Sensor technology has proved to be invaluable in helping to reduce the risk of accidents in busy mines

Sensing an improvement in mining safety and productivity

The mining industry contributes significantly to the global economy in countless ways and plays a pivotal part in our everyday lives. We are constantly looking at ways to mine more efficiently, lower our costs to be more profitable and drive environmental and social responsibility.

Most importantly though, the industry strives to be safer by reducing safety incidents. Most, if not all companies target zero harm. And in countries like South Africa, for example, the principle has been codified in the CEO Zero Harm Forum to galvanise stakeholders across mines and government. The initiative has succeeded in reducing fatalities by 88% since 1993 and occupational health-related deaths have also been reduced.

For all the discussion of zero harm in the mining industry though, one factor remains hard to ignore: While we continue to place people in high-risk environments, we will continue to see safety incidents occur in our industry. It is unrealistic to consider zero harm achievable overnight in an industry as large as mining.

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Which begs the question, what can we do today to improve the safety of people involved in operational roles to help them make better decisions and assist them in conducting their jobs safely amid the daily grind of an operation?

There is a case to look at the broader spectrum of safety within the industry, including culture and change management, processes and workflows, and the technology at play to assist in continuously improving mine safety. This article will drill down into the latter, exploring sensor technology in particular, and its increasingly important role in helping to make operations' safety more sustainable.

It's this technology which will be essential to ensuring zero harm. Culture and processes will see it adopted effectively.

Sensors and autonomy

Mining technology is evolving rapidly. The last 20 years have seen mining companies embrace technological innovation to

improve productivity and safety. The two can go hand in hand, if treated right. Accelerating technology adoption is the advent of automation, but automation technology pieces need not be just for automation.

If we break down the technology stack for an autonomous vehicle, for example, it is interesting to see what each of the technologies are and how can they be used or leveraged in a non-autonomous operation.

A good place to start is EMESRT, (Earth Moving Equipment Safety Round Table) a global initiative involving major mining companies. EMESRT engages with key mining industry Original Equipment Manufacturers (OEMs) to advance the design of the equipment to improve safe operability and maintainability.

The group has been integral to categorising levels of control for vehicle interaction risks, guiding how these risks can be managed from technology design to implementation. While these measures have helped operators to take better decisions and avoid accidents, they have also accelerated the use of technology to semi-autonomously intervene in certain risk situations, removing the human factor.

Levels 7 to 9 on safety illustrate technology's evolution in the last five to 10 years. Thanks to the Industrial Internet of Things (IIOT) and the variety of sensors becoming available, mines can now select a wide range of solutions to address the main control scenarios proposed by EMESRT.

Before we proceed, let's define the word 'sensor'.

According to Wikipedia, "In the broadest definition, a sensor is a device, module, machine, or subsystem whose purpose is to detect events or changes in its environment and send the information to other electronics, frequently a computer processor".

In the mining environment, we know that change is constant. Let's explore some of the sensors enabling the mining industry to improve its safety practices.

Global Positioning System, aka GPS

GPS or Global Positioning System enables operations to track the velocity, point in time and location (latitude, longitude and elevation) of our assets. Understanding the location of our assets, humans included, in an operation is vital to how we proactively manage a site during normal work conditions, but especially in times of an emergency.

For vehicle safety, when a GPS is fused with an IMU, (inertial measurement unit) we can obtain a clearer indication of the attitude of the vehicle, allowing us to project trajectory and time of arrival, manage traffic and understand where and when vehicles are likely to intersect. This greatly assists in developing collision avoidance technology, which can lead to a reduction in vehicle-to-vehicle incidents.

Radars

4D imaging radar uses echolocation and the principle of time-of-flight measurement to find things in its environment. The big bonus of radar is its ability to work in mining's harsh conditions, including dust, rain, snow and darkness. 4D imaging radar can tell when a vehicle is moving and at what speed. The major difference from LiDar is the radar's ability to sense at greater ranges, up to 300m, which is essential in a moving environment.

Cameras

Cameras provide context to the mining environment and can complete the picture when other sensors are leveraged. They can be used in the playback and training of operators. In real time, cameras paired with AI can provide the industry with even safer operations by analysing driving behaviours and facial expressions, automatically detecting fatigue or distraction. This is proving to be a life-saving technology in many operations worldwide.

LiDar

Light Detection and Ranging, better known as LiDar, is essentially a sonar that uses pulsed laser waves to map the distance to surrounding objects. The main benefit of LiDar is its accuracy, allowing vehicles to image and calculate at ranges of up to 60m at a few centimetres accuracy. Another benefit is the ability to leverage the data captured from the LiDar system and use it in other downstream processes.

Sensor fusion

While each of these sensors provides significant value to the end user in the mining operation, the real power comes when we can fuse the various outputs together, leveraging each of their strengths and adopting different technologies to hide their weaknesses. By combining GPS, LiDar, cameras and radar, a solution gains complete situational awareness in the majority of environments. To achieve this, there needs to be an enormous amount of processing power, in-depth knowledge of the core technology stacks and clearly defined outcomes of what is being sought.

