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MINING SOFTWARE

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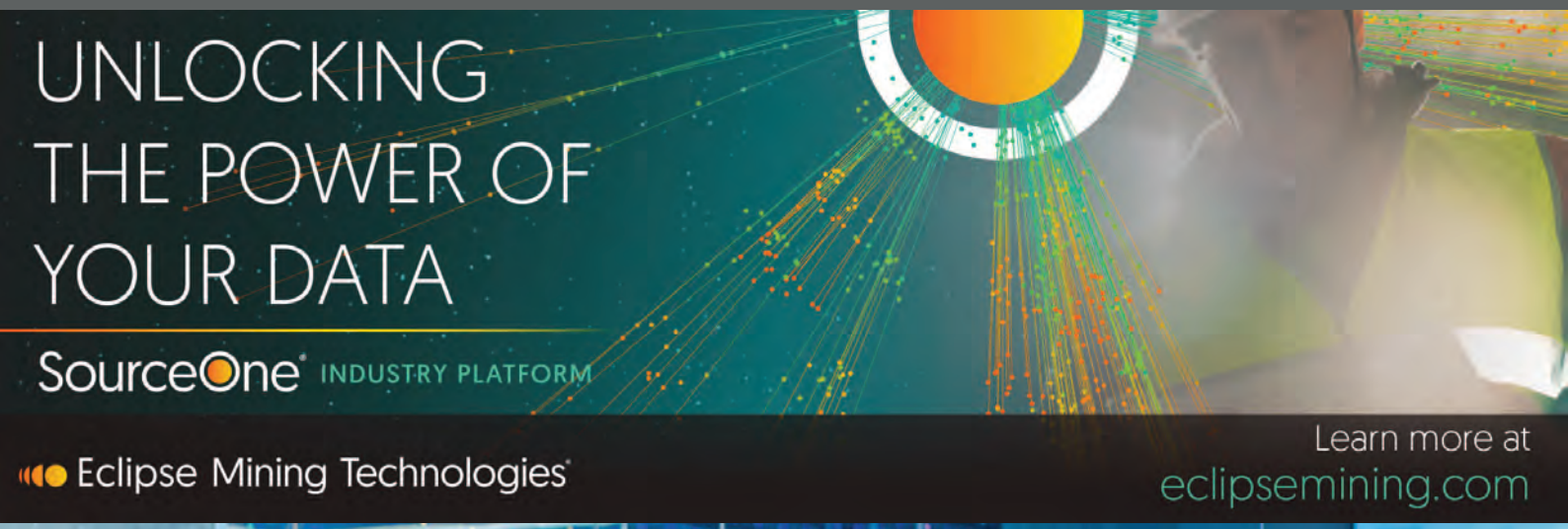


Breaking down the silos

No modern mine is short of data, but what these operations continually lack is an ability to fully leverage this data across processes. Dan Gleeson speaks to those in the mining software space to find out how far off the industry is from 'connecting the dots'

The last commodity price downturn got miners thinking hard about how they could improve productivity across their operations to lower their input costs and stay profitable as their revenues fell.

In addition to taking steps to cut discretionary spending on the likes of exploration, external contractors and growth projects, the majors also sought to increase their productivity by incorporating new technology.

The likes of BHP, Rio Tinto and Fortescue Metals spent big on autonomous trucks at their open-pit mining operations in the Pilbara of Western Australia.

A surge in labour costs from the early 2000s, a need for further operational consistency and improved safety across their operations, and expectations of operating cost cuts were cited for such a move.

On the surface, the introduction of these autonomous vehicles achieved all these goals, bringing costs down and improving productivity.

More and more miners noted these improvements and factored in autonomous haulage – both above and below ground – into greenfield/brownfield projects. Expectations are that adoption of automation will continue apace into the future.

The speed of adoption across the wider mine and processing site has not kept up with these robotic trucks.

For example, autonomous haul trucks are completing their cycles quicker than most manned fleets ever have using sophisticated sensors on the trucks and information processed on-board to navigate the optimal route to and from the excavators and dumping locations.

Yet, the excavators filling the truck bodies with material and the supporting equipment servicing the load and haul equipment have not been taken on this same automation journey. This is despite pretty much all this equipment having entered the 'Internet of Things (IoT) space' with the incorporation of sensor technology.

In some instances, this disconnect between the autonomous and manual on site is leading to trucks queuing up in front of the shovels for periods of 10 minutes or more awaiting their turn, as frustrated control room operators look on.

The operations employing autonomous equipment are aware of this – again, using sensors on the trucks, excavators, ore chutes, etc – but, in general, they have been unable to align their existing processes to stop such queues and create even greater efficiencies.

'Data silos' are partly to blame for this.

The addition of cost-effective sensors, new hardware and software platforms has seen the generation of data explode, but this data is tending to remain in one place, according to Shaun Maloney, CEO of geoscience analysis, modelling and collaborative technologies company, **Seequent**.

"There are more data silos now than there have ever been before and they are growing at an exponential rate," he said. "That is because of the deployment of data generators in the form of sensors, autonomous vehicles and automated processes."

Dis-integrated thinking

This is not to say there is no value coming from the data aggregated in these silos.

The data, whether analysed on- or off-board, has provided benefits across mining operations – from geology with digitalised core logging, to drill and blast with increased control and precision, to processing with 'smart' control tools.

"RPMGlobal's software not only integrates together, but with other industry solutions to ensure the exchange of real-time information across all areas of a mine site," Paul Beesley says

Yet, these 'digital transformation' projects tend to be run at a divisional level, with analysis and actions ending at the core logging, blasting and concentration stages, respectively.

The thinking has not been integrated.

"The head-long rush into digital adoption did not factor in the cause and effect, and investment in the changes of workflow," Maloney said.

There are plenty of reasons for this.

For starters, habits are hard to break on mine sites. Most IoT projects are configured around replicating existing manual processes in the most efficient way as opposed to disrupting the process for the biggest gains, recognising that change management is a tricky task.

Contractual arrangements with suppliers and service providers around the likes of plant throughput, drilling metres per month, mine scheduling, etc are difficult to get out of, meaning miners stick with the status quo as opposed to breaking agreements and facing disputes.

Divisional incentives also come into this conversation.

