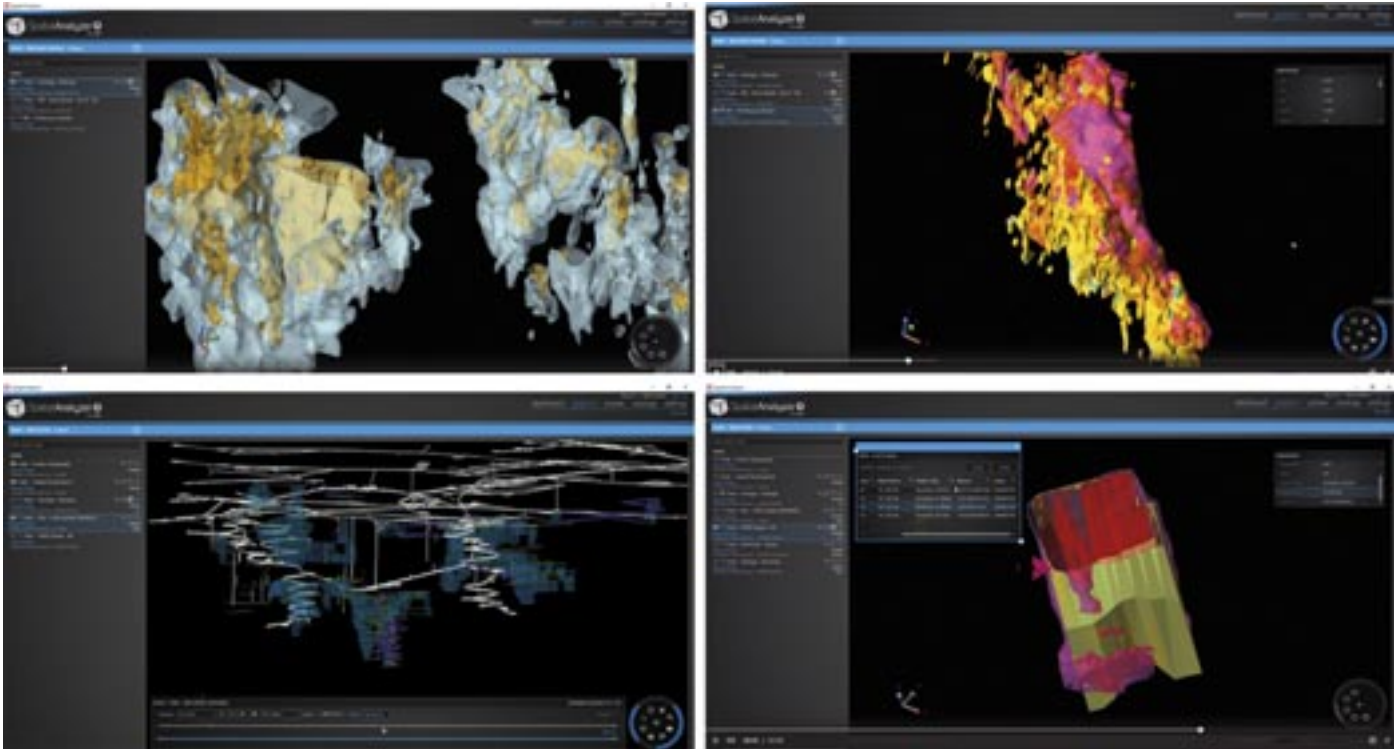# Software at mining's leading edge

Integrated datasets for Geology, Planning and Operations on MineRP 4.0

Paul Moore spoke to the main mining software players about where software fits into digitisation and optimisation plus how it is enabling the reality of a mining factory

The direct integration of technology providers and mining groups in terms of ownership and participation is something that often offers unique insights into strategies and industry directions and mining software is no exception.

November 2018 marked a full year since Toronto-based **Dundee Precious Metals** (DPM) acquired the majority equity of MineRP, an enterprise mining software company with big plans. Both DPM and **MineRP** had established themselves as thought leaders in digital transformation in the mining industry, so both believed that the transaction created a perfect home for the Terrative Digital product set that had been incubated by DPM and would provide an ideal foundation to unify DPM's own digital strategies.

