Hexagon's CAS 10 consolidates a lot of powerful sensor technology into just two hardware components

Acting on awareness

The evolution of collision avoidance technology, both surface and underground, is gathering pace, both in terms of the capability of the systems themselves, particularly on direct vehicle intervention, but also in terms of the mining industry's maturity in understanding its place and its power in an active mine setting. Paul Moore reports

In the conference call for its Q3 2022 results, Kris Smith, Interim President & Chief Executive Officer of oil sands giant Suncor Energy Inc, said that work continues across the company to improve safety and operational excellence, with a particular focus on its mining and tailings operations. "My priority has been to remove distractions from the organisation and to focus our employees on safe, reliable operations and our biggest opportunities."

A big part of that is mining equipment fleet safety, following a fatality at its Base plant mining operations on January 6, 2022 when one heavy haul truck rear-ended a second heavy haul truck while they were both driving up a mine haul ramp. This has resulted in an accelerated collision avoidance and fatigue management deployment across all of its mine mobile equipment.

Smith said that industry leading technologies for collision awareness are being deployed on over 1,000 pieces of mobile mine equipment across its operating assets to mitigate a key risk in its mining operations. It is one of the most extensive rollouts of CAS ever in mining and the company confirmed to ***IM*** that its technology partner is **Hexagon**, which supplies the HxGN MineProtect Collision Avoidance System, now on version 10.

Smith adds: "I'm pleased to say this initiative is progressing well, and two-thirds of Syncrude's Aurora mine equipment will be outfitted by year end, and installations on the remaining equipment at Aurora are expected to be completed by January 2023, nearly two months ahead of schedule."

Deployment schedules for the remaining mines are on plan, with Syncrude's Mildred Lake Mine and Fort Hills going live in mid-2023 and Suncor's Base Mine being complete by the end of next year. "As well, our fatigue management system installation, as discussed in previous calls, will be completed across all mines by early 2023 and is already fully installed and functioning at Syncrude's Mildred Lake and Aurora mines. This technology has so far demonstrated the potential to reduce fatigue related events by up to 80%."

This major CAS development is indicative of an acceleration of demand for this type of extra safety layer in mobile fleets across all the major mining markets.

CAS and the Power of One

The Suncor and Syncrude deployments for Hexagon follow some other high-profile installations including at Codelco's Radomiro Tomic operation on over 100 trucks. Hexagon's CAS has also been rolled out at Anglo American's Dawson coal mine in Australia following a close partnership with Anglo on CAS at the Sishen and Kolomela iron ore mines in South Africa.

It also follows the announcement in 2022 of a significantly improved version of its collision avoidance system. Version 10 of HxGN MineProtect Collision Avoidance System – consolidates a lot of powerful sensor technology into just two hardware components: a smart antenna and a 5 inch LCD display. The smart antenna integrates GPS, RF, Wi-Fi, LTE and Ultra-Wide Band Time of Flight technology. The in-cabin, touch-screen display features modern UI/UX consistent with Hexagon's other on-board solutions. This creates "a better driving experience, reduced deployment and training time, reduced supply chain complexity and increased operator adoption." This consolidation is representative of Hexagon's Power of One approach, to offer a holistic, life-of-mine smart solution connecting sensors and software, infield apps and cloudware to empower digital transformation.

Besides collision avoidance, MineProtect integrates systems for operator alertness, object detection, personal protection and vehicle intervention by sharing the same hardware. CAS connects to a web-based reporting and analytics platform that adds a powerful layer of safety to MineProtect. It monitors and controls critical risk events by connecting data sources via dashboards, visualising all aspects of CAS and making safety preventive rather than reactive.

Michael Hatfield, Head of Product for Hexagon's Safety solutions in Mining division, comments: "HxGN MineProtect CA offers 360-degree awareness and alerts for equipment operators, as well as insight and analytics about site risks for operations and safety personnel. Collision warning systems are fantastic at stopping collisions from happening in the very moment they are detected, but even more impressive still is that trending data from the system also provides insight into how to proactively prevent accidents. Our customers understand that to take zero harm seriously, they also need an enterprise solution to transform safety data into actionable intelligence; backed by a proven change management methodology to ensure a meaningful safety culture prevails."

He adds: "The single multi-functional smart antenna for CAS also supports other Hexagon solutions including operator alertness, fleet management and operator assist. The single display for CAS also integrates information from radars and HxGN MineProtect Personal Alert, the industry's first accident-avoidance device worn by field personnel using the reliability and precision-location technology."

To get the latest news on Hexagon's CAS evolution, ***IM*** met with Rob Daw, Chief Innovation Officer (CIO) recently at the IMARC mining event in Sydney, Australia. "Over the last three years, we have seen Level 7 and Level 8 CAS technology expanding a great deal beyond South Africa, which has been a focus are due to the soon to be mandatory situation there. Operations globally,

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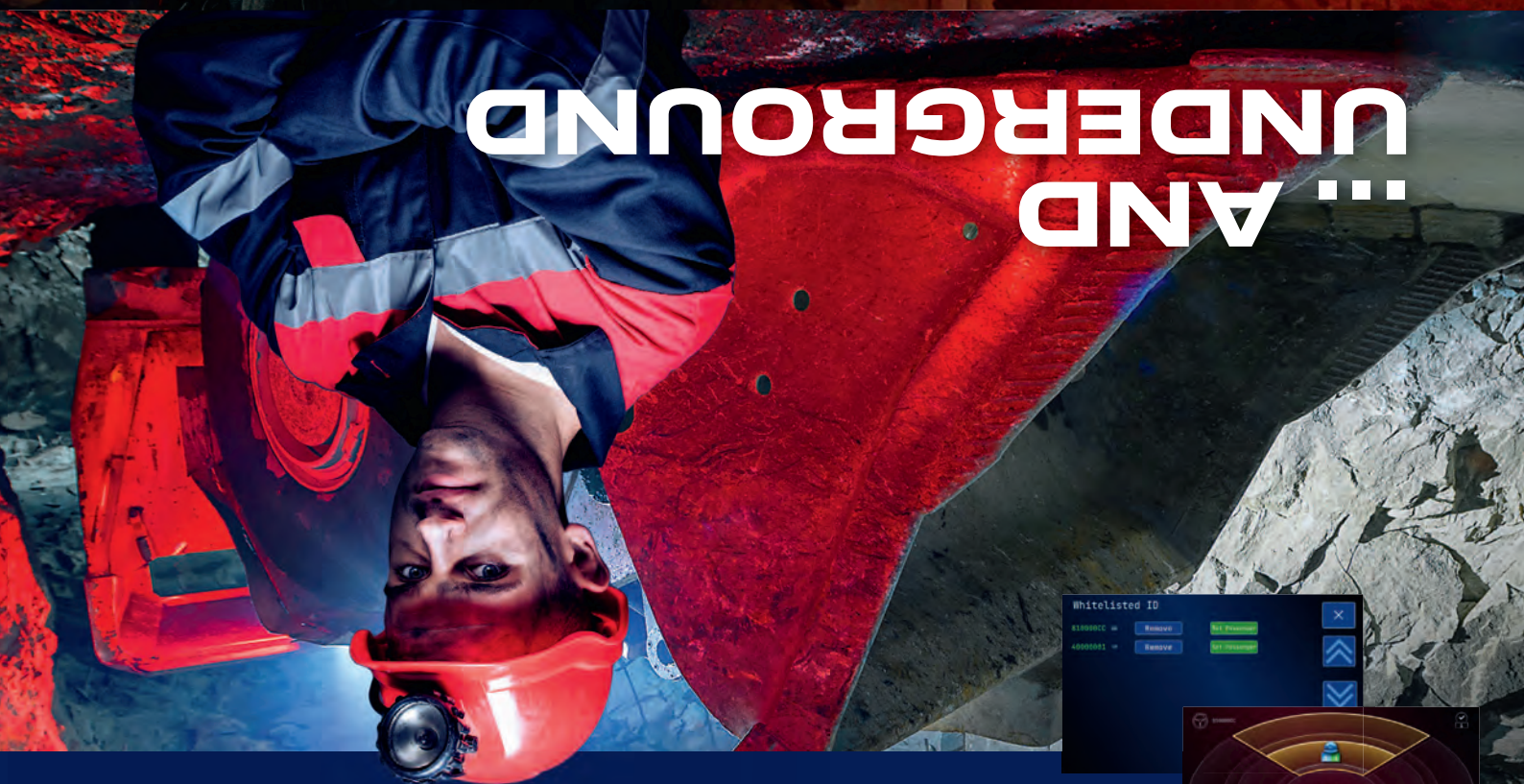

Reducing the number of on-site accidents in a mine is crucial; ensuring that personnel remain safe in both in underground and surface settings is necessary. **Becker Mining Systems** developed both the **PDS4.0** and the **smartdetect** system with safety and proximity awareness in mind.