It can prove difficult, for instance, to ask a plant supervisor to change the settings of the concentrator for the benefit of those working downstream on the flotation circuit if it negatively affects concentrator throughput. Many of these plant personnel are incentivised based on tonne per month throughput metrics, which need to be adjusted for operation-wide projects to gain traction.

And, of course, there has been the problem of interoperability throughout the sector meaning miners struggle to obtain, translate and transfer data from vendors' machines or software to the rest of the value chain. 'Data ownership' issues with OEMs and miners have proven too much to overcome in many well-intentioned integrated projects.

However, miners are starting to make breakthroughs in these areas, which bodes well for the 'digital transformation' projects being spoken of throughout industry providing the 'transformation' once thought possible.

Home truths

The disruption that has come with COVID-19 is arguably a catalyst for this re-think.

"COVID – while being a terrible event from a humanitarian perspective – is a mega event that has caused ripples we call megatrends," Maloney explained. "These megatrends will ultimately have a very positive effect on the mining and minerals sector. It has broken down so many barriers and silos; if you had any resistance to change before, that is now gone with the effects of COVID."

The inability to fly staff in and out of remote operations, and strict guidance around personnel coming on site has meant more operational oversight is carried out remotely.

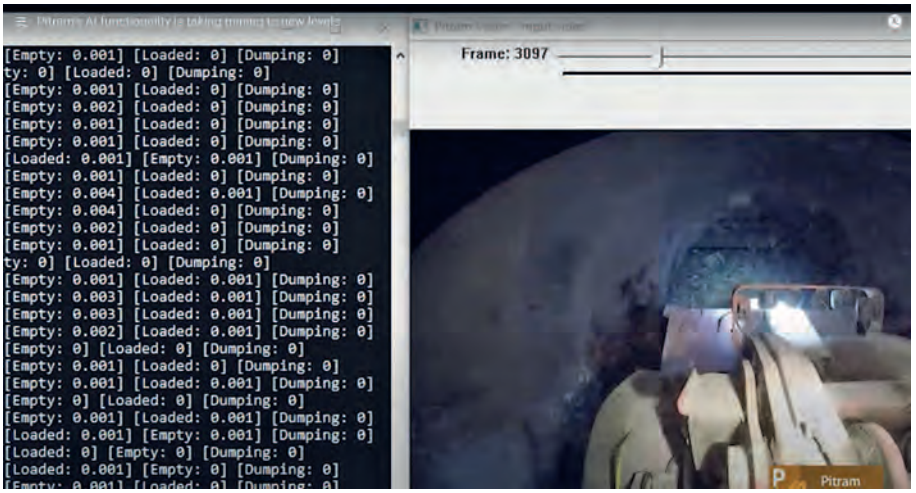
"From March last year, we had to work remotely with terabytes of data across the planet in real time, with less people on site," Maloney said. "We essentially jumped ahead 36 months in the evolution of the digital adoption of the mining industry."

Digital projects have become priorities for operations managers that cannot get on site and, in many cases, are accessing information from their homes.

The disintegrated digital process already discussed has become increasingly apparent through this lens, opening managers' eyes to the potential that could come from changes in process workflows.

This has led to miners taking a much more holistic view of their operations and where joined-up digital solutions can help them navigate through these uncertain times, relying less on more manual, on-site tasks.

Prepared for such a change, the industry has now turned its attention to the vendors supplying the software that 'connects the dots'.



"The industry has essentially said it needs to get some operational leverage between solutions from these vendors," Maloney said. "They said to the general mining package (GMP) software community: 'we are investing massively in digital transformation and you guys are hampering our operations by not playing nicely with each other; we're not gaining the potential efficiencies we can.'"

They have urged the community to break down the interoperability barriers and help them interact more freely between systems and platforms.

This pressure has seen the GMP community acknowledge a few home truths.

Adam Brew, **MICROMINE** Australia Manager, told ***IM***: "While MICROMINE does offer a solution for each stage of the mining lifecycle, we certainly acknowledge that there are some solutions that customers are reliant on, which are embedded into the culture of the operation which won't be displaced.

"In these circumstances, we strive to bridge any gaps in functionality through integration via application programming interfaces (APIs) or automated data transfer schedules. We have ensured our solutions are compatible with all major GMPs and over 30 specialist solutions and file types."

Maptek CEO, Eduardo Coloma, also reflected on how his company and the wider mining software sector was changing:

MICROMINE's Adam Brew says the latest-generation machine-learning algorithm within Pitram Vision software comes with an accuracy of greater than 99%

"As well as our in-house R&D, one of Maptek's key strategic objectives is to identify appropriate partners who develop complementary technology that enhances the value proposition for our customers," he told ***IM***. "This year marks our 40th year in business. We're mature enough to acknowledge we don't need to build everything from scratch."

Maptek and MICROMINE are not the only companies fronting up to this reality.

Lourens Du Plessis, Vice President of Sales and Marketing at **Modular Mining**, added: "Despite the successes achieved and results produced by our core technologies, we've come to understand that as the needs of the industry evolve, and integration becomes increasingly important, we won't be able to solve every problem on our own.

"With this in mind, we revised our corporate focus in early 2019 and adopted a new vision: sustainable mining powered by open technology solutions," he said. "In support of this initiative, we've begun taking

Modular Mining's Lourens Du Plessis says the company has begun taking steps to foster increased integration, interoperability and communication with relevant third-party systems

steps to foster increased integration, interoperability and communication with relevant third-party systems."

acQuire Technology Solutions Director of Product, Steve Mundell, said a key part of the company's product strategy for its flagship geological data management software, GIM Suite, is having connectivity with third-party systems for people to access and use their data across mining departments and the mining value chain.

"We have a long history of developing industry partnerships with the major mining software solutions," he told ***IM***. "This has resulted in a mature and robust interoperability strategy for GIM Suite. It means customers are able to easily share their data between systems and avoid data silos."

Dylan Webb, CEO of **Datamine**, says his company has been working on integrating its expanded offering, which now includes products from Minemax and Snowden, into the wider mine value chain.

"Integrated solutions for our clients are one of our core differentiators," he told ***IM***. "We see the significant time savings to be had and the bottom-line impact this has for our clients."

