SAFER MINES

Maximising value from resources in a safer and more environmentally-responsible way
CSIRO-developed longwall automation is being used in two-thirds of Australian longwall coal mines, as well as in four mines in the USA and 30 in China.

The VAM suite of technologies are capturing methane from coal mines to improve mining safety, productivity and reduce greenhouse gas emissions.

New methods and techniques to reduce operators’ exposure to airborne respirable dust, silica and diesel particulate matter.

Autonomous load-haul-dump systems, such as MINEGEM, designed to enhance safety and boost operator efficiency.

Microseismic systems to monitor surface and underground mine stability.

Sensing and 3D mapping technologies for improving safety and productivity.

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The VAM suite of technologies are capturing methane from coal mines to improve mining safety, productivity and reduce greenhouse gas emissions.
Technology moves quickly. I don’t mean the pace of development, but rather the opportunities to share, integrate and span industry boundaries.

Take WiFi as an example. It was invented by CSIRO scientists to deal with data flows from new telescopes in the 1990s. It’s now an integral part of so many innovative solutions – from social media, to the very fabric of Industry 4.0 where physical infrastructure meets the digital domain.

While the focus of this Resourceful edition is on how technology is changing mine safety and environmental outcomes, a second theme emerges: how these technology developments evolve and are applied and shared across industries boundaries.

Raw materials, metals and the immediate mine environment are the visible face of the mining industry. Yet, mining is also a source and creator of many great innovations that have been applied to make a difference in other fields.

For example, fast and reliable sensing developed in the mining industry for mineral-based ore sorting is opening opportunities to detect explosives without the need to open freight or undertake chemical analyses. This builds on airport scanners already in the market that deploy neutron sensors for bulk cargo scanning.

Similarly, new 3D imaging technology originally developed for underground mining is being adopted by major manufacturers to enhance situational awareness and simulation for process and quality control.

Managing water in and around mine sites is essential to safe and sustainable operations. The mining industry is delivering these technologies to other industries and to address the international water challenge. One of our latest developments, SENSEI measures water chemistry in surface and sub-surface environments, providing an early warning system to enable systematic management of our water resources. Secondly, the Bureau of Meteorology’s groundwater explorer provides an integrated view of national water resources and opportunities to ensure that regional resources are effectively managed through a synergistic solution for mining to agriculture.

Navigating the underground is hard without access to digital and satellite technologies that we all take for granted on the surface in order to deliver control for automation. Inertial navigation systems are providing precision positioning data for mining, as well as broader applications in other challenging environments.

Our partners at Mining3 have developed a fibre optic-based conveyor monitoring technology, commercialised with the AVA group’s Future Fibre Technologies, to monitor the health of bearings on mine conveyors. This technology replaces tedious manual inspections in harsh working environments and will find many applications outside mining. As the related article on page 12-13 highlights: there aren’t many industries that use conveyor belts to the extent that mining does, but there is strong interest from the bulk handling energy, manufacturing and engineering industries.

Naturally this conveyor belt innovation was built on the foundations laid before in fibre optics development, which started in the digital and telecommunications space. And of course, there are countless of examples of technologies from other fields adopted by the mining industry.

I hope that the examples shared in this edition work to inspire what mining innovation can achieve for the world – not just from an industry safety and environmental performance perspective, but also for governments and industries tackling diverse challenges in areas such as agriculture, health, security and manufacturing.

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Solutions developed to tackle mine safety and environmental performance will have a greater impact beyond the industry. JONATHAN LAW writes
Arguably, the real innovation in CSIRO’s new underground mapping technology, ExScan, is not the smart laser-based scanner, but the container in which it sits.

The enclosure has been certified to International Electrotechnical Commission ‘Ex d’ standards for use in volatile, methane-rich underground environments such as coal mines. That means it has been designed to prevent the electronic equipment it houses sparking an explosion.

The laser scanner and associated software is capable of generating real-time 3D maps of tunnels, walls and cavities underground where global positioning system (GPS) does not penetrate. These maps can be used for locating, steering and navigating equipment and vehicles.

“Nothing can go underground in a coal mine unless it’s certified to be in that environment,” CSIRO electronic engineer and ExScan project lead, Peter Reid, says.

“You can’t even take an aluminium can; it’s a potential spark hazard if it gets crushed by a vehicle. So getting electronics down there is a tricky process.”

The problem is that explosive gases such as methane penetrate equipment, and any failure of electronics that causes a spark could lead to a fiery disaster.

The solution outlined in the Ex d regulations, is not to contain explosions, but to prevent them from happening in the first place. That’s achieved by designing the container to ensure any spark would have to travel such a long way to encounter sufficient gas to trigger an explosion, and by that time, it will have cooled below the ignition point.

Many members of CSIRO’s ExScan development team spent years working with industry on the Australian Coal Association Research Program-funded project that developed the successful LASC longwall automation system (see breakout on page 3).

A major driver behind automating coal mining is to remove people from the dusty, hazardous environment near the coal face, but even the LASC automated equipment occasionally needed hands-on human measurement to guide it through trickier parts of the coal seams. The idea behind ExScan was to provide images that could be used to make those measurements automatically.