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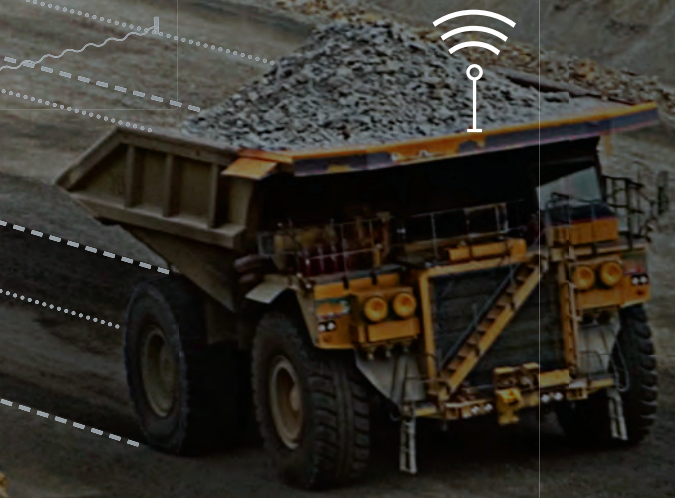

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Moving and Improving the World

Hexagon's CIO Rob Daw at IMARC 2022 in Sydney

but particularly in the APAC and LATAM regions, are now embracing and better understanding proximity detection and collision awareness. People are also seeing the benefits beyond just the main safety issue in terms of how it can improve bottom line and increase productivity. This includes CAS helping avoid tailgating and making sure you have the right distances between vehicles. But avoiding potential proximity risks also means optimising your mine design and haul roads as well as the traffic management system – and this all helps. Virtually eliminating any metal-on-metal contacts between vehicles also means a maintenance and downtime saving." From an operator point of view, in night shifts and foggy, dusty or snowy conditions, CAS combined with other technologies like Hexagon's Reverse Assist gives them an extra feeling of security as well.

On the subject of CAS in AHS mines, Daw adds: "Autonomous mining still means segregation today. Any light or other vehicles cannot mix with the autonomous trucks unless they are zoned in or out of the autonomous operating zone and even then, the trucks will still stop if they encounter a non-AHS vehicle as the AI does not yet exist for them to recognise it and automatically drive around it. By having an extra CAS layer across the fleet, the reality of mixing AHS and non AHS, in a sense an interoperable autonomous pit, moves closer."

Daw also said the market is moving on from single truck or small deployments of CAS to whole fleets. "It is a combination of market maturity with the industry need. Plus, with the work we have done with Anglo and others, the rest of the industry can now see how it looks and feels – and it is quite powerful to see a large mining truck automatically stopping – they can see that long term it is a no brainer."

Daw also said Hexagon has a whole framework in place of how it rolls out CAS – and it is done in a very structured way. Before any Level 9 capability is added, a lot of work is carried out on Level 7 and 8 configurations at the site, making tweaks and adjustments specific to that site including its setup relative to road networks and intersections etc, before the vehicle intervention element gets introduced. A lot of effort goes into training and change management as well – emphasising to operators that it is still a last resort secondary safety layer and shouldn't be relied upon to justify more risky driving behaviours.

Wabtec moves to Generation 3

In surface mining, there has been a rapid ramp up not only in collision avoidance interest but also actual installations at a fleet scale and not just trials. ***IM*** spoke to Mitch Tanzer, Global Commercial Director at **Wabtec**, to get more insight into what is happening in the market and how its own technology is evolving.

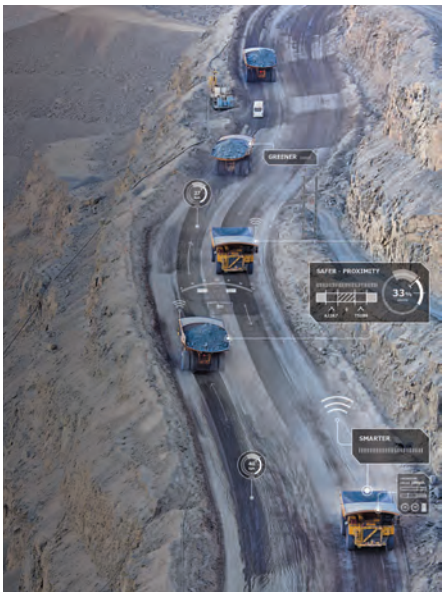
"We have certainly seen more general interest and direct enquiries. The reasons for CAS interest still vary between mining groups and from region to region. For example, due to the imminent mandate and extensive testing and implementation in South Africa, CAS is relatively well understood in underground and surface operations. The market size is huge because all mines will likely have to have L9 CAS, surface and underground, by the end of 2023. South Africa has many PDS/CAS suppliers, approaching 30. Businesses offering PDS/CAS vary from established providers to small new entrants. Many, but not all, claim to offer L9 but in many cases are unproven."

He adds: "In Australia, we are seeing a greater level of maturity in understanding what the technology is capable of and not capable of doing. Australia is a well-developed AHS market. There is also interest in the potential of Level 9 CAS to theoretically enable the mixing of AHS and non-AHS machines and the relaxing of autonomous operating zones (AOZ). Miners want to be sure the AHS can communicate with CAS, and other technologies should this mixing become possible. The primary fleet OEMs have mainly focused on getting AHS to work more efficiently, moving tonnes. So far, that has meant a closed circuit. We believe this isn't what the mines want long term. No one has got close to solving this yet, but it's coming."

A classic example would be graders, water trucks, or light vehicles that need to operate on the same haul roads that the AHS trucks are using. Autonomous water trucks have been developed but are still in their infancy. Yes, an AHS truck will, or at least should, stop if it encounters a non-AHS vehicle – but the non-AHS vehicle has no CAS to protect it. It operates against potential collisions or near misses if it accidentally comes into close contact with the AHS truck. And these autonomous mines (like any other mines) are not protected against potential collision between non-AHS machines, whether a light vehicle to a grader or light vehicle to the dozer, dozer to dozer or anything else. Tanzer adds: "These interactions mean that CAS will remain relevant in an AHS operation. We also see that more vehicles, AHS and non-AHS, will likely be equipped with smart cameras. This technology can detect and categorise fixed infrastructure, vehicle type, and people and monitor haul roads' conditions. But how does the vehicle take that data and make an informed decision? That remains a challenge. Our view is that these cameras enhance CAS. They do not replace it."

All eyes on South Africa for end-2023

It remains a fact that the main driver behind the collision avoidance system push in mining has been the expected mandating of the technology with Level 9 vehicle intervention in South Africa. This forms part of Chapter 8 of the 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 and has been suspended since then. So what is the situation today? It is widely rumoured that the regulator's intention is to mandate this for end-2023. For mandating to happen, an advisory note from the Mine Health and Safety Council (MHSC), which is a statutory body that advises the Minister of Mineral Resources and Energy (DMRE) will be submitted to the Minister for consideration and if the Minister deems it fit, he will publish a gazette. The timelines for all these processes depend on the discretion of both the MHSC and the DMRE. Not only that but feedback from a recent engagement between the Chairperson of the CEO Zero Harm Forum of Minerals Council South and the Chief Inspector of Mines is that applying for exemptions will be permissible. Stanford Malatji, Head of the Learning Hub at the Minerals Council South Africa also told ***IM***: "Our position is that should the suspension lifting take place earlier than end December 2023 member companies that cannot comply should apply for exemption with a company specific action plan showing how they can comply. The Minerals Council will continue to support its members and engage at the highest level with all the key role players towards collision prevention system ecosystem readiness."



The new Generation 3 CAS from Wabtec can curve proximity detection beams

Tanzer said that today the AHS miners want to know first and foremost that the frequencies CAS operate on aren't going to interfere with autonomous systems. "That's step one, and we've done testing with one of the miners where they wanted to validate that there would be no interference. The next step is introducing a non-AHS machine into an autonomous zone without interrupting the autonomous activity whilst creating awareness for the non-autonomous machine to operate safely."

What is happening on the ground in Australia re: CAS today? "Miners are cautious – watching and waiting for the technology to improve. There are examples of full CAS deployments. Then you have those trialling and demoing and others doing feasibility studies."

Those mines that have gone for deployments are using Level 7 and 8 functionality, where the operator gets a warning and then an advisory, but not to the point of independent vehicle action. This includes Newcrest surface sites for Wabtec, including Lihir in PNG and Cadia and Telfer in Australia. The company has also implemented CAS underground using technology from Newtrax. Newcrest was one of the industry's first adopters of CAS on this scale. Tanzer added that with another Tier 1 miner in Australia, Wabtec is to be awarded a multi-operation CAS contract for surface mining.

He also warns about the tendency in mining to use the Level 9 moniker quickly and simplistically when it is far from simple due to the implications that it has in terms of vehicle interactions. "There is much interest around Level 9 on what it is and what it could be, but there is a cautiousness. In Australia, many miners see South Africa sprinting towards its mandate. Australia has a different operating model and culture. They want to know there is a path to Level 9 instead of going there now."