Paul Beesley, **RPMGlobal**'s Chief Technology Officer, says the introduction of enterprise software applications into the mining space was a key building block towards the company integrating with other solutions across the mining value chain.

"RPMGlobal's software not only integrates together, but with other industry solutions to ensure the exchange of real-time information across all areas of a mine site," he told ***IM***. "The key is enabling customers to move data between applications at a resolution and frequency that makes sense."

Maloney, who states Seequent has been looking to collaborate with others in the software space since it was launched in 2010 (as ARANZ Geo), says software vendors are realising there are plenty of benefits that come with this industry collaboration.

"Companies are finding out they can have a much bigger impact if they stick to the solutions they 'own' and 'breathe' on a daily basis and not worry about the other parts of the mining process, instead interoperating with other businesses that have those complementary focuses," he said.

The proof

One does not have to look far for examples of where breaking down interoperability barriers can pay off.

Seequent's 3D geological modelling software Leapfrog started integrating with Maptek's Vulcan 3D geological modelling, mine design and production planning solution all the way back in 2016, with the two companies agreeing on "seamless interoperability" between the two software solutions, Maloney says.

"The link our products have with Maptek solutions is universally popular with our common customers," he explained. "The fact that they can move measures and formats backwards and forwards between an engineering-focused major vendor and a data science software solution is providing incredible value to the mining industry."

Maptek's Coloma references another collaboration that sees **PETRA**'s latest digital twin performance models come into the Maptek Evolution mine schedule optimisation platform as evidence of the increased value of interoperability.

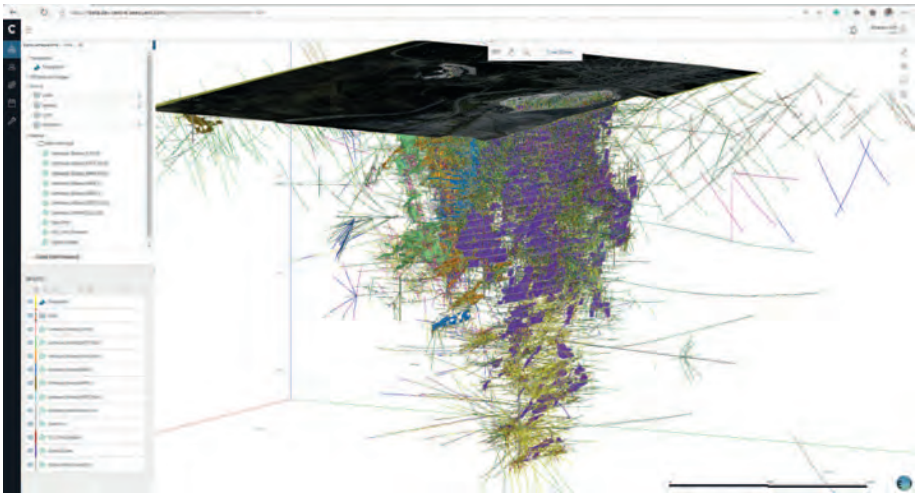
"The digital twin and artificial intelligence (AI) technologies from PETRA integrate optimised mining and beneficiation processes and the resource model, mine design and scheduling capabilities," he said. "We make it as easy as possible for customers to access the machine-learning apps by launching them from within Maptek products."

Coloma argues the software integration process must go both ways.

"We're also proactive in opening up our software for integration with customer systems through application extension toolkits," Coloma explained. "Workflows, APIs and software development kits in scripting languages allow our users to expand the capabilities of Maptek software products."

acQuire's Mundell points to a recent collaboration agreement the geoscience software company struck with cloud-based image capture and management tool Imago as evidence of industry interoperability.

"This was released as part of our GIM Suite 4.3 product update and gives GIM Suite customers the ability to view high-quality images alongside their geoscientific data within the GIM Suite interface," he said. "Geologists find value in having the data and imagery displayed together so they can quickly validate and verify any anomalies or find issues, and it is one of the most streamlined ways available in the



"Openness and interoperability are driving forces at Seequent," Shaun Maloney says. "Our cloud-based model management platform, Seequent Central, brings teams and data together across the lifecycle of a mining operation to improve decision making." Pictured: Leapfrog Geo 3D model view of underground mine development and exploration drilling, shown in Seequent Central

Hexagon Mining's Rob Daw says the recent integration of IDS GeoRadar's slope stability monitoring solution with the company's collision avoidance system means mines can now receive real-time equipment visualisation with timely alerts about hazardous areas for people and machinery

mining industry today for viewing images and matching it to geological data."

MICROMINE's Brew says it is critical the company provides a means for data to move through the various software offerings as seamlessly as possible.

"I believe it is safe to say that the ability to integrate is no longer a 'nice to have', but rather something that is essential to any operation and definitely something which we are measured against with any new or existing customers," Brew said.

"MICROMINE's data management solution, Geobank, captures and validates core sample data whilst being supported by customisable workflows and forms, creating the fundamental understanding of the resource," he explained. "From here our customers will model, design and schedule the mining of this resource either using our Micromine software or indeed a competitor software."

Rob Daw, Chief Technology Officer of **Hexagon**'s Mining division, says the company's goal of autonomously connecting ecosystems means it must integrate between "portfolios" to allow customers to connect people and processes for "better decisions and quicker access to data".

"A good example is the recent integration of IDS GeoRadar's slope stability monitoring solution with our collision avoidance system," he said. "It means mines can now receive real-time equipment visualisation with timely alerts about hazardous areas for people and machinery. Workers and equipment are protected from injury-threatening events by being forewarned of no-go-zones."

Daw also has an example from the company's planning portfolio, related to short interval control and the continued integration between activity scheduling and operations.

"Mines must make decisions quicker, more proactively and with the insight afforded by a full holistic picture of the mine," he said. "Short interval control helps bridge those gaps between a strategic plan, a tactical plan and execution of tasks in moving material. Greater control at a sub-shift level delivers even greater insights and aligns company strategy with execution.

"Our customers are seeing great benefits in this area from the integration of our scheduling solution and our fleet management solution. The data produced by that connection can pay huge dividends when it comes to productivity."

Mark Palmer, General Manager of Product Management and Marketing for **MST Global**, says the software and hardware company's roadmap focused on 'mining solutions' rather than a 'component' approach, with integration to other platforms a major consideration.