“This technology provides us with information that cameras on their own can’t,” Mr Reid says.

“It allows us to measure in 3D anything we see, as if we were there.”

The team was ideally suited to the job. Not only did the researchers have a lot of knowledge about what the industry needed but, through CSIRO, they also had access to expertise in smart design and working with materials such as plastics.

What emerged looks a little like a 25-centimetre-high version of Star Wars character R2-D2 – with a steel base into which a polycarbonate dome screws. The laser sits under the transparent dome and scans through it. To get outside into a volume of gas, any spark generated would have to work its way through a narrow sawtooth path formed by the screw thread, and in doing so, would lose most of its energy.

Should the scanner malfunction or the container become scratched or damaged, it can be swapped over in a matter of minutes, because the dome just screws off.

The team invested a lot of time in computer modelling to come up with a dome that was just right for injection moulding. That makes the ExScan devices relatively inexpensive to manufacture. In fact, they are affordable enough for a line of 40 or 50 to sit behind the mining equipment along a longwall face of between 400 and 500 metres in length, providing real-time updates of the condition of the wall. At 10 metres apart, the devices are close enough to allow redundancy – their scans overlap, which means that if one fails, its absence can be covered by others on either side to ensure overall reliability.

According to Glencore technology superintendent at Oaky North Mine in central Queensland, Lauris Hemmings, the images they generate can be used to determine and sort out coal flow blockages on the conveyor system.
under the shearing equipment and to help align and steer the shearsers themselves.

“It’s a fantastic tool,” Mr Hemmings says.

“An ever-evolving piece of equipment that takes risk management to even higher levels.”

The mine is already hoping ExScan can be used to navigate the higher risk areas of the mine, taking employees away from the coal face.

But the applications are broader. The scanners can be mounted in any orientation, even upside down, and on moving machinery and vehicles. This means they can be used to map whole mines, and potentially for vehicle navigation.

The containers themselves can be employed for other electronic purposes, such as housing camera systems, and are already being marketed separately by Eaton Industries.

In addition to Glencore, the LASC ExScan system is being trialled by five other Australian mining companies, as well as by companies overseas. The Chinese coal industry has become so interested that it has invested the resources for a couple of engineers to develop skills to deal with the large amount of data generated by the scanners. The feedback from all this activity is allowing the CSIRO team to develop new features for the scanner.

CSIRO is now determining next steps to commercialise the ExScan system.

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Building a picture of components in urban dust in communities near ports, mines and rail corridors is providing valuable data to government and industry so that they can better inform communities about air pollution. It’s one of many initiatives that award-winning image analysis research is driving across the value chain. TONY HESSELEV reports

Award-winning research is demonstrating how every picture tells a story, and how these pictures can open up opportunities from steelmaking through to environmental protection.

The research is making detailed images and data available to clients through an optical reflected light microscopy imaging system, known as Component Grain Analysis (CGA).

This system collects about 1000 to 2000 calibrated high-resolution colour images of a sample to produce a mosaiced image that is then processed with software. Size and composition information obtained for every particle can be displayed via the cloud.

For the past five years, the technology has been increasingly used to assess coal and other components of urban dust in communities near ports, mines and rail corridors. The purpose of these studies was to identify whether the source of urban dust was mining, farming or other activities. This information can help government and industry establish environmental practices and policies to protect communities from air pollution.

Such information requires accurate and consistent characterisation of the amount, composition and size distribution of dust particles. The particle size information is important because a dust particle greater than 10 microns is classified as nuisance dust and those less than 10 microns are classified as respirable dust that can enter the lungs, which has important health implications.

The key to the research is that it provides an unprecedented level of detail that stakeholders in government, industry and communities can see, use and analyse online.

“Our method is one of the only ones that can distinguish the carbon-based particulates in dust samples,” CSIRO coal petrographer and environmental scientist, Karryn Warren, explains.

The samples the researchers have used come from paper towelling, wipes from windowsills and patios, sweepings, and from high volume air samplers. Analysis of these samples can identify sources of dust to help clients understand where best to apply dust control methods – such as suppression using water and/or chemicals.

A key area of focus is on analysing environmental samples, such as sediments, tailings and urban dust, which can contain coal dust especially near railways and ports that transport coal. For example, around Newcastle, where many industries are located and from where about 150 million tonnes of coal a year is transported, the researchers used the CGA system to analyse samples and quantify and distinguish coal dust from other fine particles such as diesel and rubber from road transportation, paints and plastics from nearby industry, and organic matter including pollen and grass clippings.

The researchers also used the system on soil and sediment samples collected around ports and tailings dams, for example after a heavy rain event, to analyse whether any material has been washed out.

Beyond assessing urban dust, the technology was initially developed and used for resource evaluation studies and to better understand the utilisation behaviour of different coals. For example, miners have reduced...
exploration costs by using the research as a basis for industry-funded studies. Other studies have also helped optimise the recovery of fine coal during flotation and a particular coal’s suitability for any utilisation process such as coke-making (metallurgical coal) or power generation (thermal coal).