Autonomous Connected Ecosystems, aka ACE

By autonomous connected ecosystem, we mean a series of interconnected technologies enabling an autonomous operation. For example, an autonomous load and haul ecosystem comprises autonomous, semi-autonomous, and manned haul trucks, loading units, auxiliary equipment, light vehicles, people, haulage network, loading and dumping areas.

Increasingly, advanced technology is connecting sensors for safety and productivity solutions. Technology vendors and solution providers are working together to improve the decision-making process and the workflows of multiple solutions across the safety and production spectrum.

ACE sees one solution in a specific process connecting automatically to a notification or an action in another solution, thus improving safety and/or productivity. For example, a collision avoidance system connects to a slope monitoring system, thus alerting the

operator to both the risk of a vehicle incident and the threat of imminent slope failure. In either case, the operator is empowered to act.

Using data from multiple sensors and modularising solutions is increasingly leading towards simple and consolidated hardware architecture, sometimes known as the Smart Device Ecosystem (SDE). Installed in vehicles, an SDE means one set of components to deliver multiple solutions.

For example, in the same antenna, computing box, perception sensors and display, a mine could deploy multiple solutions for fleet management, collision awareness and avoidance, spotting assist, fatigue management, machine control and machine and asset health. Not only can all of this be confined to a single unit, decluttering the cabin, but it also reduces maintenance and capex investment.

The SDE approach takes the use of sensors one step beyond the vehicle ecosystem, incorporating overall in-pit and pit-to-port ecosystems in the following ways:

a. Slope deformation alerts in real time to vehicles equipped with any on-board solution, such as a fleet management system (FMS) or collision avoidance system (CAS)

b. Automatic blast pattern synchronised in date and time of blast to prevent and know in real time if vehicles are occupied during blast times

c. Interoperable FMS, CAS and sensors provide real-time decision actions to autonomous vehicles

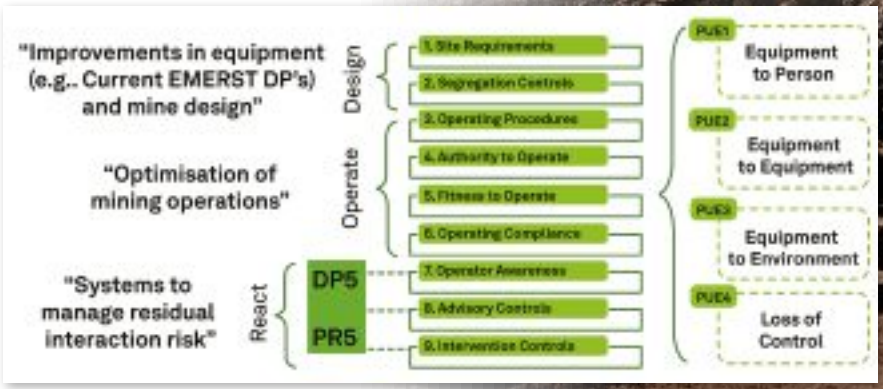
d. Near real-time volumetric change measurement feedback using on-board vehicles' LiDar and radar sensors to compare material moment traceability and minimise the consolidation time of production target vs. plan

Conclusion

By exploring the evolution of change and innovation, we can see how sensor technology has improved safety and productivity today and where future improvements lie.

An important technology step was the evolution from data collection tools to provide information for mine operators' decision-making to automating the decision-making process within FMS and safety solutions. This has helped to optimise productive material movement in real time without human intervention

Interoperability spanning solutions such as safety, mine design and automation across multiple technology providers makes it possible to automate machines and also processes based on real-time decisions to take the right action to optimise productivity and improve safety.



Technology used to develop FMS and other solutions generated huge amounts of data, which created the challenge of distilling the right information for mine operators. This led to the development of data visualisation and analysis tools that from a single source of truth provide the right information, in the right format for the life-of-mine. For example, from the health of machines, such as current engine status, or hydraulic errors and what action to take; to making the right decision to optimise assets' availability and reliability. Improved reliability allows supervisors to use this information optimally to meet productivity goals while distilling the maximum possible value of assets

Some examples of these practices distilled from the use of FMS and other solutions, such as health and safety:

a. Reduced costs by minimising the number of vehicles required for the same production goals

b. Improved productivity by adding extra available time per vehicle by optimising reliability

c. Reduced costs and improved productivity by reducing downtimes and better cycle times with driver awareness and accident prevention. ■

About the author

Rob Daw is Chief Technology Officer at Hexagon, a provider of sensor, software, and autonomous solutions. As CTO of Hexagon's Mining division, Rob oversees all technology and innovation teams and brings more than 15 years' experience in the mining industry. He provides clients with efficient, reliable, and effective solutions that meet the current and future challenges of mining operators across the globe. He is passionate about working with clients to achieve operational excellence – all underpinned by his strong analytical, practical, and methodical approach to solving problems, combined with strong communication skills and industry experience.

A Smart Device Ecosystem means one set of components to deliver multiple solutions such as fleet management, collision awareness and avoidance, spotting assist, fatigue management, machine control and machine and asset health