"In terms of the whole value chain for the mine, in addition to tracking, our digital infrastructure AXON will be the data enabler for automation and autonomous operations for the mine, connecting systems as needed," he told ***IM***. "Our software platform, HELIX, brings the application side of the solution to life, allowing us to provide the mine with the solution that best meets their needs, wherever in the mine's lifecycle they sit.

"Our visualisation package, HELIX 3D, provides the base. Using the actual coordinate system of the mine, this geospatial software solution allows the mine to 'see' the underground space in as much detail as the user needs – existing, past, or future workings, relationships with surface, infrastructure, etc. Using our tracking engine, people and equipment can be located in real time."

The company's other HELIX solution modules are added to this base as required to enhance safety or productivity for the mine, he says.

"For instance, where the data we collect or generate needs to be shared with other systems then we have the protocols available to us to communicate with them – on a two-way basis as required," he said. "This approach allows data to flow as needed."

While breaking down functional silos is vital, Modular's Du Plessis says the company approaches software integration on a more expansive scale.

"In addition to connecting the dots from one department to the next, we look to correlate data among all mining processes, machines, systems and technologies; and leverage synergies to achieve wider interoperability, automation, optimisation and value," he said.

The company can point to recently released Public APIs that, Modular says, enable "bi-directional data

sharing" among its DISPATCH Fleet Management System (FMS) and/or the ProVision Machine Guidance System, and related external systems.

RPMGlobal's Beesley acknowledges the company's move into an enterprise software environment as a catalyst for its own technology advancements and innovation in this new, collaborative environment.

"This has provided a platform to share real-time data among systems, as well as open avenues to cloud-based infrastructure," he said. "There are a number of advantages for customers that occur as a result of the move from desktop application to cloud-enabled solutions, particularly in the collaboration and data security space."

Defining the data paradigm

In this quest for breaking down data and operational silos through integration, not all data is seen as equal, according to **Eclipse Mining Technologies**.

The US-based company, which has a vendor-agnostic integrative software platform called SourceOne™, has tasked itself with educating the industry about this as miners prepare for whatever new technologies and challenges the future might bring.

Against this backdrop, extra attention needs to be paid to both the quality of data and how that data is managed and handled, according to Rudy Moctezuma, Chief Business Development Officer at Eclipse.

"If we want to take our performance to the next level using advanced technologies like automation, AI or machine learning, and break down some of these silos, then we need to streamline the data management process and make it quicker and easier to understand what the data is telling us."

This data also needs to be in an 'open format' that can be read universally and incorporated into any vendor's solution. It also should have the right context to prove useful – associated data and files that inform users how and where the original data was created and in what environment – Eclipse says.

"The more context the data has, the more useful it is," Alyson Cartwright, Moctezuma's colleague and Eclipse's Chief Innovation and Services Officer, says.

With some systems, the reality of dealing with data can lead miners to make a choice between system performance and data openness, according to Cartwright.

"For instance, they may choose to load the data in a way that enables good system performance, but then find it's not open enough to use for analytics. Or, maybe they decide to load the data in a more accessible format, but then performance suffers because many off-the-shelf solutions are not designed to handle mining-specific data."

She added: "Without good data, it's impossible to understand what is happening in mines, let alone make decision that might improve the operation."

This is where **Commit Works** comes into the equation. Its software helps sites coordinate the many silos of "planned work" so that frontline teams

With its IIoT devices and solutions – such as the Vigilante AQS™ and Zephyr AQS™ air quality stations to measure environmental conditions in real time – now installed in 34 different countries and over 145 underground mines in less than 10 years, **Maestro Digital Mine**'s success is known the world over.

All of Maestro's products, including its last mile network Plexus Powernet™, are fully digital and 'connected' to determine the health of the sensors and the complete system.

To leverage this information, the company has developed MaestroLink™ Server to monitor the equipment and allow easy and quick decisions from a centralised location. The software goes as far as indicating what the action response must be.

As Maestro Director of Marketing and Communications, Shannon Katary, says, "data is only useful if it helps determine a decision or action". Maestro has the capability to provide instruction items around its device maintenance, she added.

"MaestroLink fits perfectly into our core purpose of enhancing lives by the pursuit of productivity and safety excellence," she added.

All of Maestro's industrial IoT devices use embedded web servers along with digital technology right to each individual sensor, enabling remote diagnostics for solving maintenance problems as well as assuring sensor calibration compliance.

MaestroLink Server is a network-based software platform that features a multi-instance web-based interface to monitor and record the health of Vigilante AQS and Zephyr AQS stations along with the Plexus PowerNet underground communication networks.

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Maestro's research, industry client engagement and experience discovered that once new digital hardware is installed underground, it often does not deliver on its full promise of consistent and accurate data to ultimately drive better business decisions. Part of the long-standing problem is assuring the original data is valid, which, in turn, drives end user confidence.

"The requirement to properly diagnose the equipment in real time becomes essential to keep up with operational production demands," the company says.

"With the addition of new digital solutions, the automation and electrical maintenance department is tasked with solving ever more complex problems with resources that have not increased in proportion to the number of sensors and systems that they are expected to support," Katary said.

MaestroLink Server was developed to fill the gap between the requirement of maximising reliable and accurate operational data while reducing the impact and workload of the maintenance and support team, according to Katary.

Once installed, MaestroLink Server reaches out on the network to find and self populate the IIoT devices and network nodes, and begins to monitor both the data and advanced diagnostics of the devices.

The benefits have been seen at a Nevada-based gold mine, which was experiencing ventilation constraints. The mine's ventilation teams meet weekly to analyse MaestroLink Server data and diagnostics. By looking at the data and diagnostics, they can action the maintenance team. They can also determine which ventilation doors have been left open and send a technician to rectify the issue in real time to increase the overall ventilation supply to the working areas.

Such a process effectively makes MaestroLink Server an in-house, factory-trained Maestro technologist and engineer for the mine, working 24-7 and assuring maximum uptime of each digital device, Katary said.

She concluded: "MaestroLink Server saves time and cost by giving miners the ability to poll the diagnostics, and then turn the data into tangible actions from surface before having to go underground. The support team will go underground the first time with the proper tools, spare parts and equipment to do the maintenance once instead of multiple trips."