"Our partnership with MineRP is helping to transform our business in ways we never thought possible before. The MineRP team consistently deliver high quality levels of service and provide a platform and leading-edge software solutions to the key business problems we face in the mining industry today," Rick Howes, CEO of Dundee Precious Metals told *IM*.

Pieter Nel, CEO of MineRP adds: "The past year has offered MineRP a unique opportunity to work on the leading edge with DPM's highly advanced Chelopech mine in Bulgaria, fully maturing and proving MineRP 4.0 in a modern, digitally enabled mechanised operation."

MineRP 4.0 is a "complete platform for the integration of all mining technical disciplines traditionally offered as non-integrated, or standalone tools by various suppliers." Implementation provides mines with a 3D digital twin of all their core mining assets, as well as built-in modules for mine design and planning, short interval control and fully connected digital orchestration. In addition to integrating the previously fractured mining technical functions, MineRP also provides a roadmap for unifying the technical and ERP domains. This implies that each mining action (planned or executed) is fully represented as a work order in the ERP with linked bills of material, resources, costs and revenue, supply chain and other commercial elements taken care of by the ERP. The MineRP 4.0 Platform maintains the 3D spatial reference between ERP transactions and mining actions, providing auditability and bi-directional traceability.

DPM Chelopech mine embarked on a journey to embed the MineRP 4.0 solution in their long, medium and short-term mine planning, survey and operations management environment. Specifically of interest is the use of MineRP to create a single planning and control environment for all horizons and levels of planning. This means that the company will plan, manage and track execution in real-time, and fine-tune their ability to digitally control and respond to actual mining conditions on the fly.

Notable among the achievements of 2018 is the extension of MineRP Planner (MineRP 4.0's parametric mine design and scheduling offering) to provide capabilities for underground and surface mine design – with successful projects in gold, platinum, iron ore, base metals and diamond mines. Covering a variety of mining methods, commodities and ore-body types, MineRP says its MineRP Planner "is revolutionising the speed and accuracy of mine planning, improving the time lag associated with planning and scheduling to hours or days instead of weeks and months."

Another client where the implementation of MineRP has delivered significant value is Petra Diamonds' Finsch Mine in South Africa. Like the work done at Chelopech, a real time link has been established with the underground fleet management solution (FMS), allowing for short term planning, execution monitoring and visualisation and production dashboards and

reporting. Although each company has slightly different strategies, both Petra Diamonds and DPM are employing MineRP 4.0 in their stack to plan, visualise and control operations from Digital Operations Centers on surface. MineRP refers to this capability as 'Millisecond Mining.'

MineRP will be announcing its latest integrated solution – MineRP Work Manager in February 2019. Already well established in other industries, MineRP Work Manager was given its sea-trials with successful Proof of Concept projects in North America in Q4 2018 and will fill the space of real-time operational execution and short interval control in the MineRP stable.

More than 14 major mining companies who are clients of MineRP's first-generation enterprise mining solutions have all committed to MineRP 4.0 upgrades. Nel told IM he is very proud of the fact that MineRP has not forfeited a single enterprise client in this transition process. "When we implement MineRP, we work hard to maintain exceptional client relationship, focus on post-implementation service levels, and demonstrate commitment to continuous investment in research and development."

MineRP adds: "With more and more mines turning to digitisation to deliver improved accuracy in planning and reduced variation in operations and forecasting, MineRP's persistent strategy to focus on spatially integrated mining data has not gone unnoticed. Global digital and strategy companies including SAP, GE, Deloitte and IBM have all gone to market with MineRP in 2018 with solutions and consulting offerings centred around the ability to unify mining technical data for digital transformation in Africa, North America, Latin America, Australia and Russia."

Datamine's complete functionality offer

As an early pioneer of 3D resource modelling and estimation tools, **Datamine** says it has continued to invest in R&D and acquisitions to become one of the leading providers of mining technology across the entire mining value chain. With the acquisition of Flairbase in December 2018, Datamine now offers a complete integrated solution for underground mine planning that includes the industry leading mine survey functionality of Amine. This complements the existing toolset of Studio UG, the completely re-written design and scheduling software being rolled out to customers in 2019, along with EPS scheduler, SOT sequence optimizer, the award-winning Aegis drill and blast package, Ventsim and Pumpsim.