The technology is also being utilised by coal users, such as steelmakers, for assessing coals used in blast furnaces to make coke. Depending on the required end use, this enables steelmakers to better understand the attributes of individual coals and to use this information to construct coal blends at the highest quality for the lowest price in order to maximise returns.

The Australian Coal Association Research Program (ACARP) recognised the importance of this technology by presenting CSIRO’s project team, and process engineering specialist Dr Bruce Atkinson of Basacon, with an industry excellence award in 2018.

The awarded project team included Ms Warren, chemist and coal technologist Graham O’Brien and coal petrographer and mineralogist Priyanthi Hapugoda. CSIRO software engineers Peter Dean, Gregoire Krahenbuhl and Paul McPhee and imaging expert Dr Matthew Thurley of Innovative Machine Vision, were integral to the development of the CGA software.

“This work has made a step change in how industry utilises data and we see [the] work continuing to be taken up by our industry and its expansion internationally,” ACARP acknowledged.

The research has proved particularly important for mines, coal users (such as overseas steelmakers), ports, environmental companies and government departments.

The CGA system has been licensed to ALS, a global laboratory services company headquartered in Brisbane, Australia that undertakes routine analyses for mining companies.

Commercial arrangements have also been entered into with a Japanese steelmaker and with two other smaller companies, one in Australia and the other in Europe.

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Australia’s national science agency is working on developing technologies to improve mine safety and help the industry meet its commitment to achieving Zero Harm. CSIRO research director for sustainable mining technologies, HUA GUO, writes:

Rates of mining injuries and fatalities have fallen across the mining sector in Australia over the past two decades. However, further improvements are still needed in order to completely eliminate hazards and potential harm to mine workers.

Underground coal mines have seen the sharpest reduction of the lost time injury frequency rate, and yet remain one of the most hazardous of all mine types, due to the nature of the mine environment. Improving coal mine safety is therefore a key priority of CSIRO’s mining research.

Some of the fatal hazards in underground coal mines are caused by strata failure, fire and explosion, methane gas, mobile equipment, groundwater inrush, coal and rock outbursts, and respirable dust.

The mining industry’s number one priority and commitment is the safety and health of its workforce, and has set itself the goal of achieving Zero Harm.

Zero Harm to people is the minimum standard for all operational decisions. Every mine worker who goes to work must return home safe and in good health.

As mining is increasingly conducted at greater depths and in more geological complex conditions, remote and autonomous operations are becoming necessary to take people out of hazardous environments, away from the mining face. This will significantly reduce risks associated with underground coal mining, such as rock falls, bursts, water ingress, machine-people interactions, and manual handlings.

To achieve this goal, the industry needs to embrace digital transformation with real-time sensing and communication, fast data analytics, intelligent mining and processing systems, as well as comprehensive knowledge of the deposit and the host rock and their behaviours during and after mining.

At CSIRO, we have world-class skills and expertise that support mining safety research including geosciences; characterisation, monitoring and control of ground; mine ventilation; capture and mitigation of mine methane; mine fire and explosion prevention; groundwater assessment and treatment; mine environment measurement and modelling (such as mine 3D imaging); mining equipment navigation and control; sensing and communications; and mining and processing automation.

We have a solid and sustained track record of collaborating with the industry, and delivering world-leading technologies, practical solutions and substantial benefits to the sector. We are well positioned to help the industry achieve its Zero Harm goal.

Already, the CSIRO-developed longwall automation technology (commonly called LASC) is being used at about two-thirds of Australian longwall coal mines to remove operators from hazardous areas.

New coal mine methane-capture methods are improving mining safety and productivity, and at the same time are reducing greenhouse gas emissions.

We’ve also developed methods and techniques to reduce mine operators’ exposure to airborne respirable dust, and diesel particulate matter.

Another area of CSIRO innovation is in microseismic systems to detect surface and underground mine stability.

And our 3D rock and mine scanning systems to measure ground and equipment conditions and movement with photogrammetry, and laser and seismic techniques are also improving mine safety.

Integration of these technologies into mining processes and systems will help the industry improve working conditions for mine workers and move towards Zero Harm.

CSIRO’s coal mining research portfolio is the nation’s largest multidisciplinary research concentration and a global leader working across the value chain. This places us at the forefront of mining and processing technologies needed to maximise the value of Australian resources in a safe and environmentally-responsible way.

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Hua Guo is a mining engineer with more than 30 years experience in both mining operations and research. He spent three years with Pasminco’s underground mining operations at Broken Hill and six years with BHP Iron Ore’s surface mining operations in Pilbara, before joining CSIRO in 1998. Since 2004, he has held senior leadership roles in CSIRO for both metalliferous and coal mining research.
Innovation born from the mining industry is leading to exciting advances further afield, ranging from explosives detection to aerospace manufacturing and better community engagement. **Emily Lehmann** reports

Detecting explosives and narcotics

Explosives and narcotics are two major threats being tackled by security agents around the world.

In recent years, security agents have increasingly focused on detecting these threats in the hundreds of millions of mail and parcels shipped daily.

Standard parcel or luggage scanners, such as those used at airports, use X-ray technology to image contents.