MST Global's Mark Palmer says: "Our software platform, HELIX, brings the application side of the solution to life, allowing us to provide the mine with the solution that best meets their needs, wherever in the mine's lifecycle they sit"

can build actionable work plans to improve the productivity of day-to-day work.

"We think the biggest improvement opportunity in the resources industry is found in coordinating the day-to-day work of frontline teams so that all the departments can work together to improve the productivity of their operations," Paul Moynagh, CEO of Commit Works, said. "Our software brings the silos of data together (by integrating with mine planning, ERP, HR, safety and project tools) so that the right work can be planned and executed by the right people with the right machines, each and every shift. It's been our experience (over more than 25 implementations) that sites who use our software improve their productivity by over 20% within weeks of go live."

The Commit Works suite of integrated work management and short interval control software is designed to replace the disconnected cluster of manual whiteboards, paper and spreadsheets used in managing day-to-day operations. In replacing these tools, the company helps clients to implement a "Frontline Commitment System" that enables teams of people to commit to and execute the right work, at the right time, right across the site, it says.

"People are using our software to facilitate the human process," Moynagh said. He talks through that process: "There is a human process of engineers thinking through what work needs to be done this week to move the mine forward at the rate needed. Our system helps teams to collaborate with colleagues by putting together a plan that respects the work they have in ERP systems but also respects the reality at the mine face."

The principle of such a tool is quite simple, but the influx of manual management operating systems, short interval control options and fleet management and planning platforms, to name a few inputs, has made things complex for frontline teams over the last few decades, meaning practical operating plans and instructions struggle to filter down to the frontline people with the ability to affect the outcome. This causes waste through avoidable coordination and organisation problems every shift.

"Our Frontline Commitment System takes this cluster of spreadsheets and manual whiteboards into an easy to use and sustainable digital world," Moynagh said.

"At the same time as helping the team collaborate and get the right 'plan-do-check-act' behaviours in place, we are making sure the data from the face is visible to all and can be used to carry out the required short interval control associated with the work as it happens."

It is this type of digital implementation that can set operations up for further value-enhancing activities down the line, according to Moynagh. "The really practical act of organising the frontline work so it can happen each shift means teams can reliably go to work with a plan that makes sense," he said. "This helps them deliver results within weeks of implementing.

"Getting control of day-to-day operational work with a commitment system like ours can pay for any number of other digital transformation projects you might do down the track."

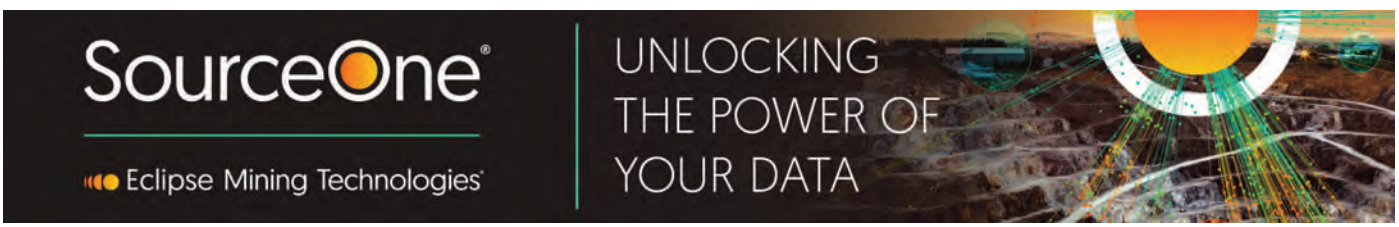
There are several examples of where the company's implementations have significantly improved operations within weeks. For instance, the former Rio Tinto-owned Kestrel underground coal operation achieved a 51% increase in operational hours within 12 weeks of 'go live', while the team at a Canadian gold mine saw a 35% increase in gold output within 14 weeks of implementation.

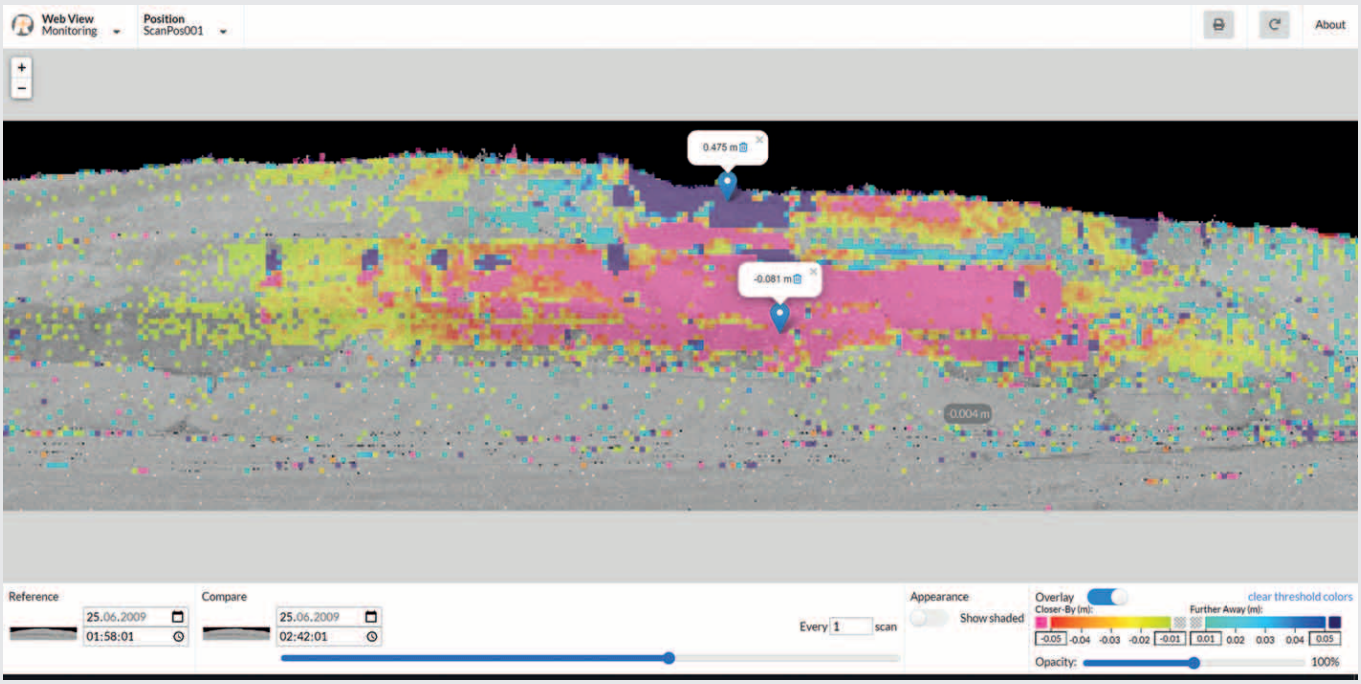
"The industry is under pressure as resources become more scarce, harder to mine and less productive," Moynagh said. "Mines are doing everything they can to improve productivity; once our software has been implemented, operational teams are delivering 20%-plus improvements in production within weeks.