In Latin America, Tanzer says the market is also really booming today – partly due to the concentration of world class large open pit mines there, especially in copper. "The mines there are relatively mature in their approach, and Level 9 trials and testing are underway. A relatively small group of well-established CAS suppliers operates in Latin America. The big miners in Chile, Peru and Brazil are already looking at how they will make Level 9 work for them. The miners that deployed or trialled more basic systems are now looking to upgrade."

He argues that North America has been further behind the CAS curve, having tended to rely on driver assistance vision related technology. But that big CAS moves like that being made by Suncor are now helping drive things forward as no one wants to be left behind their peers on a major safety related issue.

So how is Wabtec's CAS technology evolving and what differentiates that offering? First of all it is among the most experienced in CAS in the industry, with its L7/L8 CAS solution already in use across 40 mines, with 370 million hours of operation. Late in 2021, it announced its CAS solution had passed all necessary criteria when paired with Komatsu's Machine Intervention Controller. Wabtec was also able to definitively decelerate a haul truck under a controlled deacceleration strategy. This initiative proved the

RealTrac in real time

The **PROVIX**-supplied RealTrac collision avoidance, positioning and mine management system was developed to eliminate collisions and to track heavy equipment, vehicles, and personnel on the surface or underground. The developer of RealTrac is RealTrac International, based in Ponte Capriasca, Switzerland, which comes from a long history of underground mining and is well experienced in working with CAS and mine management systems. With over 7,000 tags in use and a ten-year underground mining service record across 12 mines, the RealTrac system is available in North America from PROVIX. PROVIX states: "Unique amongst CAS systems, RealTrac provides a standalone CAS for V2V and V2P Proximity Detection solution that is fully expandable to include positioning, tracking, communication, notification, and mine management in real time. The system provides audible and visual warnings to the operators of heavy equipment while at the same time providing haptic warnings to personnel. Tags vibrate and illuminate to provide early warning to personnel of their proximity to operating equipment. If a collision is imminent, the RealTrac triggers throttle disconnect and electronic and hydraulic activation of brakes to safely stop the equipment. This functionality is 'equipment agnostic' and can be applied to both new and legacy assets." The modular system relies on both UHF and UWB (Ultra-Wide Band) technology, a wireless data transmission technology that provides rapid and reliable data transfer rates at the speed of light, as well as object positioning with an accuracy of 1 metre. One of the key benefits of the technology is the high-speed data transmission via a radio channel. UWB technology is based on the IEEE 802.15.4 standard, which combines sensors and actuators into a single wireless network. As a fully scalable system, Provix says RealTrac CAS can be implemented without any infrastructure deployment. "The standalone CAS system is easily expanded to a full positioning and tracking program where all data is transmitted through the deployment of RealTrac network nodes that are fully operational in both surface and underground sites. Once RealTrac is deployed, a complete mine map is presented with all pertinent location data available for use in legacy systems in real time. APIs provide the gateway to interface between existing apps. The RealTrac system becomes the backbone for effective mine planning, determination of ventilation requirements, personnel planning and blasting coordination. RealTrac provides object positioning, voice communication and vehicle to personnel tag warnings for increased safety and maximising production efficiency."

broader communication capabilities of its GPS integration solution, which helps to optimise brake functions and mobility dynamics of a large rigid body haul truck. The tests undertaken by Wabtec were to determine the ability to integrate and decelerate Komatsu 730E and 860E haul trucks at speeds up to 30 km/h. The tests marked the first time Wabtec has validated a mining product at Level 9 for a major OEM. Wabtec went on to expand testing for a variety of interaction scenarios and decelerations and has improved the Vehicle Intervention Solution performance by adjusting detection zones for braking distance, speed, and real-time payload and haul road grade.

Tanzer stated on its latest CAS evolution: "We have spent the last two and a half years going through a rigorous development effort. In early 2023, we will release our new Generation 3 CAS platform. The development process has included getting feedback from our existing customers and partnering with industry groups such as EMESRT. We have done a complete refresh of our user interface. We have drilled down into the key scenarios using the EMESRT storyboards. Yes, you have the 26 EMESRT potentially unwanted events. When you apply them operationally, we discovered that the storyboards involved multiple sets of these. We wanted to simplify it by looking at the highest-risk scenarios, where the likelihood of fatality is the highest. The hardware has undergone a major upgrade, including Ultra High Precision GPS. The logic and intelligence behind our software will set a new standard. One example is that the new Generation 3 CAS can curve proximity detection beams. This one feature is a step change in how the system performs. There are many more that we can't wait to share! To be at this point is exciting."

He adds that the GPS accuracy has improved materially, up to 10 times, depending on whether you are using SBAS or RTK corrections. One aspect of this development, as stated, is focusing on the highest collision risk scenarios first but in a structured way.

"If you can solve these scenarios first, you have reduced 95% of the risk, and in surface mining, the biggest issue is haul truck to light vehicle. Then you go down to the next layer of scenarios, always ensuring that you aren't unintentionally breaking something you already solved. It's a delicate process. It is critical that you are not frustrating operators by over-alarming."

Finally, is there interest in CAS from the large quarry operators with multiple sites but also smaller miners or is it still dominated by the big mining houses? "Very much so. These operators are trying to achieve the same thing – to better manage their vehicle interactions and reduce collision risk. The social license to operate and safety are just as important to these companies. When companies like construction and contracting major Kiewit join EMESRT, that is when you know these other types of companies are paying attention. This is just the beginning."

Booyco on CAS evolution

Putting safe distance between people and the range of mobile equipment on surface mines – from off-road dump trucks to excavators and loaders – Collision Avoidance Systems (CAS) have become integral to mining safety. Underpinning the success of CAS has been years of intensive research and development, says **Booyco Electronics** CEO Anton Lourens. This work has actively embraced various new and existing technologies, further raising the reliability and functionality of CAS.

"Pioneering companies like Booyco Electronics – in this game for over 16 years – have taken advantage of developments in satellite positioning systems, for instance," says Lourens. "This has enabled us to achieve greater performance in collision algorithms."

"We have become interested in smart vision systems that allow intelligent perception of people, vehicles, objects and other risks," he says. "Wearable technology also allows us to enhance context and to readily distribute safety information. New technologies have even allowed us to embrace cutting edge fatigue detection solutions."

He explains that Industry 4.0 has brought levels of digitalisation and automation that could not be envisaged until recently. In response, Booyco Electronics has invested vigorously in software-based solutions, paving the way for increased flexibility to customise solutions for specific needs.

"This has meant that our equipment can be improved and customised through its software elements rather than its hardware," he says. "Functionality can therefore be adapted more easily, and can be applied remotely through a wireless connection instead of requiring in-person attention on site."

Rapid developments in sensor and tracking technology were also delivering exciting opportunities to advance CAS capabilities. Integration is really the key to success in these endeavours, he argues.

"We have progressed considerably down the path of combining the power of sensors with information technology," says Lourens. "This allows us to capture extensive data about the respective locations of personnel and machinery

through PDS."

Digitalisation gives Booyco Electronics the ability to upload and analyse this data in real time, so that it can inform on-mine decisions and enhance safety strategies. More than this, CAS can now contribute to emerging automated mine ecosystems. As autonomous mining is gradually rolled out in the sector, CAS can be relied upon to support this process with the necessary safety levels.

Lourens told ***IM***: "The effective application of collision prevention systems (CPS) requires different technologies to deal with the respective conditions of underground and opencast mining. Moreover, these technologies need to be integrated within a single CPS system where a mining operation has concurrent interaction requirements on both surface and underground. While surface mining can make use of global positioning systems (GPS) as a key enabling technology, underground operations must rely on other sensing technology, mainly on low frequency (LF) systems that can penetrate rock. In general, this means that it is easier to achieve a more holistic view of a surface operation – to determine the respective locations of trackless machinery and pedestrians. In the underground environment, the systems tend to give a more isolated view of relative vehicle-to-vehicle and vehicle-to-pedestrian interactions."

He adds: "There are multiple other technologies that make a valuable contribution to CPS – and it is important that these are well integrated for maximum impact. In our system architecture Booyco Electronics is able to harness the value of various technologies in supporting safe working patterns. Radio frequency (RF), for instance, can be used to communicate data generated from GPS sources – helping to pinpoint where objects are, their direction and their proximity to each other on surface. In terms of potential collision scenarios, underground workings with bord and pillar layouts tend to be simpler as the roadways are developed with well-defined intersections. The travelling speeds of trackless equipment is usually also slower, ranging from 15-20 km/h up to 30 km/h. By contrast, surface vehicles can travel up to 40-50 km/hr, creating different challenges for CAS interventions. The intersection points on surface are also sometimes less defined and therefore require more sensing of the possible interactions."