The drawback of X-ray scanners is that they only give you a picture of what’s inside, resulting in many false positives. For example, X-rays may pick up modelling clay in baggage contents because it looks like something suspicious, when further interrogation would reveal it as innocuous.

That’s where CSIRO’s magnetic resonance sensors step in. Magnetic resonance sensors are able to directly and accurately detect the presence of explosive and narcotic substances, such as nitrogen.

CSIRO has been developing magnetic resonance applications for the mining industry over the last 20 years. Its most recent success has been a bulk ore sorting sensor solution that uses magnetic resonance to identify high grade ore from waste.

The CSIRO team, based at Lucas Heights in New South Wales, recognised the opportunity to apply the underlying magnetic resonance technology to security applications.

“The advantage of magnetic resonance for explosives and narcotics detection is that it directly detects the presence of the substances by latching onto its chemical signature,” CSIRO team leader, Richard Yong, says.

“We take advantage of physical properties by sending a radio pulse into the material and reading the response signal for nitrogen. It’s fundamentally the same sensing technique for measuring copper in mineral ore as it is for measuring nitrogen in an explosive.”

Building on the success of the CSIRO-developed air cargo scanner, a nuclear-based solution used to scan cargo at airports around the world, the team is working with Chinese manufacturer Nuctech on two magnetic resonance-based technologies for parcel scanning.

The first is a hand-held scanner with a sensing head that’s 15 centimetres in diameter. It can be used by an individual to scan for explosives and narcotics under clothing and within packages, without making any contact with the person, luggage or parcel—a key advantage over other techniques.

The second solution is a magnetic resonance-based scanner on a conveyor designed for use on large parcels. It accurately measure substances, as opposed to simply imaging what’s inside like X-ray machines do.

“Magnetic resonance-based scanning is incredibly accurate, but it’s slower than X-ray-based scanners,” Mr Yong says.

“We envisage security officers initially scanning parcels using an X-ray scanner, and then sending identified packages for further analysis using our magnetic resonance scanner to either confirm or nullify as suspicious.”

Mr Yong believes this solution would be particularly useful for detecting threats in the hundreds of millions of mail and parcels sent daily.

A fully-operational prototype of the CSIRO and Nuctech conveyor-based parcel scanner has been developed. The next stage will involve securing interest from the market for trials.

“We are not the only group to explore magnetic resonance for security applications, but we believe we are best placed to scale up solutions,” CSIRO group leader, David Miljak, says.

“A fair amount of magnetic resonance-based research happens on very small sample volumes. But there aren’t many laboratories positioned to take the measurement to a conveyor that is 10-times bigger, like we have done in the mining space.

“Our advantage is that we have proven that we can scale these sensors for mining applications, at an arguably more challenging scale, than for luggage or parcels.”

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Trialling 3D imaging tech with Boeing

New 3D imaging technology developed to rapidly build a high-quality picture of the underground mine environment, is being applied to large-scale manufacturing.

CSIRO has developed a software and hardware system that’s capable of generating 3D models. It integrates stereo-vision with prior knowledge of the scene, such as from a laser ranging system, which speeds up and improves the accuracy of 3D image reconstruction.

The technology is called Stereo Depth Fusion and has attracted the interest of aeroplane manufacturer, Boeing, who is working with CSIRO to demonstrate the benefits of this approach for manufacturing.

“Just like in mining, manufacturers require high-resolution 3D images for situational awareness and simulation,” CSIRO team leader, Marc Elmouttie, says.

This supports operational decisions in regard to safety, productivity and process optimisation.

“Quality control measures for manufacturing processes involve inspecting product details and validating it against design. This can be, depending on the industry, very time consuming, manually-intensive and prone to error,” Dr Elmouttie says.

“Our 3D imaging technology can overcome these drawbacks, by providing data that can be analysed quickly and possibly autonomously.”

Beyond manufacturing and mining, Dr Elmouttie believes that the technology is advantageous in any application where high-speed 3D imaging is required such as in some medical imaging applications, as well as for equipment wear analysis.

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Tackling the corporate trust issue

As highlighted in CSIRO’s recent Australian National Outlook 2019 report, a social licence to operate continues to be a top business risk facing industry today.

CSIRO maintains a large social science effort, with one of its most recent successes culminating in the spin out of its social insights capability into a new Australian company, VoconiQ.

Launched this year, VoconiQ uses a data-driven approach to tackle declining trust in industries spanning mining and agriculture to fisheries and infrastructure.

“We capture real-time insights into community sentiment across time and locations, with the aim of helping companies, and the communities they work alongside, build greater trust and mutually-beneficial outcomes,” VoconiQ CEO, Kieren Moffat, says.

Having grown strong market demand from big players such as BHP, Rio Tinto and Newmont Gold in the mining domain, it’s no surprise that other industries grappling with their social licence are paying attention to this social insights service too.

In the agriculture space, VoconiQ recently secured contracts with AgriFutures Australia and LiveCorp, adding to work already underway with Australian Eggs.

The company also announced a project involving several farming, fishing and forestry groups, which has been set up to tackle the challenge of community trust following concerns over the public perception of their industry practices and value.

