertise and intimate knowledge to jointly develop a fit-for-purpose solution." "

University of Pretoria's VDG pioneers new underground test

An engineering team at the University of Pretoria (UP)'s Vehicle Dynamics Group has pioneered an underground procedure which tests the performance of collision-avoidance systems (CAS) in an effort to improve the safety of workers on mines by reducing unwanted interaction between vehicles and pedestrians. CAS assessments were previously limited to above-ground testing, and UP says its involvement in this has been a game-changer in the CAS space, having contributed significantly to the increasing maturity of commercial offerings. "With the VDG's recent development of an underground testing system, it is anticipated that the technology readiness of current underground CAS offerings will be even more improved." The performance of CAS is tested by way of a stage-gate approach. The first stage gate is a lab-scale test, which is conducted on light vehicles in a controlled environment. The CAS is installed on the light vehicles exactly as would be done in a mining environment. "These vehicles are equipped with brake robots that control the stopping distance and can be controlled to represent minimum brake specifications, while high-precision GPS accurately measures the speeds and positions of the vehicles," explains researcher Dr Herman Hamersma. "An advanced data capturing and control system is used to control the brake robot, and to record the GPS data and the decisions communicated to the test vehicle by the CAS." If the CAS passes the lab-scale test, it can proceed to the next stage-gate, where the system is subjected to a single interaction test, which is conducted in an environment that is more representative of a mine. To date, testing has been limited to surface tests due to the reliance on high-precision GPS as the ground truth measurement. However, the VDG team's recent development of an underground system makes use of lidar (which uses laser light to calculate distances), cameras and automotive radar to measure the distance between objects and their speeds. The system has been tested at a training facility at one of South Africa's underground mines, and the first live underground single interaction test is in the pipeline. The system will be used to validate the lab-scale results of underground CAS solutions in their intended underground environment where line of sight, dust and uneven, slippery road surfaces are serious concerns.

Underground collision avoidance test by the University of Pretoria's Vehicle Dynamics Group with LHD approaching a pedestrian dummy with underground measurement system

Schauenburg builds on Level 9 roadmap

With a substantial amount of underground and surface Proximity Detection Systems (PDS) installations deployed, **Schauenburg Systems** told ***IM*** it is proud of the current status of its Level 9 solution roadmap. "With more than 4,000 systems currently deployed, Schauenburg's Collision Management System (CMS) solutions are designed, manufactured and supported locally. This enables Schauenburg to provide exceptional service, accompanied with rapid support to clients, opposed to foreign-manufactured systems."

Schauenburg Systems adds that its CMS products adhere to the stringent guidelines as stipulated by the Minerals Council of South Africa to achieve Level 9 compliance. "Our product portfolio ranges from multi-technology tag-based solutions to Artificial Intelligent (AI) camera systems which assist with mitigating the risks associated with Trackless Mining Machines (TMMs), pedestrians and hazardous objects within an operational environment."

Schauenburg Systems has been developing and producing PDS systems for the mining environment since 2005 and the latest effort in terms of design, manufacture and supply is focused on Level 9 PDS systems to assist the mines with compliance in terms of sub regulations 8.10.1.2 (b) and 8.10.2.1 (b) of the Mine Health and Safety Act.

The company gave some useful detail on the significance of these sub regs. Trackless Mobile Machinery Regulations (TMM Regulations) were promulgated under notice N.R. 125 in the Government Gazette of the 27 February 2015. The TMM Regulations form part of Chapter 8 of the regulations made under the Mine Health and Safety Act No.29 of 1996 (MHSA). The regulations came into operation three months after the date of publication in the Government Gazette, except for sub-regulations 8.10.1.2 (b) and 8.10.2.1 (b) dealing with collision avoidance of diesel-powered TMMs.

"At the time of promulgation there was no available technology to enable diesel powered trackless mobile machines to comply with the requirements of sub-regulations 8.10.1.2 (b) and 8.10.2.1 (b). Therefore, the unavailability of technology means that compliance with the above-mentioned sub-regulations was not feasible. The challenge remains that deployment across all mining sectors to implement Level 9 by end-2020 will also not be feasible due to challenging interface constraints between the PDS suppliers and vehicle OEM suppliers as well as Level 9 readiness of TMM machinery. This circumstance of when the dates will be finalised is causing stakeholders uncertainty on how to effectively plan the way forward with technology, budgets and roadmaps to continue."