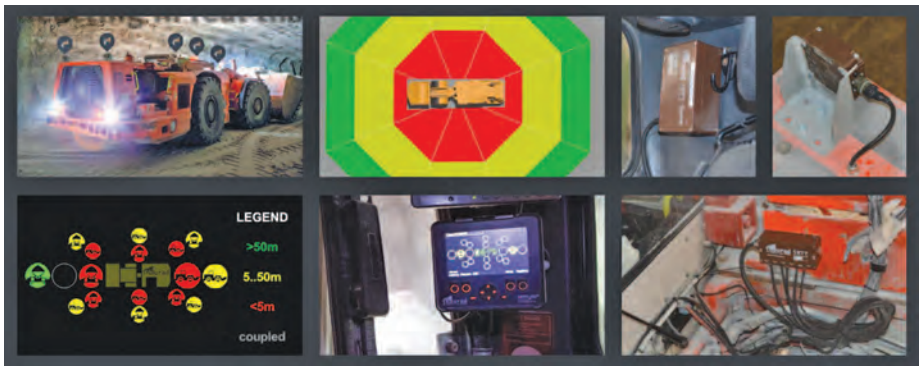
indurad's radio & radar combination

After a recent competitive process managed by Hatch and BHP, the global miner in 2022 selected **indurad** to provide the Jansen potash mine in Saskatchewan with a next generation proximity detection system.

At the core of the solution will be a new indurad iProximity 5G solution utilising both its iRTT (indurad Radio Transponder Tag) and iSDR (indurad Scanning Dynamic Radar) to offer new levels of reliability, accuracy and scalability. Partner and subsidiary company **xtonomy** is working to apply the radio (which uses precision UWB – Ultra Wide Band and reliable sub 1GHz) and radar collision avoidance technologies on mobile assets. The companies believe that both the active (radio transponder) and passive (radar) systems should be combined to maximise safety.

indurad uses radio and in this case also radar technology to provide proximity detection solutions for both mobile and fixed assets, while xtonomy, a subsidiary 100% owned by indurad, focuses on advanced vehicle guidance up to full autonomy. Christian Riedel, xtonomy Managing Director, told ***IM***: "When it comes to collision avoidance, we are working in close collaboration. We are utilising some of the iRTT sensors with iProximity software and extending those with radar-based collision avoidance. Our strategy is to have a combination of technologies, to allow us to go beyond anything that is currently available."

Dr Bernd Steyer, Project Manager at indurad adds: "BHP had a clear agenda for Jansen to implement Level 9. Our existing solution was EMESRT Level 9 ready, but our aspiration is delivering safety along with business continuity. iProximity 5G is our next generation offering to meet these requirements. The key elements are sub nanosecond synchronised vehicle antennas, optimal bandwidth utilisation and high



The iProxmity 5G system being developed by indurad includes both radio and radar sensors to provide a highly accurate solution

measurement rates delivering the accuracy of a 'underground GPS.' The industry demands assurance that production levels could be maintained but with safety ensured at the same time."

The rollout of iProximity 5G at Jansen will commence in 2023 with a step-wise approach and will be applied on a range of machines including Sandvik Mining battery electric LHDs, trucks, a range of other utility vehicles and the large borer miners themselves. iProximity has already been used at a large scale at an underground nuclear waste repository in Germany and other mine sites in Germany and South Africa including on Sandvik LH514, LH517 and LH621 LHDs but this will be the first large scale Level 9 implementation with the Generation 5 technology.

The hardware includes pairs of antennas at key access points to track ID and direction of travel of all vehicles, equipment and personnel. Nearby personnel, equipment and infrastructure tags are located through an array of ultra precision, time synchronised on-vehicle antennas. A simple interface provides operator feedback. Battery powered tags in cap lamps or belts worn by miners allow personnel to be tracked by large vehicles and base gates. Everything is underpinned by a complex software system developed in-house. indurad accepts it may not be the lowest cost system on the market but argues it is certainly one of the most capable and advanced.

Riedel went into some of the attributes of each technology. "iProximity sensors using the sub 1 GHz radio help you to see around corners and in other non line of sight applications. The passive 2D radar is good for line of sight. Both have their strengths. For safety the combination is also good in terms of redundancy." Operators can use either static CAS zones, or those that bend with the steering directions, or zones that are adaptive based on a known mine map. There are three CAS zones - green (detection), yellow (warning) and red (braking). The brake procedure is managed by the vehicle controller (PLC) based on target/obstacle distance and trajectory information.

UWB-based iRTT has also been extensively proven underground in hard and soft rock mining on drill rigs and feeders; but in other industries it has been used for very complex applications such as across an entire shipping container terminals with over 1,000 antennas and tags to track all personnel, vehicles and cranes with advanced safety features. In addition to the CAS aspect, it also functions as a real time localisation system. "It offers multiple features in a single system, with high accuracy 2D or 3D localisation. It has extremely high accuracy giving both distance and orientation, with fine control of detection zone shape and size, reducing false alarms in busy mining areas. It can also be used both underground and on surface."

The Level 9 ready system actually uses dual-frequency radio - Short Distance Radio at sub 1 GHz and UWB at 6.5 GHz. Distance calculation is achieved by using Angle of Arrival (AoA), Time of Arrival (ToA) and Time Difference of Arrival (TDoA). Riedel argues that this is levels above most of the basic PDS based systems used today

Matrix – surface and underground solutions

Matrix Design Group has both surface and underground CAS offerings. The OmniPro collision avoidance system for surface mines uses Visual Artificial Intelligence (Visual AI) and machine learning to enable line-of-travel, crosswalk and blind-spot pedestrian and vehicle alerting for small- to medium-sized mobile equipment. Consisting of up-to-three 120° field-of-view cameras, the OmniPro system works without personal wearable devices or tags. OmniPro not only "sees" and identifies people and hazards, alerting with visual, audible and/or tactile alerts, it also photographs and reports zone breaches. "OmniPro has the ability to work effectively without requiring tags on workers or equipment, reducing cost and hazards posed by lost or broken tags," said Brian Jones, Vice President of Business Development. "It has also been designed to minimise nuisance alerts which can desensitise workers to zone breaches."

Through its Visual AI object recognition technology, OmniPro has been taught to identify and report on a library of "objects," including people, vehicles, equipment, stop signs and pedestrian signs. The user can select what objects will be included and whether to integrate with the machine or operate as alert-only. Additionally, depending on the mine's needs, OmniPro's wireless solution can trigger a stop sign, pedestrian light, voice alert or crossing arm. Especially when a worker is inexperienced or tired, this camera system provides a safety backstop that can help prevent accidents. All incidents are recorded and can be reviewed to provide insights for additional safety training as needed. "OmniPro's cost-effective and customisable solution can be adapted to match any operating environment through its programmable field-of-view zone grid configuration tool, which enables it to meet the safety requirements of different mines. Each system operates independently and is easy to install."

For underground mining, Matrix's IntelliZone proximity detection system automatically warns personnel if they are dangerously closed to active mobile machinery or entering an unsafe working area. It allows users to create customised Caution, Shutdown and Operator Zones around all mobile equipment. Its control system interfaces with machinery, providing the ability to slow down or stop a machine should personnel move into the zones designated around it. The system is intended to enhance miners' awareness of potentially dangerous areas around working machinery and instil safe operating practices.

Unlike bubble-zone systems, IntelliZone's patented shaped-zone technology minimises nuisance alerts and allows long-range, through-curtain detection, enabling increased productivity for mines. "Mines adopting proximity detection technology have two choices – advanced machine-shaped zone systems or 'simple' bubble zone systems," said Jones. "Both generate warning and shutdown zones, but only IntelliZone offers reliable, proven technology that helps protect workers without slowing down mine production."

Originally introduced to the American market in 2009, it says more than 90% of all US underground coal mines operating with proximity detection systems use Matrix technology. It has both MSHA and IECEx global certifications and is also sold in South Africa and Australia.

relying solely on Short Distance Radio and 1D "bubble" type zone ranging. It is also capable of reading BLE beacons and working with WiFi/LTE at a high level for data transmission and at a vehicle intervention level with CAN Bus, J1939 (fully ISO 21815 compliant); indurad has successfully tested compliance with Nerospec SK before on the application of PDS to LP LHDs in South Africa.

Adding the passive 2D iSDR radar results in a maximum level of robustness, especially for stationary objects and operator guidance of heavy vehicles – the radar is maintenance free and unaffected by dust or smoke, for example, unlike LiDAR. The same iSDR technology is also being used on xtonomy's autonomous haulage system which has been applied on ADTs but also rigid trucks like the Cat 777G.

The ruggedised and compact iSDR can be used underground with 360° measurement area (round scan); giving measurement of distance to surfaces, persons and objects. It is ideal for specific anti-collision scenarios of ϙ90 m and has an extremely high update rate up to 4,500 measurements per second and accuracy up to <10 mm depending on measured range & environment. It also allows rock detection for tyre protection reducing OPEX and downtime.