“A social licence has been a challenge for mining for some time, and now agricultural and other industries are experiencing similar pressures and are looking for ways to build deeper trust with communities,” Dr Moffat says. 

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A suite of three technologies that work to mitigate methane emissions, by either destroying the gas or capturing it, is gaining the attention of miners seeking to reduce their emissions.

**ROBERT HOBSON** reports

Methane poses a unique challenge in the coal industry as risks associated with it are not only a safety hazard, but a significant contributor of greenhouse gas (GHG) into the atmosphere. It is the second most abundant greenhouse gas, and 28-times more potent than carbon dioxide in trapping heat in the atmosphere.

In 2017, fugitive methane emissions from coal mining and handling, and decommissioned mines represented 5.3 per cent of Australia’s total net GHG emissions.

In response to this challenge, CSIRO has developed a suite of three technologies that aim to mitigate methane emissions by either destroying or enriching the gas or capturing the ventilated air – known in the industry as Ventilation Air Methane (VAM) – from coal mines and using it to generate electricity.

“Our first technology is a mitigation unit called VAMMIT, which is a compact flow reversal reactor with a newly-structured regenerative bed to destroy methane in a cost-effective manner,” CSIRO lead scientist and technology inventor, Shi Su, says.

“Whereas the second technology is a capture and enrichment unit, called VAMCAP, which essentially collects and separates the methane from the ventilated air using carbon composites.

“Our third technology, VAMCAT, uses a catalytic combustion gas turbine to create electricity from an otherwise waste product.”

Dr Su developed several research projects including a $7.1 million project primarily funded by the Department of Industry, and a $1.95 million project funded by Coal Innovation New South Wales, and established a research team to develop the technologies from fundamental studies to pilot scale and mine site trials.

CSIRO research engineer, Jon Yin, adds that VAMMIT and VAMCAT work in environments with a low VAM threshold. They can be operated as independent units or be used together in different configurations, which are determined by the needs of the coal mining operations and mine site conditions.
“TO ACHIEVE
SELF-SUSTAINING
OPERATIONS YOU NEED A
MINIMUM CONCENTRATION
OF METHANE. FOR VAMMIT
IT’S 0.3 PER CENT AND
FOR VAMCAT IT’S 0.8
PER CENT – BOTH ARE
LOW CONCENTRATIONS
AND WORLD-LEADING
BENCHMARKS,” DR YIN SAYS.

“In practice, the VAM concentration
sometimes drops below 0.3 per cent,
and that’s where the VAMCAP technology
comes into play by treating part of the
ventilation air. Its aim is to enrich VAM
from very low concentrations, to a much
higher concentration, to about 25 or even
30 per cent. The enriched methane can
be used to assist the operation of the
VAMMIT and VAMCAT units.

“And the waste heat from the VAMMIT
and VAMCAT units can be used by
VAMCAP for stripping methane
in the regeneration process.

“The three VAM technologies are
complementary. Depending on the
mine site conditions, a company may
choose to use one technology or
a combination of them.”

This is economical because the units
are modular, which makes them easily
transportable, reduces the installation
costs, and makes it easier for mine
operators to scale up their fugitive
emissions mitigation efforts.

“They can be easily added to an existing
VAM plant and/or to a new ventilation
air shaft as the ventilation systems
are not going to exist in the long
term, so maybe for 10 or 15 years until
mining operations finish,” Dr Yin says.

“So from then on you can move the
VAM units to a new ventilation air shaft
system, and that’s why we developed
the technology at a portable scale.
Otherwise you will have problems like
the very high cost of relocation, which
can be higher than building new units
or VAM plants,” Dr Yin says.

CSIRO’s VAM technologies are
world-leading and possess significant
advantages over others. They have been
developed and successfully proved at
a large scale at a mine site. With all
necessary operating data, engineering
and safety management experience,
they are ready for further scale up.
They can also be potentially applied
in overseas coal mines, such as in the
US and China.

Supported by Coal Innovation New
South Wales, the team is developing
a catalytic version of VAMMIT for
mine site trials. These will target a
minimum methane concentration of
0.15 per cent and lower operational
temperature (below 650 degrees
Celsius), suitable for some mines
with a VAM concentration of under
0.3 per cent over a substantial period.

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A new Australian-designed and distributed acoustic sensing system – AURA IQ – is changing the way mines manage conveyor belt maintenance. It is much safer, more accurate and more efficient than conventional monitoring methods, and could save mining companies millions of dollars.

LOUISE POBJOY reports

Maintaining conveyor belts in mines is a significant problem, with conventional monitoring methods unreliable, time-consuming, labour-intensive, costly – and often hazardous.

Recognising the need for a better tool to identify and monitor conveyor belt wear, Australian mining research organisation, Mining3, has partnered with the AVA Group’s company Future Fibre Technologies to create the groundbreaking AURA IQ solution.

According to the AVA Group’s group head of innovation for extractives and energy, Andrew Hames, the greatest maintenance burden for conveyor fitters is detecting and replacing worn rollers.

“Even a small width belt contains 2500 rollers per kilometre, and there are two bearings in each roller. A mine with 60 kilometres of conveyors can replace up to 40 rollers per day,” Mr Hames says.