"The Amine solution has innovative, time saving features for End-Of-Month (EOM) reporting, including functions that automatically generate cost codes for each type of advance for
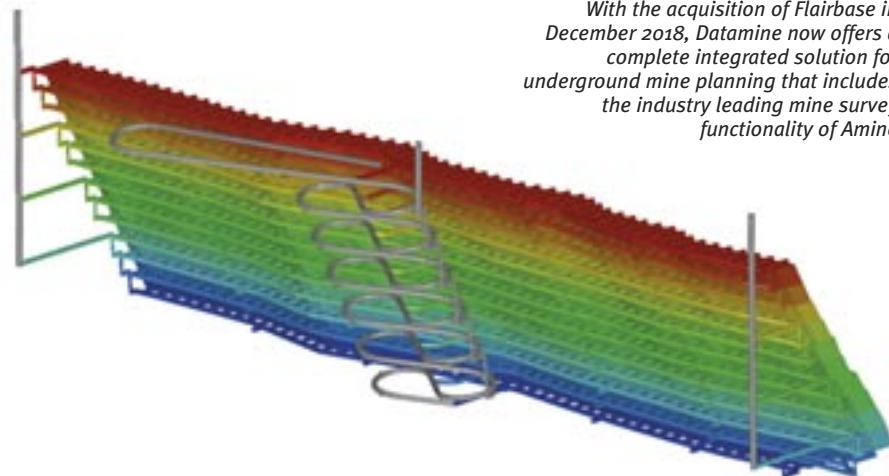
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the month. EOM survey reports can now be produced in minutes, rather than hours or days. New features for Survey Memo generation allow plans to be issued in less than 60 seconds, instead of thirty minutes or more."

Studio UG is a completely rebuilt 64-bit application that Datamine says can robustly handle larger datasets, multiple synchronised views and full block model display including slices, blocks and point cloud representations. Data processing can now be completed in one step as Studio UG processes all the data types with a single click. "New sequence rules created using attributes delivers an additional method to generate sequence links, and the integrated scheduling features means a schedule can be rapidly updated with design changes without any loss of previous manual interventions within the schedule."

For open pit mine planners, the Studio OP technology has matured over the past year and Datamine states that many customers are benefiting from the automated pit design features. "This saves time and allows the engineer to investigate a much greater number of design possibilities to ensure the best option is selected, and any changes to geology can be responded to right away. The design automation is so compelling that one customer recently watched a short tutorial video on the Datamine YouTube Channel and placed an order the very next day."

Throughout 2019, Datamine says it will be releasing ongoing updates to its full range of technology across exploration GIS, geological database, resource modelling, mine planning and production management systems, continuing their commitment to providing customers with ongoing support and value.

A raft of new GEOVIA solutions

Dassault Systèmes in November 2018 introduced new releases of its flagship **GEOVIA** solutions: Surpac 2019 and MineSched 2019. Surpac 2019 – already supporting open pit and underground

operations and exploration projects of all types – gets optional stope optimisation capabilities and a better user experience through improved collaboration and data management. MineSched 2019 now enables short-term planners at sub-level caving operations to produce integrated long-term and short-term development schedules that align with their production schedules to meet capacity and material quality targets.

"We are seeing an increase in the number of underground mines in planning stage or in operations. Our customers across the globe have been asking us for stope optimization capabilities integrated directly in GEOVIA Surpac, their go-to geology and mine planning solution. We've listened and today we are delivering natively in Surpac 2019, the industry proven stope optimisation technology from Alford Mining Systems. Using Surpac 2019, underground mining engineers can generate optimum stope shapes for a range of underground mining methods and produce stope inventories from a block model," says Raoul Jacquand, GEOVIA CEO.