Legislation has driven the need for enhanced safety in underground and surface mining and initiated the advent of advanced products and information systems that have pioneered the era of underground and surface intelligent mine safety systems. Schauenburg quoted the following milestones related to Level 9 PDS solutions it has achieved:

- Proximity Detection Solutions for mining industry since 2005 (lab scale Level 7).
- Started with a typical Level 7 PDS solution referred to as SCAS I (2006 - 2010).
- System evolved based on client requirements to a Level 7 and Level 8 referred to as SCAS II (2011).
- Added additional technology/hardware to be suitable for Level 9 solutions - trials started (2013 – 2017).
- Implemented ISO21815 Protocol (initiated by EMESRT) and started interface testing with vehicle OEMs (2018).
- Successfully completed lab scale and single machine tests with University of Pretoria, including vehicle OEM and 3d party supplier interfaces (2019).
- Interface solutions for both old and new generation TMMs, which include third party interface suppliers.
- Registered trial sites for both Surface and Underground.

Schauenburg Systems has already Invested upwards of ZAR30million in development of its Level 9 PDS solution which involves an engineering

department consisting of approximately 15 engineers. "Schauenburg has always and still is committed to deploying a viable Level 9 solution to the mining Industry of South Africa. We have been part of the ISO21815 discussions since its inception through EMESRT and still provide reviews and insight with the rest of the industry. We now have our PDS systems on the ISO21815 protocol and have done extensive interface testing with some of the vehicle OEMs and we are involved with projects to showcase on-site single machine and multiple machine tests which include stakeholders such as vehicle OEMs, 3rd party interface suppliers, major mining clients, University of Pretoria and Schauenburg."

Surface single machine tests were conducted with a well known South African vehicle OEM at their testing grounds using the ISO21815 protocol "which was verified by the University of Pretoria as the independent testing authority and the tests yielded great success. All our Level 9 systems have been designed to cater for dynamic zones (zones that adjust automatically based on machine input to our PDS). This has been our drive as this solution on dynamic zones will undoubtedly provide the mining sector with an effective Level 9 PDS safety system with minimal impact to production."

To summarise, Schauenburg Systems says it is committed to finalising and providing all its clients with a Level 9 solution once we have tested and vetted all required tests as per DMR guidelines. It argues that a "mature" and commercialised Level 9 product offering takes time if one considers:

- Development, testing and qualification of a Level 9 system,
- Ensuring all stakeholders are ready for the applicable legislation date,
- Budget planning to ensure adequate funds are allocated timeously in order to achieve goals in the planned time,
- Resource planning (labour and parts) that is key for the industry to be ready for the final implementation dates on diesel powered machines for Level 9.

Schauenburg Systems has already Invested upwards of ZAR30million in development of its Level 9 PDS solution which involves an engineering department consisting of approximately 15 engineers

"Based on this enormous effort and investment required for Level 9 roll-out, Schauenburg Systems is committed, proud and focussed to provide the market with a quality, fit for purpose safety solution that will add value where it is due in the months to come" said Ettiene Pretorius, Head of SBU - Smart Platform Solutions at Schauenburg Systems.

Booyco continues success of CXS

With South Africa due to adopt some of the highest collision avoidance standards in the world, **Booyco Electronics** says it has also been working hard to ensure the necessary technology, systems and testing is in place.

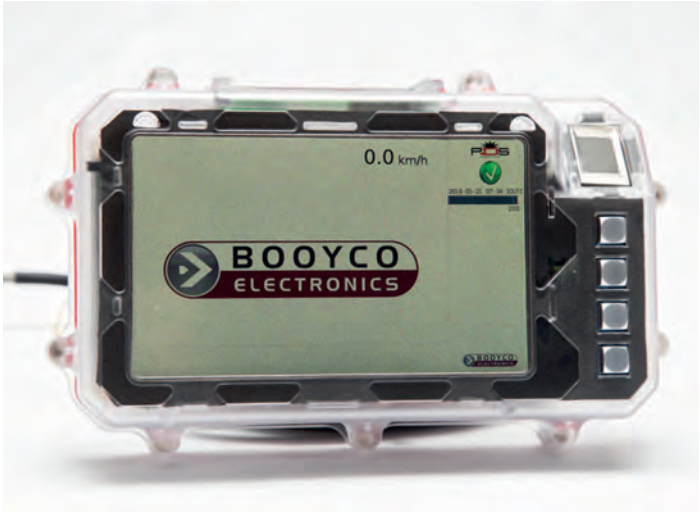
"Constantly developing our in-house technology to meet global standards and ever-tightening local regulations, Booyco Electronics' leading solutions are at the forefront of international safety systems," says Anton Lourens, CEO of Booyco Electronics.