Schauenburg moving to ProXYmus

Schauenburg Systems is one of the longest established PDS/CAS players in South Africa. Underground, Schauenburg's Collision Avoidance System (SCAS) offers early notifications to both Trackless Mining Machine (TMM) operators and pedestrians to eliminate the occurrence of a Potential Unwanted Event (PUE). Potential collisions are identified and communicated as either Level 7 (TMM operator warning), Level 8 (TMM operator advisory) or Level 9 (TMM intervention). With well over 4,000 deployed systems, Schauenburg offers solutions for both surface and underground mining operations and is suitable for Light Delivery Vehicles (LDV), LOCOs and TMMs. Customers include some of the major South African platinum mining houses.

It has also grown its surface offering and has two Surface Collision Avoidance Systems (SCAS), the portable Light Vehicle Basic (LVB+) system and the Heavy Vehicle Basic (HVB+) system. The LVB+ system is intended for daily visitors to ensure compliance prior to entering an operational site whereas the HVB+ system caters for bigger vehicles and fixed installations. The HVB+ complies with the ISO 21815 standard and is classified as a full Level 9 system. Both systems offer dynamic zone configurations and 3 programmable detection zones sizes (safe, warning and critical zone). These zones can be adjusted to best fit customer needs and traffic management plan. Furthermore, Schauenburg's dynamic detection zone algorithm complements the production targets of clients as Potential Unwanted Event (PUE) detection is a function of vehicle speed and eliminates the occurrence of false warnings and unnecessary Level 9 TMM intervention.

IM spoke to Gawie Croeser, Head of Strategic Business Unit Intelligent Vehicle Solutions: "Definitely there has been a big upswing in underground Level 9 vehicle intervention activity – one of the reasons aside from the expected, but still not finalised, mandating of Level 9, is that vehicle to person or V2P represents a major day to day injury and fatality risk. In surface operations, the main risk is based on V2V or metal to metal collisions. The moves on surface are also more influenced by the potential to increase productivity and you could argue that in South Africa it will act for some surface mines as a precursor to installation of autonomous haulage."

Croeser added that the surface industry has also been slower to implement the ISO 21815 protocol, however, which to some extent has been a hinderance to the PDS suppliers being able to progress in that market. Bell is somewhat of an exception, having drive by wire already implemented on their machines as well as being committed to open autonomy technology as well, working with Pronto AI and xtonomy.

"The ISO 21815 protocol is still relatively new – if you consider the market size of South Africa

compared to global sales, you can see why there is a delay in having it implemented by the OEMs. We encounter two scenarios – where the OEM makes available an ISO 21815 interface and we can work with that directly. But with legacy machines where that upgrade has not been made, then we tend to work with a third party interface supplier like Nerospec or Engine Control Systems. They supply if you like the translating functionality whether that be ISO 21815 or some proprietary CAN BUS protocol. For a really old machine with no CAN BUS then you they may have to use some form of actuator and valve control to make it L9 active. The third party activity will likely reduce within five or so years as legacy machines are replaced with ISO 21815 equipped new machines."

On Schauenburg, Croeser said it is currently busy with final development of its next generation SCAS PDS solution, ProXYmus. "It is a highly accurate solution with a special focus on the coal market, especially for continuous miners. The problem to date has been that because of the close proximity of workers beside the unit and its type of sudden movements including non-linear, you need CAS with very high accuracy – centimetres instead of metres. Field trials will start early 2023 with the intent to have a commercial system by Q3 2023. The much more accurate solution is not restricted to coal, in fact it will be our main new SCAS offering with equal application potential in the hard rock market as well."

He added that the current SCAS II has been running for more than 10 years and that a lot of lessons have been learned. "There are a lot of new PDS entrants in the market which is great in the sense of collective focus on safety as well as pushing the established players like us to push our technologies further. Customers can gradually replace SCAS II with ProXYmus by installing new hardware modules on existing machines as ProXYmus is designed to be backwards compatible."

Newtrax® readies for the robots

In September 2021, **Newtrax Technologies Inc**, a wholly owned subsidiary of Sandvik Mining and Rock Solutions, introduced the next generation of the OptiMine® digitalisation solution, which evolved to become OEM agnostic and include Collision Avoidance as a core functionality.

Newtrax CEO Alexandre Cervinka told ***IM***: "We are trying to unleash the robots – for Sandvik the future is autonomous and battery electric. What is hindering exponential growth in this sector today is the application scenario. Today, when you sell AutoMine equipped machines, or any other autonomous underground machines, they still have to operate in a segregated and gated area of the mine. We have the strategic responsibility of developing a CAS that will be good enough for these automated machines to roam in areas of the mine with conventional manned equipment as well as pedestrians. That's our moonshot at Newtrax."

To enable that, Cervinka emphasised that you need a functionally safe system with new perception technologies – the whole industry is well aware that current systems are nowhere near go enough to enable coexistence with automated equipment. Most of these have been designed mainly for low speed V2P interactions in mind, which are the main use cases in coal. "It leads to some choices. We need to use technologies that will work at high speed – autonomous loaders operate at up to 32 km/h. In a V2V case, you are looking then at some very high effective closing speeds."

He also talked about the importance of both measuring position accurately as well as considering situational context. Positioning data give info about objects and how fast they are moving but does not tell you what gear they are in, how much payload they are carrying, or if they are going uphill or downhill. These are all telemetry factors that might impact stopping distance and can be used to reduce nuisance alarms.

Newtrax's CAS like some of the other systems on the market uses multiple radio frequency (RF) technologies to provide high-precision ranging. "The key for us is to use technologies that allow us to see around corners otherwise it is just not good enough. And with our focus on automated high-speed BEVs in underground hard rock mines, we need proximity sensors that won't be affected by metallic ore with conductive or magnetic properties, or by magnetic field interference from non-intentional radiators that happen at low frequency."

Newtrax OptiMine CAS links intelligent cap lamps to a warning system inside the cab of underground mobile equipment – the hardware on the machine includes a tablet, a hub and proximity ranging sensors. The system provides the vehicle operator with a virtual view of any pedestrians in the immediate area of the machine, along with an escalating warning system for both as the distance between them narrows. This escalation transitions from a warning to vehicle intervention, where the vehicle automatically reduces speed and comes to a controlled stop should the system recognise the presence of any pedestrian wearing an intelligent cap lamp in the high-risk zone. The same technology is also designed to improve the safety of vehicle-to-vehicle interactions.

The cap lamps have a total of 10 different radios installed for communication, positioning and proximity detection. Since big mining houses with many mines have very heterogeneous communication and positioning networks including WiFi, LTE and leaky feeder, Newtrax had to offer a device that was network agnostic to enable corporate-wide roll outs. Cervinka also raised the point about how the firmware of these CAS systems will be updated – as it is impractical and unsafe to have hundreds or thousands of these CAS devices in a mine running on different versions and trying to upgrade them via spotty wireless coverage – its solution for that is intelligent cap lamp racks where when the cap lamp is on the rack it has a wired connection to the internet to enable quick and systematic firmware upgrades.

Newtrax has now demonstrated the capabilities of OptiMine CAS to most of the top tier underground miners and mining contractors in H2 2022. It is also working with five early adopters, which include contractor Barminco plus miners Gold Fields and Sibanye-Stillwater. Sibanye-Stillwater has invested $17 million in OptiMine Collision Avoidance System (CAS) technology to reduce accidents, injuries and fatalities at its Stillwater PGM underground mining operations in Montana.

In South Africa, Gold Fields' Sven Lunsche, VP Corporate Affairs, told ***IM*** in July 2022 in relation

Epiroc takes CAS position with Mernok acquisition

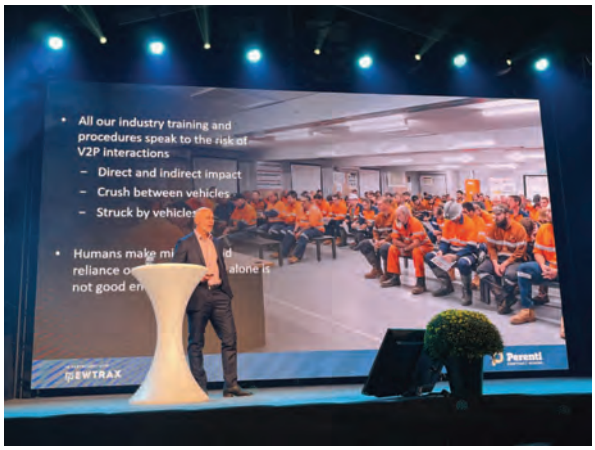
As ***IM*** went to press, Epiroc agreed to acquire **Mernok Elektronik (Pty) Ltd**, a South Africa-based company that provides advanced collision avoidance systems for mining companies. With this acquisition, Epiroc will strengthen its position as a world-leading provider of automation and safety solutions for mining operations, it says. Mernok Elektronik is headquartered in Pretoria, South Africa. The company designs and produces proximity detection technologies and collision avoidance systems of the highest level (EMESRT Level 9) applicable for either a single machine or an entire mixed fleet of machines regardless of manufacturer or type of equipment, it says. Mernok Elektronik's customers are primarily in Africa, with its systems designed to significantly reduce the risk of vehicle accidents, strengthening operator safety as well as productivity. The company's focus was initially vested in three main areas, namely mining applications, military applications and high-end industrial applications. In 2016, it decided to re-focus the company to service only the mining sector. Back in 2019, it teamed up with Booyco Electronics and Selectronic to bring new generation technology to the proximity detection system space. Mernok Elektronik has about 45 employees and revenues in the fiscal year ending February 28, 2022, of approximately ZAR80 million ($4.7 million). The acquisition is expected to be completed in the March quarter of 2023.

to South Deep gold mine: “We are currently rolling out the Newtrax system, which will have full Level 9 capability. We are currently finalising the OEM safety testing phase as well doing factory acceptance testing for components as they pass the OEM testing phase.” He added: We also believe that using the full capability of the Newtrax system which is not only a collision avoidance system but will also enable fleet monitoring from both a maintenance and productions scheduling perspective will in effect improve our reliability and reduce overall maintenance effort while at the same time improve operational scheduling and performance.”