"That is not because they have purchased new capital equipment or tried new mining methods, it is simply that teams are able to coordinate their current people and equipment resources more effectively. A lot of the waste in the process starts to disappear. More of the plan gets done more often, increasing production, decreasing cost, improving compliance to plan and making operations safer.

"We see operations struggling with the inherent variability that comes with the reality of mining. In our view, sites should work on removing the causes of this variability through better coordination of frontline work before they spend significant capital on automation."

Moynagh, here, referenced words from David Balkin, former Senior Director of McKinsey in Australia and New Zealand, who said: "There are very few, zero capital cost initiatives that have such a rapid and significant impact on the productivity of resource





The RIEGL Monitoring App allows the detection of movement trends by sliding through the timeline of acquired scan data

RIEGL says its VZ-i Series of 3D terrestrial laser scanners are ready to meet the demanding challenges of remote mining operations, with three new easy-to-use and intuitive apps supporting scanner users in their daily workflow, especially in critical situations.

The company's 3D terrestrial laser scanners can be smoothly integrated into any network infrastructure by using LAN, Wi-Fi and LTE interfaces, the company claims. This capability enables fully remote operation of the scanners.

With the installation of these customised apps for automatic data acquisition and data processing, the user gets automatic real-time results without any required user interaction.

The Slope Angle App, Design Compare App and Monitoring App ensure operators receive the data acquired by the respective scanners immediately "as well as relevant, reliable and accurate deliverables to make prompt and appropriate decisions", Thomas Gaisecker, RIEGL Manager Mining Business Division, says.

RIEGL Slope Angle App

Using this app, slope angles are calculated automatically from scan data. Critical slope angles can be highlighted and sent to the relevant user, eg the operator of loaders. The real-time information helps them keep the slope angles of stockpiles and dump areas within defined limits.

Users receive the information on a web browser on every device, which is connected to the mine network. No software installation or processing of the data is necessary, and everything is processed automatically within the app on the scanner.

RIEGL Monitoring App

With this app, change detection can be calculated to a given reference scan. This allows detection of movements of, for example, highwalls long before it is visible to the human eye. The interpretation of movements through a time series of scans allows the prediction of a possible slope failure.

"This information can truly save lives, ensuring personnel have enough time to evacuate staff and remove machinery from endangered areas," RIEGL says.

RIEGL Design Compare App

Overcut and undercut calculations can be made on this app based on a given design model. "While undercut indicates a waste of money, overcut can involve potential safety risks," RIEGL says. With the use of this app, the operation of heavy equipment such as excavators can be optimised to streamline the mining process.

In addition to these new apps (more information in the video here: https://youtu.be/Ro88VzsOxUo), RIEGL has further optimised its RiSCAN PRO and RiMINING software packages.

RiSCAN PRO is the companion software for RIEGL Terrestrial 3D Laser Scanner Systems. It is project orientated, with the entire data acquired during a measurement campaign organised and stored in RiSCAN PRO's project structure. RiMINING, meanwhile, is designed to optimise and simplify scan data processing in open-pit mining. The focus of the software design is on workflow simplification and automation.

LIS Geotec Tool

The new LIS GeoTec Plugin enables geotechnical analysis of scan data by providing statistical tools within an easy-to-use graphical interface, the company says. Besides the calculation of dip direction and dip angle of rock faces, it allows for the analysis of discontinuities by creating pole plots and colourising the scan data by clusters of similar orientation. This gives specialists a better understanding of stability, joints and faults on the analysed rockfaces, according to RIEGL.

"We are ready for the mine of the future," Gaisecker says. "And what particularly distinguishes our hardware and firmware architecture is that it is open for developers. Using the provided RIEGL documentation, every software

company assets. Implementation of Commit Works frontline commitment system should be considered ahead of but also in support of other automation initiatives to reduce variability and improve performance on site."

Software facilitators

Despite Moynagh's assertion, the time for automation appears to be now for at least the major miners in the industry.

In terms of automation adoption, the sector is in the fast-follower stage, with eyes on widespread acceptance in the next 10-15 years.

There are plenty in the mining software industry helping to facilitate this transition, with Beesley arguing RPMGlobal is one such company.

"When considering automation, a starting point plan is crucial and RPMGlobal has solutions that provide detailed planning and forecasting critical to any automation project," he said. "A realistic plan that is continuously updated with data from trusted sources is a critical step in the uptake of automation."

One of the key aspects to operating an autonomous mining operation is giving the correct instructions to the equipment when it is required, according to Beesley. In this context, it is no longer acceptable to plan weekly, and let the supervisors on site react to changes in the mine plan.

"The mine plan needs to be continuously maintained," he said. "RPMGlobal has led the charge on extracting data from fleet management systems, maintenance systems, enterprise resource planning systems and many others to inform the plan and communicate the updated plan back to the operation."

MST Global's Palmer said the increased uptake of automation will require the convergence of data streams into one end point.

"I believe that one of the key requirements of software will be the ability to interface with, and track, autonomous machines and consolidate this information to one accessible point," he said.

"We, as MST Global, have no need to focus on the automation itself, just facilitate the most effective use of it."

This is where the modular nature of MST Global's HELIX platform can be useful, expanding from simple visualisation tools, to vehicle information tied to proximity detection and access management systems using geospatial tracking information and Edge devices, Palmer said.