He highlights that much of South Africa's mining sector had been aiming to meet raised government standards for collision avoidance by the end of 2020. These new standards align with Level 9 requirements as defined by the Earth Moving Equipment Safety Roundtable (EMESRT) initiative.

The company's latest generation Booyco CXS technology is suitable for both underground and surface operations within the mining industry. The system automatically gives a Level 9 intervention instruction to trackless mining machinery. This instruction should then automatically slow the machine down or bring it to a complete stop when a hazard is detected, and is not reliant on the operator reaction.

"Even during the COVID-19 lockdown, we have continued to work on integrating our technology into the range of different OEM machines, as well as mines' own systems," says Lourens. "This integration – which begins with the ISO21815 collision warning and avoidance standard – is vital to ensure that collision avoidance systems are effective in practice."

To further enhance collision avoidance, the company has also developed its Booyco Electronics Asset Management System (BEAMS), which collects and analyses data from the CXS system. This allows mines to identify patterns which indicate unsafe



The Booyco CXS the company says is a comprehensive integrated response to Level 7, Level 8 and Level 9 safety levels as defined by EMESRT

behaviour and can be used to design an appropriate intervention to prevent accidents being caused by such actions.

Booyco Electronics recently also stated that it is equipping 19 mechanised mining machines with its latest Booyco CXS proximity detection solution to enhance safety during the development phase of underground operations at B2Gold's Otjikoto gold mine, in Namibia.

According to Lourens, the order was placed by Murray & Roberts Cementation, one of the contractors establishing the underground stoping horizon for the Wolfshag zone at Otjikoto mine. The contract also includes sensing devices for 120 underground personnel on the operation, which will be included in the employee's cap lamp to provide an alarm.

"Our equipment will help achieve the highest level of safety by mitigating the risk of collisions between pedestrians and vehicles, and between vehicles, on this project," Lourens says. "The installation of our CXS units is in line with the commitment by the mine and the contractor to zero harm in the workplace."

Murray & Roberts Cementation's project will take 28 months and will be conducted with local company Lewcor Mining. The contract will include a decline of 5 m wide by 5.5 m high being driven to the orebody from a portal in one of Otjikoto's depleted open pits. The operation will be highly mechanised, with equipment including drill rigs, dump trucks, LHDs and utility vehicles, as well as shotcreting and ancillary equipment. MacLean Engineering confirmed earlier this year that it had won an order for 3-Series Cassette Trucks from the mine.

Lourens highlights that Booyco Electronics' latest generation CXS system is a comprehensive and integrated proximity detection solution, taking a step beyond being just a warning system to become a "true collision avoidance system".

He added: "The CXS system on this project will deliver Level 7 and Level 8 capability in terms of the Earth Moving Equipment Safety Roundtable (EMESRT) and can also accommodate Level 9. Although there is not yet a legal requirement for collision avoidance systems in Namibia, our customer and the mine adopt a global best practice approach to all aspects of safety in mining operations."

With the mine's location more than 300 km north of Windhoek, it is important the equipment is robust and reliable to ensure maximum uptime, according to Lourens. "To ensure that the equipment performs optimally, we have trained the customers' artisans on how to look after it," he said. "A qualified serviceman from Booyco Electronics will also visit the site regularly to audit performance, assess the equipment and conduct any necessary maintenance."