Barminco’s pragmatic approach

During a presentation at Sandvik’s Innovation in Mining customer event in Finland, Mick Radi, Vice President Australia - Perenti Contract Mining, which principally includes Barminco, said: “In the last two years, collision avoidance has become a business-wide priority for us – the turning point was a fatality event when we lost a very experienced and very knowledgeable colleague. That event revealed to us that experience provides no immunity to this hazard. As such we need to turn to technology in a really big way so that we can eliminate this type of event.” He added: “Taking a pragmatic approach, we are engaging the operators in the process of design, after all this system needs to work for them...we are relying on best practice and standards, and we understand the constraints of what we are trying to do. Our system must be independent of the mining infrastructure in which we are operating, as contract miners we are not in control of that infrastructure. Our CAS solution needs to be peer to peer.” He said in Barminco’s stats the need is evident – over a period of about 20 years, it has had about 80 collision events, of which 24 were serious potential incidents, and seven of them involved interaction between heavy vehicles and pedestrians.” As he had mentioned one of those resulted in a loss of life. In the wider WA stats, from 1989 to 2018 there were 12 fatalities of which seven were V2P related, mainly involving trucks and loaders. “Barminco’s realisation was that V2P was the first problem that we had to solve. Our CAS must be built on existing controls. So over many years we have introduced administrative controls that have taken away some of the risk. We cannot let our workforces become desensitised to the risk. The system needs to be invisible until you call upon it – like an airbag in vehicles – it is that last line of defence.” Crucially he emphasises that the industry needs a globally accepted set of requirements. Barminco operates globally for 15 clients and if each one of those has different expectations it makes it difficult to keep the system simple and repeatable. “These requirements need to be established so that there is an extremely high probability of success and acceptance through performance. When we have a consistent CAS standard, we will then be able to evaluate one CAS supplier to another.” But it also has to operate with minimal impact on the mining cycle. Given the fact that there are huge numbers of V2V interactions on a typical decline, which could result in numerous L9 slowdowns, this would have an unacceptable effect on the cycle time – while V2P interactions are far less, they carry a much higher risk. So for Barminco that is the first problem to solve with CAS – specifically Level 9 CAS for V2P protection involving trucks and loaders, but still with Level 8 protection for V2V (ie where the operator gets a warning that includes directional indication and distance but without automatic vehicle slow down or stop).

Based on the V2V data, the next L9 deployment would be for ancillary vehicles like work platforms, chargers etc. Barminco is also putting in interim steps like enhanced camera systems and area denial systems to provide additional risk reduction. At the heart of Barminco’s CAS introduction strategy is what it calls its functional specification document – a very thorough document with at the last count, 78 scenarios that talk to what could happen in terms of V2V and V2P; and how Barminco foresees that the interaction should occur in terms of how the machine should respond. It has used that to go to market. The spec also aligns with the ISO 21815 protocol. “In fact it exceeds that specification by calling for posterior intervention as well as liner movement intervention – this protects personnel from crushing between articulation zones or against the environment where the machine is at a standstill.” Barminco’s CAS testing is being



Mick Radi, VP Perenti Contract Mining, speaking at Sandvik Innovation in Mining event in Tampere, Finland, September 2022

TORSA's take on CAS

Spain's TORSA recently unveiled its next generation Collision Avoidance System for shovels, haul trucks, auxiliary and light vehicles, building on the first version of its system that was deployed at Antamina in Peru. ***IM*** spoke to Gabino de Diego, Director Of Business Development, to get more insight in the new solution, which is LiDAR based.

Q When you say your new generation CAS system is designed to perform at Levels 7-9 does that mean the truck can be automatically slowed or stopped (Level 9) and have you proven this yet in testing (or do you have plans to do this testing)?

A Our system has been designed to perform at EMESRT levels 7-9. For intervention control (Level 9) actions, we have developed a specific hardware and software following the standard ISO 21815, that contains all the messages and implement the negotiation sequences to connect to the vehicle's PDIM to be able to take control of the machine should situation requires it. Additionally, we have a generic input and output interface where to connect analogue and digital signals that will be able to control different devices in the vehicle, other than the PDIM. Currently, we have this system implemented in shovels. For trucks, we are in conversations with the University of Pretoria to have our CAS system tested in their labs by Q1 2023.

Q It builds on the system you deployed at Antamina but the release mentions that the "CAS system has clocked up millions of hours of operation to date in various mines" - can you give any more detail about those locations?

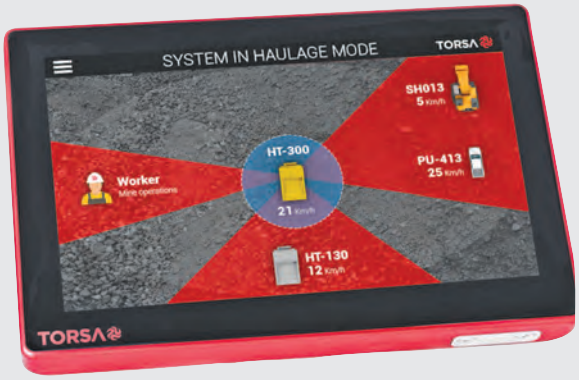
A Our previous generation, 2D CAS, has been installed in Antamina since 2016 in more than 100 vehicles, and the system is still operating. Now, we are running a PoC (proof of concept) of the new 3D CAS in Antamina, where they are interested on testing the level 9 capabilities of the new system. Additionally, 3D CAS has been installed in Marcobre and Antapaccay, and we are also taking part in RFQs with other mines in Colombia, Mexico and Chile.

Q Have the deployments been on single trucks, groups of trucks or whole fleets?

A One of the key features of our system is that it provides value from the first instrumented vehicle. Thanks to the 3D LiDAR, CAS system will be able to "see" all the objects around it, regardless whether they are tagged, for example, the mining front. Obviously, if the other vehicles are tagged, the information provided by the system to the machinery operator is richer, as it will not only indicate the presence of an obstacle but provide information about the obstacle itself. In the operations we are currently working on, our system has been deployed in more than 200 trucks.

Q Have the deployments been Level 7 and 8 compliant deployments ie where it will give the operator a warning and then advisory when there is a risk of collision?

A Yes, all the deployments we have made to date, have been Level 7 and Level 8 compliant. For Level 8, we have developed a predictive algorithm that will evaluate the trajectory of two adjacent vehicles and will rate the level of alert based on the probability of those vehicles crossing paths at some point. If the paths will cross but vehicles won´t be at the crossing spot at the same time, system will play a low risk alert sound and show a green colour on the display, just to inform to the operator that there is another vehicle approaching. On the other hand, if both vehicles will be at the crossing spot at the same time, system will play a high risk alert sound and show a red colour on the display, instructing the operator to change behaviour to avoid collision.



Q Has your system been proven in challenging environments such as heavy snow or fog and how does it handle these conditions?

A Our CAS system has clocked many hours since the first installation in 2016 and has gone through all weather conditions, showing great performance even in challenging environments. All sensors installed outside the cabin are IP67 and, before deploying them in the field, our engineers have spent many hours testing all the sensors in the labs simulating all possible weather conditions, including snow and heavy rain. We are very concerned about quality. All our products are designed and manufactured in-house, what allows us to control every step of the process. The result is a robust system that will perform in every condition.

Q What are the key differentiators between your system and other CAS systems in surface mining such as those from Hexagon and Wabtec?

A The key differentiator of our system is accuracy: the unique combination of high precision sensors allows our system to measure distances with a tolerance in the region of centimetres. In the field, one centimetre could be the difference between life and death. Additionally, ours is a system born in the mine. Literally, when we started developing it, our engineers had an office in the mine and they would spend time programming and designing the hardware, while getting the feedback directly from the operators, the final users of the system. Our engineers got to know first-hand all the aspects and features that final users of the system would like to see in it. In the end, thanks to this close collaboration, we can say our CAS system has been designed by them and for them.