Mining3’s data acoustics systems leader, Paul Wilson, explains that some mines employ up to eight staff to walk up and down belts three or four times a day to identify wear. The tools they rely on – their hearing, infrared cameras or microphones – are flawed, because human hearing is unreliable; worn bearings don’t always emit heat; and microphones pick up too much background noise or staff move too quickly to collect useful sounds.

Staff also face hazardous conditions and often can’t access many sections of conveyor belts, which cross natural obstacles and rise on gantries to fill surge bins. In addition, bad weather can make it virtually impossible to walk the belts.

“My operators had no way of detecting bearings, so either replaced them too early which was expensive, or they’d collapse and cause damage, and that also becomes very costly,” Dr Wilson says.

AURA IQ was designed to address these problems. It comprises the Future Fibre Technologies’ award-winning Aura Ai-2 fibre optic detection and sensing technology platform in combination with Mining3’s advanced signal processing algorithms and data analysis.

The unique system transmits a series of short laser pulses along a single fibre optic cable retrofitted along the length of a conveyor. When bearings wear, they vibrate. Vibrations travel through the conveyor’s frame and onto the cable, causing microscopic changes in the backscattered laser light.

Data from these changes is simultaneously gathered from every metre of the conveyor, and AURA IQ processes this data and alerts operators, on- or off-site, about potential failures.

AURA IQ’s data can detect a broken ball or cracked cage in a ball race, observe and track idler bearings as they wear, and predict bearing seizures.

“The Aura IQ Cloud and network solution wirelessly connects the IQ Edge Server to a central cloud reporting and analysis platform,” Mr Hames says.

“Alerts and reports from conveyor assets – located anywhere in the world – are accessible on any internet-enabled device in near real time, without the need for specialist software or equipment.”

The research behind differentiating sounds and categorising them into the different stages of a bearing’s lifecycle is brand new, and as Dr Wilson tells us, it’s game-changing.

“This is a radical idea. We’ve completely changed how we monitor the signals from bearings,” Dr Wilson says.

It seems that others agree, with AURA IQ being a finalist in Austmine’s 2019 METS Innovation Award and winning Mining Magazine’s Bulk Handling Award in 2018.

AURA IQ’s success could come down to it reducing the number of belt walks needed to maintain conveyors, significantly improving mine safety and occupational health initiatives.

“Fewer belt walks means staff have less risk of fatigue, heat stress, and exposure to noise, dust and atmospheric contaminants,” Mr Hames says.

“The chance of injury from exposure to moving machinery, challenging environments and extreme weather also decreases.”

And because fewer staff are needed for belt walks, their time and labour can be focused elsewhere. Dr Wilson believes this will improve overall mine performance.

“You can divert spare staff hours onto long-term maintenance jobs and get plants running more efficiently,” Dr Wilson says.
Aura IQ’s daily asset reliability reports will also help improve mine performance by giving maintenance technicians, site personnel, regional operational hubs and global headquarters deeper insights about every conveyor, at every site around the world.

The data in AURA IQ’s reports is inherently reliable, accurate and independent, because it doesn’t rely on conventional monitoring and subjective interpretation.

“[T]he fibre optic system is far, far better than human senses,” Dr Wilson says.

“The signal processing and the mathematics we use takes all the noise and interference away and reveals just the diagnostic signals for the bearing conditions.”

Better data means big financial and time savings for mines, because they can accurately predict when bearings will wear and schedule maintenance.

“Unscheduled stoppages cost a lot of money. When your plant is turning over a million dollars a day, the last thing you want is the conveyor belt to shut down for eight hours,” Dr Wilson says.

Predicting bearing wear also offers other financial benefits, including not wasting money on changing good bearings unnecessarily, and minimising failures that can lead to fire and expensive conveyor repairs.

Dr Wilson explains it’s been over four years of hard work to get the technology to this point because it’s so complex.

“It has a lot of mathematics, signal processing and two different expert systems in it. We’re starting to do some machine learning and artificial intelligence as well, which will be fitted in the next generation tool.”

The AVA Group ultimately aims to develop AURA IQ into a complete conveyor health monitoring solution. Improvements have already started, with the integration of vibration, temperature and current draw monitoring of conveyor motor drives and pulleys.

AURA IQ has already undergone four highly successful trials in Australia and two ‘first adopter’ production trials – one in Queensland and one in South America.

And while there aren’t many industries that use conveyor belts to the extent that mining does, there has been strong interest from the bulk handling, energy, manufacturing and engineering industries.

“[W]e have very strong interest from 18 countries across six regions that our technical support team are working through now. The return-on-investment models completed are extremely compelling,” Mr Hames says.

“Fewer belt walks means staff have less risk of fatigue, heat stress, and exposure to noise, dust and atmospheric contaminants.

Paul Wilson, Mining3
An open-access, central repository for the nation’s groundwater data, the Australian Bureau of Meteorology’s (BoM) Australian Groundwater Explorer has quickly become a powerful tool for everyone from policymakers to pastoralists.