Becker Mining – Level 9 solution set for 2021

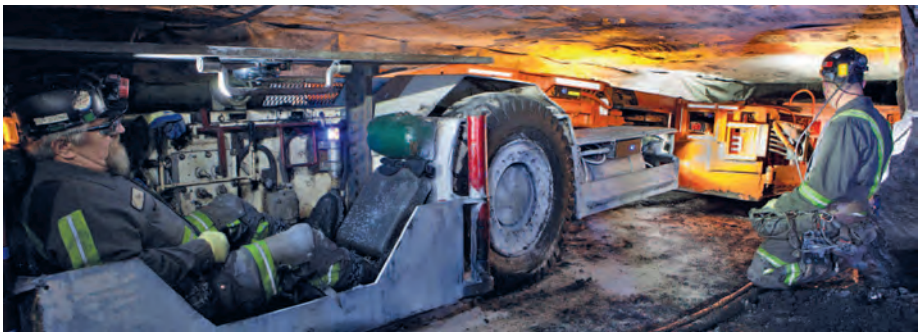
Becker Mining Systems' Jonas Maximilian Becker, its Engineering Manager told ***IM*** it has a project under development at the moment to take its existing CAS system to the next level, specifically to meet EMESRT Level 9 requirements and also to conform with ISO21815 standards. "That is the main goal for our new CAS system which we are calling PDS4.0. We feel the differentiator will be that it will be more connected than other systems as we wanted it to have integrity with MineView, our state-of-the-art, web-based light SCADA software solution which enables innovative management of complex infrastructure and information using a 3D model. We have various global mining customers that already use MineView with our hardware underground so it is important for us to ensure that PDS4.0 is part of this."

MineView already helps Becker customers visualise performance of its CAS (UCAS for underground and ICAS for surface) via its tagging and tracking capability, using proprietary protocols. Becker says it is aiming to start trials of its PDS4.0 systems in Q2 2021, probably at the University of Pretoria's VDG test centre initially. It is already trialling the tech at its own test mine in Germany. PDS4.0 is planned to be available by Q3 2020. For now it would be a mine retrofit solution but discussions are also ongoing with equipment OEMs about also offering a factory fitted solution.

The company also told ***IM*** that typically a problem with existing systems is that the machine operators view CAS as an annoying system that is always beeping and interrupting their concentration work processes. There have been examples where CAS installations have been damaged by operators. "So we also wanted to focus on our offering being as practical and intuitive as possible. Notably we wanted something that minimises false positives for the operator without missing real dangerous situations. Our system has three sensor technologies that combine for maximum reliability – electromagnetic for obstacle detection, UHF for long distance detection of other vehicles and workers & RFTOF which offers the required accuracy."

Perfecting L9 in coal then hard rock

IM spoke to Ian Cillie, General Manager of **Strata Worldwide** in South Africa, which has one of the longest running and most advanced installed bases of Level 9 PDS globally. He comments: "In the absence of regulatory standards globally, what EMESRT did was to create a platform on what expectations were. The requirements are without doubt difficult, but they at least represent a start to where ISO will go and where global regulation will eventually be. That said, some mines in South Africa have said that initial EMESRT standards and testing were not as relevant to their own conditions as they would like. We have done a lot of testing for and with customers in an underground situation where they have taken a lot of what EMESRT has done but made it more practical to their own environment. This is a kind of organic testing with customers."



Strata's Gen 2 HazardAvert is already being trialled in SA hard rock mines as well as being deployed in coal mines that have been using Gen 1 for years

Today, as it is the only real benchmark available, Cillie said the key mining customers looking at PDS are setting EMESRT as the main bar to start testing and trials, whether those are independent tests or through UoP's Vehicle Dynamics Group. EMESRT protocols are very similar to those cited in the ISO21815 standard, which will take over in the next few years as the bar to meet once all parts have been published, given that it is issued by the International Organisation for Standardisation. And while South Africa is the current focus due to the DMR mandate, Cillie said the Strata engineers in Australia are already getting a lot of questions and there is a lot of work being done, not just by EMERST but also ACARP and Mining3. "But the focus is very much still on SA due to the legal deadline looming, despite having been extended. A lot of the mining players are watching what the others are doing."

In collision avoidance technology, Strata has a long history of running Level 9 systems going back 13 years – a long time before it was called Level 9. It was referred to as full slowdown and stop. This autonomous stopping technology was first applied in the underground coal industry in SA and has been running very successfully ever since. Strata says it has always been the leading PDS supplier in that market. "The larger underground coal miners in South Africa chose Strata from the beginning, and the learnings we achieved have enabled us to meet a lot of the EMESRT demands today. One of the differentiators over other PDS is our system is incredibly practical and easy to run. It doesn't need a high skill level to change out components and set up fields or to resume operations if there is an issue."

It happened in UG coal first as the initial DMR mandate required all trackless electrical equipment to have the technology installed, well before it was required on diesel machines. In SA this meant mainly continuous miners, roof bolters, feeder breakers and shuttle cars. Cillie conceded that this is an easier form of interaction to manage with PDS due to the machines being slower moving, tethered and often more "intelligent" than a lot of the ageing diesel LHD and truck fleets. That equipment requires the addition of an interface to be able to use the technology.