Q Can you give some customer feedback on the performance and reliability of your system?

A Fortunately, we have received great feedback from our customers about the accuracy and performance of our system. However, the best feedback provided to us was from one operator who told our technicians that he would not operate the shovel because the system had been deactivated. He even called his supervisor to ask them to reactivate the CAS system, arguing he was not able to operate safely if system was not on.

Q Are you active in the South African market?

A After many success stories in LATAM, Torsa is bringing that expertise to South Africa. With a portfolio focused on health and safety and products like their vibration monitor and collision avoidance system, Torsa's goal is to make the work in the mine easier and safer, and improving the life of the people working both in open pit and underground operations. This was demonstrated in 2020 when Torsa's vibration monitor received the BHP People's Choice Award. Torsa's South African branch opened in November 2022, with professionals that will be able to assist every step of the way; our sales and FAE team will help you decide the best product based on requirements and our team of engineers will install and maintain it in the field for the best performance.

conducted on Sandvik loaders and trucks in partnership with Newtrax – "that partnership has accelerated our learnings and we believe because of this we will develop a better solution for the industry." For example, on the described approach for L8 for V2V and L9 for V2P, Newtrax's Cervinka comments: "The system does both simultaneously – the system on the vehicle is programmed to limit the control mechanism to L8 for V2V but simultaneously will kick in the L9 control when there are pedestrians around."

A universal vehicle interface

Nerospec SK with its NeroHUB provides a universal interface between the detection technology and the mobile mining machine and is completely agnostic to both. Nerospec SK company CEO Dr Eric Pohlmann told ***IM***: "Our sweet spot is to deliver industry standard EMESRT - Level 9 Vehicle Intervention Controls (VIC) to any mine operation, any machine OEM, any machine type and age. We can enable any vehicle to adapt to any of the sensor-based collision warning systems. We are the first 100% agnostic fleetwide solution provider in this field. Our growth has been initially driven by the market demand in South Africa which is globally leading the CAS technology forward."

For almost a decade now Nerospec has worked with most of the major PDS/CAS vendors as well as 45 different machine OEMs, with over 150 different machine models and it have delivered over 3,000 successful machine installations. Nerospec says it assists mining companies "to deploy robust, fail to safe VIC solutions aiding Level 9 CRAWL and STOP collision avoidance capabilities" as they are known in EMESRT.

Pohlmann adds: "The mines have diverse fleets of many types of vehicles – so they want to integrate not just the primary load and haul equipment but also light personnel vehicles, chargers and shotcrete sprayers, plus other utility vehicles. Our range of Vehicle Intervention controllers provide a single interface to all models, types and ages of both intelligent and non-intelligent machines and offer multiple interface combinations of CAN Bus, analogue and digital signals as standard."

EMESRT Level 9 intervention control standards require intervention, through automated & Fail-to-Safe machine control, to prevent unsafe Vehicle to Vehicle and Vehicle to Person collisions. The proximity detection technology alerts operators to avoid any possible collisions, and if not acted upon by the operator, the Nerospec intervention control technology will safely bring the machine to a crawl and then a stop without operator input, mitigating collisions and fatalities.

Pohlmann commented: "Through our intelligent reporting platform we have recorded year to date, an average intervention count of roughly 600+ Level 9 stop events per week across our customers' fleets, also noting a drop of roughly 21%, from 2021. This is showing the technology's adoption and the behavioural change it is driving."

Nerospec says the machine deployment follows a well proven and tested method. Pohlmann said: "We test the different standard vehicle approaches on each machine type to ensure braking and stopping will be as smooth as possible. And that may require various adaptations of the VIC system sensor set-up or machine intervention methods, as the full Level 9 must take control of ignition, throttle, engine, transmission, retarder and brakes - that is how complex the interface is."

In some cases, Nerospec will also add its own speed sensors to the vehicle, to enable a fully redundant way to understand the speed and better control it. And once a mining vehicle has a neroHUB installed as a CAS related interface, it also by default offers additional safety elements including Speed Brake Interlock (SBI), which monitors, controls, and maintains the vehicle speed at all times to prevent any runaway scenarios. Or a Speed Limiting Interlock (SLI), where you can limit speed based on pre-programmed rules within specific locations – for example where you know there is usually excess water and therefore the road can be more slippery.

Another string to Nerospec SK's bow is that it provides data logging capabilities for valuable insights into machine health and productivity performance through Short Interval Management and Control (SIMAC®) software. Pohlmann: "Our range of HUB controllers acts as a black box recorder for an independent validation, verification, and oversight of any event past or present. These valuable insights can be tailored to the mine's specific needs, goals, and focus areas."

How does it work with the different machine OEMs to ensure cooperation and interoperability? "Our preferred approach is always to do this jointly with the OEM, where we will create an electrical and hydraulic integration plan for the specific machine, even down to its particular serial number. Because even two loader types from the same machine OEM may not have exactly the same type of control system due to different parts being used by the machine OEM for various reasons."

He adds: "We have been very successful collaborating with various machine OEMs and have even become the standard for Level 9 Intervention Controls on some of their fleets whereby customers place orders directly on these machine OEMs for the Nerospec SK control kit on machine. There are some cases where the machine OEM does not deal directly with the mine such as for light duty vehicles (LDVs). In these cases, we work with the mine directly and through strict processes such as failure mode analysis (FMA) and fail-to-safe methodologies we ensure a working control solution similar to when we work with a machine OEM."

Another strength is that underground, the NeroHUB effectively enhances connectivity with the mine's WiFi or LTE network and it can provide a Bluetooth-based positioning system when used together with battery powered reference points known as NeroPINs. These are positioned in known fixed mine plan locations or throughout the mine for greater accuracy. Most underground mining vehicles don't as yet have controllers that perform fleet monitoring and the NeroHUB can also perform this function.

Nerospec SK has now been in this market for almost a decade and as stated has over 3,000 NeroHUBs running in South Africa – which shows

the extent of its CAS market role. They are installed on over 30 different OEM's mobile equipment on over 100 different machine types. Clients include Glencore, Anglo American, Impala Platinum, Gold Fields, Assmang, Samancor, Sibanye-Stillwater, and Sasol Mining to name but a few. Beyond South Africa, interest levels are also increasing, with recent activities in Mongolia, Kazakhstan, Australia, India, Canada, and the US – and not just underground, also relating to surface equipment. Some of the major mining houses are also considering standardising with Nerospec SK as the VIC solution across all operations. And with a potential mandate to install Level 9 CAS by end-2023 across South Africa, things look set to get a lot busier.

The VIC-specialised teams are headquartered out of two bases one in Johannesburg, South Africa and the other Velbert, Germany. Velbert is also the home of parent Schmidt Kranz Group, which has worldwide offices and includes other mining related companies, so as Nerospec grows into new mining hubs, it will be able to leverage these other regional offices and enhance them with its own specialist staff. It also uses reseller partners as well. From a hardware and software point of view, Nerospec is fully vertically integrated – it designs its own electronics with more than 40 engineers and actually manufactures the systems in South Africa, including the neroHUBs controllers. Plus it creates all of its own software.

Discussions with OEMs are also advancing – including a case where an equipment supplier wants Nerospec to help provide an interface as a standard option for their new machines but also retrofittable on their sizeable fleet of older machines that are running. Effectively it provides them a "CAS-ready" Nerospec interface. Of course, in reality on a project by project basis there will still need to be some customisation and testing during implementation – and as an agnostic VIC, Nerospec will also take care of that.

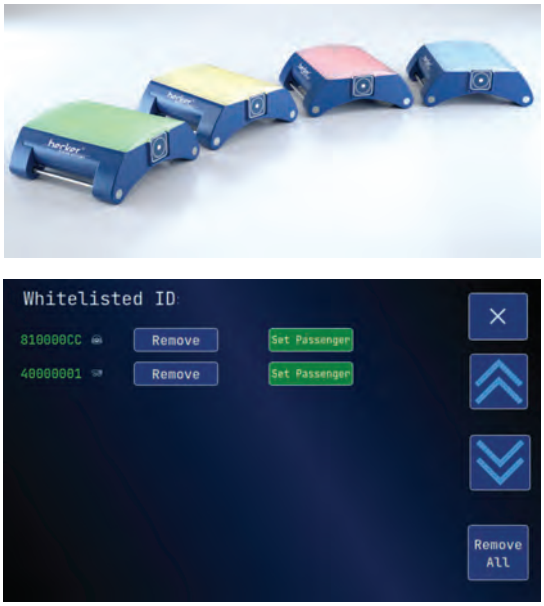
Becker's smart proximity solution

Becker Mining's latest and most advanced underground CAS offering is its PDS4.0 which is described as a smart Proximity Detection System. It forms part of the Becker Connected Mine (BCoM) offering as part of the suite of communication solutions that come under SMARTCOM. Other key elements of BCoM include MINCOS (automation); ENDIS (energy distribution); MINETRANS (haulage); and MINESUPPORT (infrastructure). The idea is that the mine is at the same time digital, connected and totally integrated, based on real time identification and monitoring that can be based on LTE, WiFi or leaky feeder. Smartflow is the complete infrastructure and information management system from Becker for mine monitoring, which is able to display the entire infrastructure, process flows, current state of technical devices and machines, and mobile components on a 3D mine building model. Mobile machines and people are displayed via tagging and tracking; with monitoring of individual and composite processes based on process flow diagrams. It includes a graphical presentation of current and past data progressions using trend graphs and diagrams.