Webb says Datamine also has something to offer in the automation arena.

The company's recent addition of Snowden's Supervisor, when combined with Datamine Studio RM, is helping clients automate their processes more easily through the integration of tools they are already using, or by making some upgrades to their current processes, he said.

"Another example of this is our partnership with PixPro – a photogrammetry solution which works with Sirovision and Studio Survey to automatically generate surfaces and volumes from drone LiDAR data," he said.

Maptek Resource Tracking supports operational business improvement by delivering data in-shift where and when it can be acted on, according to Eduardo Coloma

Daw says Hexagon's automation focus is holistic; going all the way back to the data acquired at the very beginning of the value chain and reconciled at the end: from geological modelling through to the execution of tasks and operations.

"Many companies are starting to execute on such data-management strategies, allowing them to access and gain more insight into their data," he said. "We're increasingly seeing Edge devices capturing data and bringing it back to the office where it's transformed into information for more proactive decisions.

"IoT, cloud computing, AI, predictive analytics and, ultimately, automation are all playing a role in this shift towards the connected ecosystems strategy."

Maptek's Coloma sees network advancements as integral to the increased uptake of automation in the industry.

"In the next five to 10 years, mining will see a massive consolidation of automated tasks, supported by on-demand data analytics and seamless data networks," he said. "The uptake of 5G technology will facilitate adoption of this type of development and access to its benefits."

Solutions such as Maptek Resource Tracking (MRT), the company's live material tracking and reconciliation system, will take advantage of this increased bandwidth. MRT supports operational business improvement by delivering data in-shift where and when it can be acted on, according to Coloma.

He added: "While there's automation to increase speed in this process, there's still the capacity for geologists to see the correlations with the resource model and further refine or correct the data association."

Modular Mining's solutions have been interacting with autonomous vehicles for close to a decade, with Komatsu's FrontRunner AHS for mining haul trucks incorporating the DISPATCH FMS as the supervisory control component of the system.

Michael Lewis, Technical Director – Technology, Komatsu, said automation goes far beyond unmanned trucks, "extending to a broad spectrum of automated functions and machine types, across five levels of full operator versus full equipment responsibility".

Modular added: "Recognising that each mine has its own unique requirements and that customer operations span the levels of being autonomous-ready, Modular Mining is committed to developing solutions across the automation spectrum, including offerings specific to truck spotting, assisted operation (including active blade control), payload management and more."

What next?

Automation is only part of the story.

Now armed with oodles of data, an open mind

about breaking down operational and data silos and some spare cash thanks to an upturn in commodity prices, the industry requirements are vast and varied.

Modular Mining says it is being tasked – and is ready to deliver – a whole suite of optimisation solutions for mining companies. Miners are putting pressure on them to not only deliver data, but to make it "relevant and actionable".

RPMGlobal says powerful simulation capabilities that miners can use for their own internal projects are often requested. A recent example of this is a solution to simulate electric vehicles with an aim to quantify different haulage options for an operation, Beesley explained.

"We are working with industry partners (OEMs and mine operators) to ensure that we are able to model all options available in this shift towards a carbon-neutral future," he said.

The company is also increasingly asked to come up with solutions that not only augment existing expertise within the mining company environment but fill in some industry skill gaps.

"With a shortage of mining engineers in a lot of countries, together with limited capabilities in CAD-based design products, RPMGlobal's Strategic Design Optimiser tool combines the complex tasks of optimised stope and development design into a single, coherent automated process," Beesley said. "SDO uses parametric design principles and optimisation algorithms that enables users to make small tweaks to designs in one area that lead to the change rippling through the rest of the design— a task that would otherwise take days because each edit would need to be done manually."

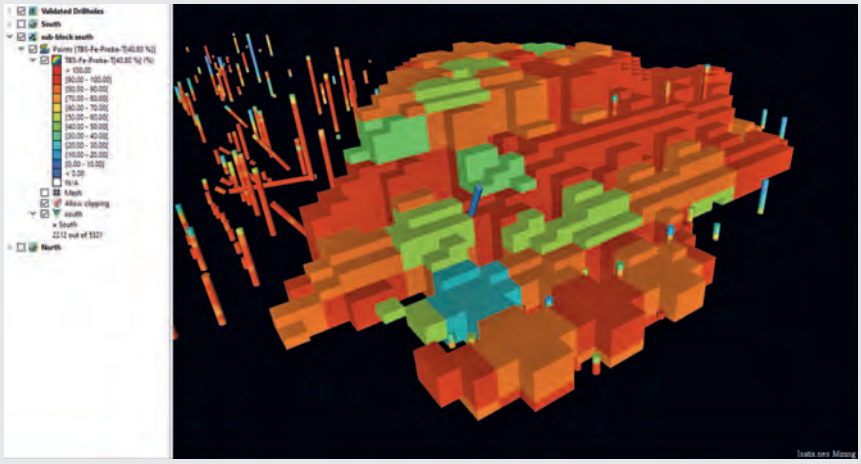
Maptek's Coloma says the company is continually seeking to understand the customer challenge first and then find the right technology or a better way to solve it with an expanding array of tools. This is where the development of sophisticated algorithms is helping it deliver higher-level optimisation and an integrated approach to areas such as mine scheduling.

This demand for enhanced optimisation tools has led to the development of Maptek's BlastMCF solution, which, according to Coloma, optimises drill, charge and timing designs to suit site conditions and

Geostatistical simulations allow the quantification of grade variability and the exploration of various scenarios from many different resource estimation standpoints, according to **Geovariances**.

Yet, despite the inherent ability to tackle risk analysis, a series of factors have prevented simulations being incorporated into the mainstream chain of information processing prevalent in the sector, the applied geostatistics company says.

"The main technical block to the widescale use of simulations has undoubtedly been performance: it still takes a length of time to produce simulation realisations in sufficient numbers to allow meaningful risk analysis to be performed. This problem is made worse when the size of the dataset increases."



A probability map of exceeding a grade cutoff derived from geostatistical simulations in Geovariance's Isatis.neo

To get over this problem, the latest version of Geovariances' geostatistical software, Isatis.neo, introduced a high-performing simulation methodology, SPDE.