Its features include open-access information on more than 900,000 bore locations and logs, as well as interactive 3D hydrogeology models.

Now the latest data upgrade to the Explorer, which adds CSIRO and Geoscience Australia hydrogeochemistry data, is turning this resource into a powerful tool for minerals exploration.

The tool’s hydrogeochemistry datasets cover almost all of Australia, with Tasmanian data to be added soon. Most of these samples were originally collected and analysed by the water departments of the states and territories, with CSIRO undertaking the mammoth task of collating, standardising and running quality assurance and control checks on the data. The data reveals hydrogeochemical signatures of groundwater.

“We’re primarily trying to find what the signature of a mineral deposit looks like in groundwater,” CSIRO team leader, Nathan Reid, says.

“We then see if we can find similar signatures in other areas that are not near known mines. There’s a lot of exploration now going on with companies looking at the data and trying to find new deposits based on it.”

The Australian Groundwater Explorer was born in 2014 thanks to a government imperative to centralise precious water data.

“Groundwater data is collected and managed by each state and territory, and each one has their own database, their own formats and terminology,” BoM senior hydrogeologist, Eloise Nation, says.

“To collate data in the past, you had to go to each of these agencies separately to collect it, standardise it and stitch it together.

“It was a lot of work and it was difficult to get a picture at the national scale of what Australian groundwater was doing.”

The Australian Groundwater Explorer forms a key part of the BoM’s suite of groundwater information products and brings together data on bore locations and logs, groundwater levels, and salinity measurements.

CSIRO and Geoscience Australia had long been collecting groundwater samples and doing deep analysis on its hydrogeochemistry, but this detailed data was available either internally on hard drives or at best via non-user-friendly portals.

BoM collaborated with CSIRO and Geoscience Australia to add this data to their Explorer to boost the resource and make this data openly accessible.

“The majority of groundwater originates as rainfall – it hits the ground, goes through soil, rocks, the aquifer, and at some point in its journey, we sample it from a bore,” Geoscience Australia’s, Luke Wallace, says.

“That water is trying to tell us the story of where it came from. It has a chemical signature from every rock it’s passed through, and we use chemical fingerprinting to unravel the detective story and join the dots.”
These chemical signatures help to piece together a picture of the systems lying beneath.

“It gives us the potential to ‘see’ through 30 metres and even beyond 100 metres of cover,” Dr Reid says.

“Some other exploration techniques are hampered if the bedrock is covered by sediments and sands. But as water moves through rock, a little bit dissolves here and there, and that signature is preserved to give us an idea of what the underlying geology is like.”

Water is the quiet collector of these precious clues.

“It’s a passive sampling technique – we listen to the data and work out the story,” Dr Wallace says.

Groundwater hydrogeochemistry data is another technique in the exploration tool kit to help understand the underlying geology beneath the sands and sediments masking it.

“We analyse groundwater samples for 60-odd elements and a few other parameters, isotopes and sometimes age-dating,” Dr Reid says.

“We’re basically looking for everything: gold, nickel-copper, uranium, platinum and palladium systems.”

“We throw the book at the water and see what it tells us, rather than trying to find a specific target. That’s been one of the failings of how companies have approached sampling in the past. If they’re looking for gold, they might only analyse for gold and a couple of other pathfinders, which means they might miss a nickel or copper deposit.”

“Our aim is to find out about the geology, which can help target areas of interest based on whether you’re in a prospective rock type.”

Geoscience Australia analyses for some 120 different compounds and other parameters.

For the past three years they have been doing comprehensive suites of analysis to assemble data to help the scientists of tomorrow.

“We realise we may not come back to this bore in the future, and that we’re likely to have more questions than we have right now. So we’re thinking about the future and analysing for everything.”

“We look at field parameters, major and minor elements, traces, precious metals, a whole suite of isotopes, noble gases and organic gases,” Dr Wallace says.

“We’re looking from a minerals, groundwater systems and energy perspective, and we can provide environmental baselines, as well as exploration tools.”

CSIRO has adapted a sampling application (FAIMS Android app), which was developed by Macquarie University. This open-source field app helps to standardise the hydrogeochemistry data from all sampling.

“It’s basically a digital field notebook and we encourage everybody collecting groundwater to use that and then all the data comes in the same format,” Dr Reid says.

Adding value to the Explorer database, CSIRO has released the Hydrogeochemical Mapping of the Australian Continent report, along with state-by-state hydrogeochemistry atlases that provide interpretation and an in-depth look at the data.

“The atlases look at all the hydrogeochemical data from each state and make interpretations based on the statewide geology,” Dr Reid says.

“The atlas includes interpretations on major aquifer systems, how they were behaving, whether we could see known deposit styles in the state data and then if there were any areas of interest in the data that were not near known deposits and might be worth exploration follow up.”

David Gray, a global leader in exploration hydrogeochemistry, is the lead author on the new CSIRO report and credited with assembling much of the national data.

“Over the past four years, Dr Gray has been getting whatever data he can on groundwater chemistry from all over Australia.”

The data came from decades of CSIRO analysis, as well as the state government departments, the mining industry and universities. And it involved standardising information that came from more than 100 years of data collection.