To facilitate design and increase efficiency, Surpac 2019 includes collaboration and data management enhancements through the integration between Surpac and Dassault Systèmes' 3DEXPERIENCE platform. Data management is now more efficient, configurable and able to be performed from within Surpac itself, removing the need to login to the 3DEXPERIENCE platform separately.

Surpac 2019 supports the OMF (open mining format) file format, a new standard for the mining industry to exchange mining data between mining software applications. Dassault Systèmes becomes one of the first companies to adopt these guidelines, thereby displaying its commitment to openness and interoperability, and demonstrating its leadership in the industry.

GEOVIA MineSched™ provides scheduling for surface and underground mines of all sizes and types, improving productivity and profits beyond
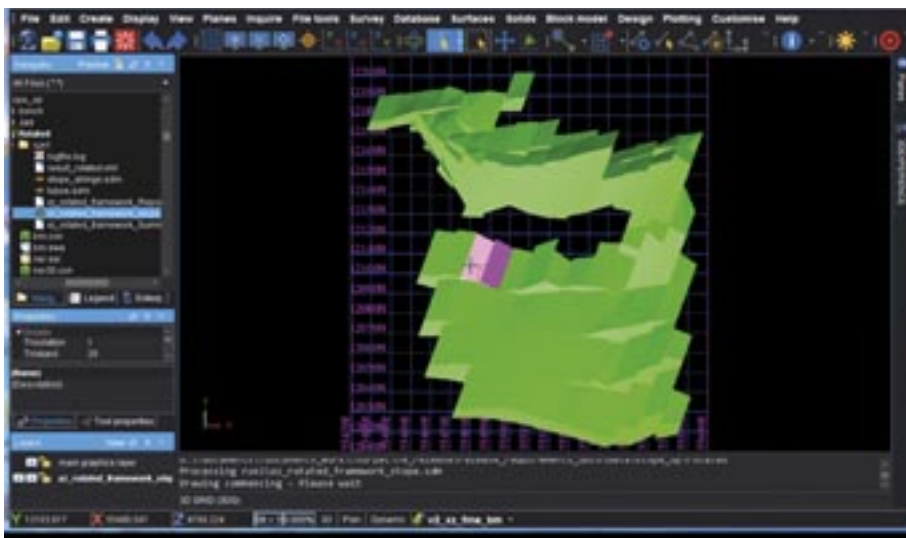
GEOVIA Surpac 2019 Stope Optimisation can be used for a variety of underground mining methods

what's possible with manual scheduling. The MineSched 2019 release enhances tactical scheduling for sublevel caving (SLC) operations by enabling short-term planners to produce short-term and long-term development schedules that align with their production schedules to meet capacity and material quality targets. It also provides underground short-term planners the ability to quickly and accurately create schedules from ring designs and allows rings to be imported and grouped under a mining location name.

Grouping SDM files as a single model enables planners in SLC development to import ring designs, define activities and precedences, and create a combined schedule for both development and production, making scheduling easier with more accurate reporting.

This workflow adds the ability to import rings in the SDM format, either from GEMS or Surpac Stope Slicer, which include the attributes MineSched requires to create the tactical plan, such as material, volume, grade, and sequence.

With this enhanced workflow, underground planners and schedulers create their tactical schedule with the ring attributes included in the SDM file, rather than requiring the block model. The attributes available with each ring produce more accurate schedules and eliminate the need to recalculate the attributes when creating locations smaller than a block.

Defining the mine planning and scheduling space

RPMGlobal says it continues to define the mine planning and scheduling software space with the release of its short-term scheduling solution, XECUTE 1.10. The release builds upon the core capabilities of XECUTE and features advanced upgrades which have improved the live planning

environment that utilises enterprise enablement to deliver real interdepartmental collaboration. XECUTE was designed to bridge the gap between short term planning and operational execution and has been adopted at several sites globally.

The companies that have adopted XECUTE have realised the potential of a collaborative, live planning environment and the improvements this could bring to their mining operation. The addition of XECUTE means schedules can be produced quickly and planners can respond to necessary changes making them not only more agile, but also more trustworthy by increasing predictability in the plans they publish.