This approach, unique to Isatis.neo, addresses multiple issues users face today. It helps integrate more and more data, boost productivity and deduce an answer quickly, the company says.

"At the same time, this outcome is enriched with an assessment of the uncertainty that can be attached to that answer," it added.

The tests conducted at Geovariances using Isatis.neo have shown users can obtain simulation realisations up to 50 times faster in 2D and three times faster in 3D than running the standard Turning Bands method. The key ingredient to allow that quantum leap in performance is the solving of Stochastic Partial Differential Equations, hence the name given to the new algorithm (SPDE).

This algorithm came from a two-year research consortium Geovariances conducted in partnership with the Center for Geostatistics from MINES ParisTech and major mining companies including Anglo American, BHP, Eramet, Kinross, Newcrest and Orano.

"With Isatis.neo, it is also possible to extract a representative subset of simulations selected among a more extensive set to evaluate projects," the company said. "Indeed, even if the production and post-processing of multiple simulation realisations are now more than ever a practical solution to many resource estimation problems, the ability to still focus on a few realisations remains very appealing to all practitioners."

Machine-learning algorithms have been implemented into Isatis.neo to speed up processes and deal with even bigger datasets. An example is the Sample Clustering functionality, which is used to define geological domains. This is an essential step in the mineral resource modelling process, according to the company.

Alongside this, Geovariances, in late 2020, launched a new research consortium to accommodate bigger datasets by "putting geostatistics in the cloud".

"The aim is to speed up results and free users from computer limits regarding performance and storage capacity," the company said.

Geovariances is starting with the simulation functions, which will be provided as "microservices" or "libraries" to be recalled from Isatis.neo or companies' own in-house applications.

Another advantage is that users will be able to connect multiple software solutions in a cloud environment without the need for their interfaces, the company added.

Geovariances is additionally working on developing robust implicit geological domain modelling, with an alternative already available in Isatis.neo being the multiple-points statistics (MPS) methodology.

"MPS allows modelling complex relationships between facies and geological body shapes," the company explained.

The principle is to mimic a reference image. This image can be an analogue if the geological environment is known or derived from knowledge of a previous mining area. From the facies model, it is easy to then derive the estimation domains, the company says.

Geovariances recently applied MPS for a senior gold mining company with the objective of the study to assess resources and quantify risk in planned extensions.

The work resulted in a realistic 3D facies model built with data from several hundred drill holes and constrained by specific geological features such as shear lenses.

"Geovariances is striving to make these rather complex techniques accessible," the company said. "It is what led us to develop Isatis.neo, a user-friendly software solution."

desired outcomes. Engineers can evaluate the options presented that provide trade-offs between multiple objectives such as cost, fragmentation, vibrations and powder factor.

"The chosen design can be loaded straight into Maptek's BlastLogic with the drill design, charge design and electronic tie-up generated by the optimiser."

MICROMINE has made some significant developments with machine-learning algorithms, which is also improving operations for miners.

Brew said: "We have been working with new ways to automate data capture, as well as drive new ways we can adopt new technologies like machine learning to recognise images, removing the need to manually enter data."

He offered up the latest-generation algorithm within its Pitram Vision software, as an example. This algorithm now comes with an accuracy of greater than 99%, helping refine and enhance loading and haulage processes.

Daw says Hexagon's integrated approach to drill and blast is addressing industry demands around automation, electrification, energy efficiency, water use, sustainability and digitalisation.

"The recent acquisitions of Blast Movement Technologies and Split Engineering complete the final pieces of a puzzle that separates Hexagon from competitors in this space," he said.

"That means a well-designed blast pattern using planning software developed over half a century; effectively executed using machine-guided, high-precision drills; followed by proven fragmentation analysis and blast monitoring that minimises loss and dilution."

He concluded: "This holistic approach ensures data is transformed into knowledge that informs the next blast pattern design – a feedback loop to ensure continuous improvement."

Seequent's Maloney says the ambitions of clients he deals with are focused on enabling geologists and engineers to collaboratively work together.

"The geoscience part of the equation is a big focus in the exploration area – greenfields or brownfield," he said. "This sector has always been the domain of the geoscientist."

What has not historically been the domain of the geoscientist is the operations side of the business.

"Once we start production, it becomes an engineering exercise, rather than a geoscience exercise," Maloney says.

"The industry is starting to realise the emphasis should be about what is actually being mined. They are looking to bring the geoscience into the decision-making phase right down to optimisation of blasting, scheduling and the plant – elements the geoscientist can feed back into the block model.

"There is a lot of energy going into that and it is a big trend we see picking up speed."

This is a development acQuire's Mundell also acknowledged: "Companies are seeking centralised access to better data, from more sources, and in a shorter time frame.

"Data collection – and how we manage original observations and measurements over the history of a mine – determines whether geoscientific information becomes a fundamental link in the mining value chain or remains a collection of disparate data points."

He added: "This data can then be relied on to feed machine learning and AI and allow companies to work towards the digital mine of the future."

The required fire power

The industry's demands and wishes are expansive, but COVID-19 has brought about a unique set of circumstances that means miners are finally prepared to make such improvements.

Maloney explains: "Historically, the evolution of processes in the mining sector have been based on the time-honoured tradition of: 'if it aint broke, don't fix it'. This means an existing process will stay in place unless something is broken."

A commodity downturn is one example of something 'breaking'.

"In 2014 and 2008, for instance, people started looking at operational efficiency and the technology to help deliver that," Maloney said.

At that point, the industry had a desire to become more productive, but didn't have the cash to spend on productivity solutions.

"Conversely, when things are going well with commodity prices, the industry has the money available, but digital adoption or change is discretionary as things are not 'broken'," Maloney said.

In this scenario, any inefficiencies in operations are more than covered by strong commodity prices, meaning profits continue to flow.

Today, with a global pandemic in full flow, the situation is different.

"We have the commodities markets on what looks like a long growth cycle for all the right reasons, for a change, and the prices for these commodities are factoring that in," Maloney said.

"At the same time, the industry has a desire for digital adoption as COVID has meant change management is a necessity."

He concluded: "For the first time that I have seen, the industry has a desire and the resources to commit to real digital transformation with a long runway ahead of us.

"This is unique in history, and the mining and minerals industry is really going to benefit from that." IM