Strata has also worked closely with key OEMs like Sandvik and was the first PDS supplier in SA coal mining to start working with diesel LHD machines. Level 9 was achieved on these units several years ago at Anglo Coal operations. Overall, Strata says it has over 1,000 HazardAvert systems in South Africa running for more than a decade and these are true Level 9. "Getting from Level 7 to Level 9 is a big jump in terms of technology, system intelligence and reliability. It cannot be bypassed by the operator. Our systems do self-diagnostic checks to make sure there are no faults with the machine, and if there are, HazardAvert will put the machine into complete stop. This forces the mine to keep up with high level maintenance. We knew the market would evolve to Level 9 so we focussed on that from the start. We have been very successful in coal and are now focusing on hard rock."

Looking at hard rock, Cillie said it has recently completed the most comprehensive testing in the industry to date at an underground manganese mine in the Northern Cape province. "This is been a highly successful test with an incredible set-up utilising the EMESRT protocols and expert consultants. They have been able to pull it all together and make risk assessment reports for the client. Following a technology review only two PDS suppliers were selected in the end for the trials, Strata and one other. Tests started on the surface then moved underground. The mine is still reviewing the results but both companies performed well."

Some South African mines are waiting for a more cost-effective solution for collision avoidance. High-tech Level 9 systems include costly sensing technologies to ensure they reach the required standards. Other mines are still dominated by underground rail haulage and in these cases, less sophisticated systems are more than adequate.

Strata's Gen1 HazardAvert system for coal mining was primarily V2P (vehicle-to-person or pedestrian). This is where the coal industry originally saw the most risk. But things are changing, and coal miners are now looking at V2V (vehicle-to-vehicle) for faster moving diesel units. Strata has now developed the Gen2 system that includes V2V and it says it is the first company in the industry to start V2V PDS rollout. Strata now has V2V flameproof and non-flameproof options. The Gen2 system has been available in coal mining for about three years and will be used in hard rock.

Cillie said key to its success with customers in coal and now in hard rock has been the incredible

reliability of HazardAvert's electromagnetic (EM) fields. "Once we set it up it doesn't waver; it is very predictable and most of our competitors cannot yet match that. In a highly mechanised mining environment where machines are often in close proximity to other machines and to people, if the fields vary you start getting a lot of false positives and warning alarms which will negatively impact productivity and employee morale. Even though our EM fields increase depending on speed, they remain consistent and predictable." EM, while the backbone of the HazardAvert system, is one of several sensing technologies that Strata uses. On surface Strata's system uses HPGPS with geofencing for longer range and fast-moving machines, and EM for close proximity. Underground, EM is the primary method as it works through dust, air curtains and even a certain amount of rock strata.

Interestingly Cillie said that some of the larger equipment OEMs have not shown the level of interest that might have been expected in offering PDS options, or at least the interface to allow the technology to be used. Part of this is related to SA just representing a small part of their global market share and partly them not wanting to take on the implied extra safety liability inherent in providing solutions. Also, most mines have mixed fleets underground, so it makes sense for the miner to fit one system of PDS across all their machines as it is easier to train personnel and safety technicians. Strata's HazardAvert is OEM agnostic and works with any type and make of equipment, regardless of age. That said as ISO21815 comes in and becomes more of a global issue, it is likely the equipment OEMs will want to offer a factory fitted solution.

Hexagon VIS broadening its scope & functionality

To get an update on **Hexagon Mining**'s progress in surface mining Level 9 CAS technology rollout, ***IM*** spoke to HxGN MineProtect Portfolio Manager, Marcos Bayuelo. The company's core offering is Vehicle Intervention System (VIS), an additional layer of safety on top of its Collision Avoidance System, (CAS) helping to avoid incidents, injuries, and fatalities. Mine VIS manages traffic in the pit and, by reacting when and if operators do not, it ensures safety rules are followed, including the vehicle taking action.

He comments: "All VIS functionalities and features are now integrated with CAS, such as operator notifications for launch alarm, asset protect, brake alert. This allows our customers to understand if they had an incident that could have been avoided if VIS was installed, as well as current interventions before VIS is enabled. Customers can see the outcomes of intervention: how many over-speeding incidents, ramp alerts, near misses – and any actions that would have been taken automatically by the vehicle, avoiding an issue or reducing the consequences of it."