Looking in more detail at PDS4.0, the system facilitates bi-directional notification and alert messaging against potential collision for both V2P and V2V. It warns the operator and interacts with the vehicle as well as warning the pedestrian in that case. It includes a detection alert (typically 50 m) then approaching alert with the vehicle automatically slowed and collision alert where the vehicle is automatically stopped. The zones are configurable by software. All vehicles and workers are equipped with a tag. Range is up to 500 m with an accuracy of ± 1 m and 90% reliability. It relies on UHF and RF-ToF. UHF is used for comms between peers while RF-ToF is used for precise distance measurements.

Jonas Maximilian Becker, CEO, Becker Mining Europe: "While a lot of this is common to different CAS providers today, there are several standout features of our system. The different stakeholders can actually communicate with each other by confirming or updating their statuses or acknowledging the other. Another unique aspect is whitelisting of detected tags to declare a safe state." The whitelisting was developed by Becker to manage certain collision avoidance scenarios as outlined by EMESRT. Especially looking at normal head on traffic, following traffic, plus interaction of machines in confined spaces: "The driver can also request a whitelisting from a miner outside the vehicle who will be prompted via their tag – they can then acknowledge they are safe by pressing the button on their tag twice within a defined timeframe. This helps to avoid the situation with some CAS today where workers have to step back 30 or 40 m away from moving vehicles to avoid any slow down or stop being initiated. Another scenario is whitelisting of a vehicle where you have quite a narrow tunnel where two vehicles have to pass each other, without the system making both stop. It also allows a driver of a personnel carrier to whitelist a group of tag IDs for passengers he is carrying."

The miner also has an emergency button on their tag to communicate an emergency to other miners and vehicles around them and can even remotely stop a vehicle themselves if they feel unsafe. This could be if miners find themselves in a dangerous situation while being declared as safe such as accidently being trapped behind a vehicle. However, being accidentally declared as whitelisted is a very unlikely scenario as the vehicle's driver and the person in question need to take an action.



PDS4.0 has unique whitelisting capabilities to help minimise disruption in certain L9 scenarios

To start a vehicle the driver must select his or her ID and approve with a predefined numerical pin. All acknowledge events are logged in the system for post-accident investigation. The whitelist can be accessed and configured via the OMI (Operator Machine Interface) in the operator's cabin.

All of the information is stored for up to 30 days on the PDS4.0 control units and is communicated to the central mine database when miners and vehicles pass a WiFi access point or LTE signal. Becker's Smartflow can then visualise the data and create statistics and reports from it.

On the hardware Philip Henry, the responsible Lead Engineer at Becker Mining Europe, adds: "The system is actually pretty compact without too many accessories that need to be connected. There is no intelligence inside the sensors – there are just basic UHF antennas with all the intelligence inside the PDS4.0 Control Unit. This makes it much easier and cost-effective to replace antennas if they are damaged during operations. In terms of the vehicle interface the system is compatible with ISO 21815 but it can be achieved via other means as well including CAN BUS."

So where is the system commercially to date? Becker says it has completed the system development for the industrial version of PDS4.0

and has three active pilot installations. One of them is in Canada and is now being evaluated by Worley on behalf of Vale for one of its operations along with a range of other PDS offerings. The two other pilots are at mining operations in Europe.

Finally, Becker offers the WRAP260 router with UHF tagging and tracking as an additional technology along with PDS4.0. These are WiFi based wireless access points, available with two or three access points in one device which transfer tracking info via fibre back to surface. The number installed will depend on the accuracy the customer is looking for – typically they will install one every kilometre so will have 500 m of range from each access point.

It is also worth noting that Becker Mining Systems also offers smartdetect; which is a GPS-based CAS designed to work in surface mining environments. smartdetect is comprised of three key components that work in conjunction with each other - the controller, cameras installed at the extremities of the vehicle and a touch-screen display to provide the operator with a visual of their surroundings. Henry comments: "Both systems are complementary for customers that have a ramp and have underground machines emerging to surface. We have done testing already that shows the integration of smartdetect where it effectively acts as another source of information with PDS4.0."

Strata's world of safety solutions

Strata Worldwide cut its teeth with its HazardAvert PDS in South Africa, starting in the underground coal mines there around 2007; it was one of the first, and also remains one of the leading systems in place in the coal industry globally, but has also branched out into underground hard rock, including a major project at Assmang's Black Rock manganese operation which is still being rolled out and will be the company's largest Collision Avoidance System (CAS) related project to date once completed.

HazardAvert, now on Generation 2, is a Level 9 capable electromagnetic system that works with field generators and personnel-worn receivers. The generators are installed onto equipment and create electromagnetic zones that surround the unit. Personnel wear Personal Alarm Devices (PADs), which detect these zones and trigger alarms of warning and danger to all applicable parties when the zones are breached. Although electromagnetic (EM) is the backbone of the HazardAvert system, which is primarily used for close proximity detection, it also uses UHF for longer range and faster moving machines. Underground EM is still the primary method as it works through dust, air curtains and even a certain amount of rock strata. And while it is not the newest technology available in CAS, Strata argues that it wins out in terms of reliability and repeatability versus other approaches, especially up to a range of about 30 m. It is arguably also one of the most proven technologies in terms of sheer numbers of installs and longevity.

The US mining markets, notably underground coal mining, are significant for HazardAvert today, and now also are the Australian coal and metallic mining sectors – one of the world's Tier 1 miners recently contracted to supply HazardAvert on almost 700 vehicles and for nearly 1,000 personnel at a large underground metals mine in the country, after a two year selection process that included onsite demos and saw Strata selected from four final options.

Tony Napier, Strata Worldwide President APAC & Managing Director told ***IM***: "In Australia things are gaining traction with collision avoidance after mixed results with trials over the last decade or so. While the regulators have indicated at safety forums they do not for now intend to mandate it, they see the increasing reliability of the systems, so are encouraging mines to install the technology whether Level 7 or up to Level 9. There is a desire for Level 9, but there remains cautiousness that it will not impact production with false alarms."

In the case of the Tier 1 customer, their requirement was Level 9 ready but they are starting with Level 7 and working up from there after intensive testing and trials with the intent to initially have Level 9 capability on certain vehicle types. The HazardAvert rollout with the major miner includes both EM and RF. And beyond metals, Strata is also rolling out its system with major underground coal operators in Australia. Much of this is driven by Level 9 to avoid Vehicle to Person (V2P) hazards especially between people and continuous miners or shuttle cars.

Strata now also has the SafeSITE HazardAI offering, which has evolved out of the acquisition in August 2022 of the assets and intellectual property rights to Bright Path AI (BPAI) and its artificial intelligence-backed camera solution, developed by construction and quarrying major Boral Ltd.

Strata was already working closely with Boral on a Level 9 solution which was installed on a skid steer. This included a Nerospec NeroHUB vehicle interface, and Strata works closely with Nerospec on many of its installs. The construction and quarrying market in Australia, and also elsewhere, is pushing towards Level 9 as seen in mining. Boral is now using Strata's HazardAI at 26 of its concrete and asphalt production sites.

The acquisition of the BPAI technology and software platform enables Strata to provide customers with powerful systems that allow operators from several industries – including mining – to improve workplace safety and reporting. The system is set to be trialed at a gold mine operation in Western Australia in early 2023. Strata is also working with a number of large construction and materials suppliers at some of their industrial facilities.

At the core of the BPAI system is stereoscopic camera technology teamed with edge computing and deep neural networks that monitor people on foot in restricted zones, and a mobile digital vision sensor – currently in development – which is mounted on equipment to alert operators to pending collisions with personnel or other objects. The technology is designed to provide an extra set of eyes to avoid mistakes while at the same time allowing organisations to monitor, benchmark and report overall performance to achieve data-driven improvements.

But it is just one of a range of solutions that Strata now offers. Phil Jones, Project Manager at Strata adds: "As an additional part of SafeSITE HazardAI, we have in our portfolio the Dotnetix SAFEYE long range 3D camera system that can detect pedestrians and mining machines at long distance. It utilises two UV cameras for close proximity ranging together with a full colour camera for recording incidents. Both systems are backed up by state of the art software supplying the AI element. It is proven in mining in South Africa and is well suited to larger mining equipment. We represent the solution worldwide outside of South Africa and it complements the BPAI HazardAI system, which is better suited to light and smaller machines. All this is supported by our behavioural change expertise aimed at educating the workforce on safety best practices."