“Dr Gray dealt with all the quality assurance and quality control issues to tie together around 320,000 data points on groundwater hydrogeochemistry from across Australia.”

“As far as I’m aware, there’s nothing of this magnitude anywhere else in the world,” Dr Reid says.

Dr Wallace adds that there’s been a lot of goodwill between BoM, CSIRO and Geoscience Australia to make the Explorer and Atlases happen.

“We’ve all come to it with our unique expertise and worked together to create a national resource for the greater good.”

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REAL-TIME GROUNDWATER MONITORING

World-first trials of CSIRO’s automated sensor system, SENSEI, are providing promising, real-time results to better monitor and manage groundwater impacts in mining operations. DAVID SIMPSON reports

CSIRO’s new automated groundwater monitoring system, called SENSEI, is a year into its world-first trial at Heathgate Resources’ Four Mile West uranium mine, some 550 kilometres north of Adelaide in South Australia.

Heathgate’s commitment to developing and operating Four Mile West as a world’s best-practice in-situ recovery (ISR) mine provided an ideal opportunity to trial SENSEI technology in a challenging environment.

ISR mining involves injecting alkaline or acidic fluids with an oxidant within a permeable geological formation, typically an aquifer. During this process, it is essential that the mining fluids are contained within the mining zone, as they are not only resource rich, but also have the potential to adversely impact adjacent areas, particularly aquifers.

Groundwater monitoring is an essential part of regulatory compliance.

Conventionally, as is the case at Heathgate’s Beverley, Beverley North and Four Mile mining operations, this is done by manually pumping groundwater samples from each of a series of wells on the perimeter, overlying and underlying the mining area. The samples are then analysed to ensure that no mining fluid has drifted outside the immediate mining zone, laterally or vertically, and has been safely contained in the mining aquifer.

The manual sampling process at the mine typically takes two operators a month to complete, with analysis adding another time lag, so it can be two to eight weeks before the results are known. If anomalies are detected, the time between incident and action risks complicating the remediation process.

The value and benefits of SENSEI are evident. SENSEI solid-state sensors inserted into the wells can provide real-time, continuous data on pH, redox potential, conductivity, temperature and water level.

Results from the SENSEI system, that comprises the sensors and associated software, can be monitored onsite or remotely via the cloud.

With support from NERA Heathgate Resources, (National Energy Resources Australia) and Boss Resources, the SENSEI trials at the Four Mile West mine began in November 2018 and, according to CSIRO project manager, Daniella Caruso, are progressing well.

“At the moment, we’re in the middle of phase one of the trial, in which ten sensors were deployed in the inner region of the lateral environmental monitoring wells,” Ms Caruso says.

“By collecting data and matching it with the manually derived results, we’ve learned most of the SENSEI architecture is working well after ten months in the field.”

“A major benefit of the field trials is that we’ve learned which components are working well and identified others that need optimising for underground water monitoring conditions.

“All the above-ground infrastructure is performing well, in conditions ranging from sub-zero nights to near 50-degree daytime maximum temperatures.”
“WHILE OUR SENSOR MATERIALS ARE PERFORMING WELL, WE’RE CONTINUING TO IMPROVE SOME COMPONENTS THROUGH THE TRIAL TO OPTIMISE THEIR PERFORMANCE UNDER FIELD CONDITIONS TO HAVE A LONGER LIFESPAN.

“THE RESULTS SO FAR INDICATE EXCELLENT PROGRESS TOWARDS VALIDATION OF THE MATERIALS AND CONSTRUCTION OF THE SENSEI SYSTEM FOR THIS APPLICATION.”

According to Ms Caruso, achieving twelve months in the field is a big step forward, particularly because the underground components are exposed to 15 to 18 bars of pressure as the monitoring well-depths range from 150 to 180 metres. The trial is proving that SENSEI will result in miners increasing their operational efficiency with autonomous real-time access to accurate data.

Next steps for the trial involve optimising components and continuing to check results against manual testing.

Before SENSEI can fully replace manual testing, both users and government regulators must be satisfied that it meets rigorous groundwater monitoring requirements.

Then the benefits of lower-cost, real-time monitoring and remote access can be realised.

For CSIRO’s SENSEI team, this will be the first step in the journey that will potentially involve applications in other areas of the mining, water and allied industries.

“We’re thankful to Heathgate Resources, NERA and Boss Resources for their sponsorship and support in providing the opportunity to field test our SENSEI technology,” Ms Caruso says.

The CSIRO team is now looking for partners to bring the technology to market.

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RESOURCES INNOVATION SHOWCASE

Orebody knowledge and precision mining

Join with colleagues from a diverse range of technical backgrounds to learn from CSIRO, Australia’s national science agency, how the accurate characterisation of resources can help you unlock the knowledge that will drive exploration, mining and processing success.

Keynote speaker: Asmita Mahanta
Manager Technical Services and Data Integration, BHP
Date: 18 February 2020
Cost: $200 (for a full day event plus access to RIU’s ‘The Opener’ Sundowner)
Venue: Esplanade Hotel, Fremantle
For full program and to register: events.csiro.au/RIS

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