Hexagon has also introduced a new way of performing dynamic configurations, meaning the customer can now configure notifications in a more dynamic way: ie notifications can be configured as a dynamic voice output with specific words or phrases for dynamic unwanted situations. "For example, a voice message 'Slow down! Light vehicle in front' can be configured when an unwanted event of low criticality is detected, or a 'Stop light vehicle in the rear' if a high criticality situation is detected. This allows our customers to customise the Level 8 notifications to the site specifications and provide actionable directions to operators to enhance the decision-making of the final users, increasing the system adaptability, and effectiveness to enable operators to avoid accidents."

In addition to the integration of CAS 4.6 with IDS Georadar, introduced in June 2020, the system can now log vehicle encounters, enabling mine management and operations to understand risk exposition of their vehicles. "Our customers can now measure traffic density and see the risk exposition of individual vehicles in the mine in relation to and interaction with other vehicles, as well to understand if risk locations are correlated to the traffic density of the place, enabling new ways to measure and normalise the risk to which our operators are exposed."

CAS integration with Hexagon's Operator Alertness System (OAS) also means one GPS antenna for positioning for both systems, as well providing external camera awareness; a top view of the traffic and radar detections on a single screen for the operator, decluttering the cabin and enabling a single source of safety information. It also means capability to record video via external camera whenever there's unwanted interaction, allowing real-time assessment and classification in control room (*for more on OAS see this month's Fatigue Management article*). The company adds: "We are trialling the benefits of a combined CAS-OAS at operations in South America and Australia with good results. Main benefits seen to date are video proof of near-miss collision events (system confidence), and cause and affect correlation between collision and fatigue." MineEnterprise CAS Analytics also now means that KPIs can be monitored monthly, weekly, daily, ie top 10, top-20 operators under risk, system availability, etc. A whole new set of dashboards includes the integration of OAS heat maps and collision avoidance data.

Recent CAS deployments include large copper mines in Peru and Chile, a large coal mine in western Canada, large coal mines in Australia and continued deployment at Anglo American's Kolomela iron ore mine in South Africa.

Wenco on the CxS challenge

IM talked with Eric Winsborrow, EVP Corporate Strategy at **Wenco International Mining Systems** on the topic of where the industry is heading in terms of surface CAS. "There is certainly a lot of momentum within in the industry toward deploying collision awareness or collision avoidance systems (CxS). I deliberately use x to cover both cases, as the terms awareness and avoidance are often used without clarifying their critical differences. Awareness technologies provide operators with clear guidance on how to avoid a collision, while avoidance technologies intervene to apply that corrective action to equipment by providing braking signals to OEM trucks."

Wenco argues that while technologies have levelled up in recent years, a key problem remains: "How can us technologists provide a comprehensive CxS system that works effectively in any condition, at any speed, and within any proximity to ensure equipment, people, and objects in the environment consistently maintain clearance between each other? The automotive industry has made great strides in this pursuit, but the mining industry has yet to fully adopt these most recent advances."

Winsborrow comments: "We all know the challenges that beset systems that solely rely on GPS. To address them, Wenco has made underlying changes to its hardware that allow for vehicle-to-vehicle communications in GPS-deprived locations. We have now adopted the V2X-Locate standard and partnered with Oxbotica to provide SLAM technologies to our CxS and AHS technologies. Not only with V2X-Locate enhance connectivity between vehicles, it also allows us to improve our GPS data quality to DGPS. That improvement enables us to identify vehicle position with sub-one-metre accuracy, 95% of the time."

Of course, it surprises some people this technology remains immature even as certain sites have dozens of AHS trucks deployed. "Why hasn't it filtered down yet? There are two reasons, really: Cost and the reluctance of mining companies to take on the risk of deploying critical safety technologies that are not yet mature. CxSes require a large investment and dedicated attention to maximise their value. Once a system is implemented throughout an organization, it proves difficult to change. Yet, even an immature CxS can contribute toward safety improvements through the extensive data these systems produce and the insights they can provide. AI/ML models can easily analyse all interaction data and provide insight to address the underlying risks of potential unwanted events - from risk-prone intersection and road design to fatigue and other behavioural issues with operators."

Wenco says its view is very much aligned with overall EMESRT guidelines. "We are actively looking to extend our safety portfolio to provide additional detection systems that address additional levels of control (eg EMESRT Level 5) and include measurement and control of underlying factors that can cause potentially unwanted events, such as fatigue and distraction." IM