Executive General Manager of Product Strategy, Michael Baldwin stated, "Once XECUTE has been implemented, you get unprecedented visibility and agility in planning, and that's credited to XECUTE's unique live planning environment. With this release we have added integration with MinVu. This gives XECUTE integration with all major third-party data capture systems used on sites today; an extensive library that only continues to grow. The data is also validated through MinVu's intelligence, ensuring planners not only have

access to up to date information, but also accurate data they can rely on to amplify their decision-making capabilities."

MinVu's ability to pull this data directly from areas where it would otherwise remain in 'silos', means manual data processes are completely eliminated and users spend less time gathering and manipulating data and producing reports. With more time planning with the right information available, planners can evaluate more scenarios and deliver real value through achievable plans.

"We have also started to build XECUTE into an augmented reality environment on iPads, iPhones and Android devices. This means you can access the information on mobile devices regardless of your physical location which is often a problem with remote mining operations. This also allows for clear communication of the plan, including any updates to the plan," Baldwin said. RPMGlobal will continue to expand this interface with more data from the MinVu acquisition making the mobile application the "go-to portal" for planning and operational teams on site.

The latest release also sees new scheduling functionality, including upgrades to the integrated product optimiser as well as intuitive user interface improvements that make the live planning a better overall user experience.

ThreeDify extends range of GeoMine suite

ThreeDify says its GeoMine is being used on a global scale "to help mine planners and investors determine an optimum open-pit to underground transition point to maximise their deposits' economical potential." GeoMine-Optunimizer the company says took the guess work out of mine planning by quickly evaluating multiple what-if scenarios with the objective of maximising total profit of the entire mine. "For example, we have helped clients conduct

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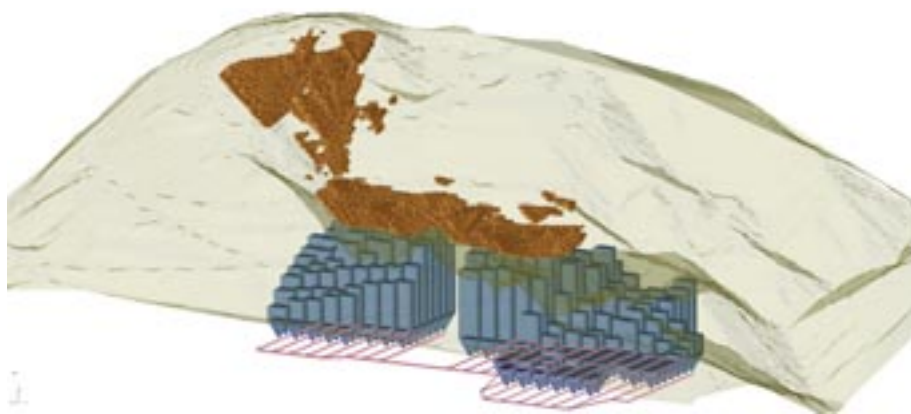
GThreeDify says it now offers total mine optimisation from open pit to underground in ThreeDify GeoMine

feasibility studies on their project via Optunimizer; after detailed what-if scenario analyses, they found the best strategy to achieve the fastest ROI."

Recently, ThreeDify has also announced the general availability of GeoMine-GSM, a suite of GeoMine modules for gridded seam modelling, optimisation and design. In addition to the existing 3D block modelling, optimisation and design modules in ThreeDify GeoMine, the newly introduced GeoMine-GSM modules are tailored for stratified deposits such as coal seams, thin phosphate or limestone etc, where the width and length of the deposits is considerably larger than the thickness and thus can't be accurately modelled by a conventional 3D block modelling scheme. "This addition equips ThreeDify to provide a fully integrated solution for virtually any deposit."

ThreeDify has also announced the availability of GeoMine-Cavemizer (GMC), a new module, specifically built for block caving and sub-level caving operations. "GMC's Footprint Finder allows the user to determine the best footprint for a block caving or sub-level caving design from a block model. The parametric Cave Designer tool can quickly create multiple design scenarios from a given footprint, and accurately calculate reserves, and estimate recovery and dilution for caving stage with its own recovery and dilution factors. The parametric Cave Designer is capable of automatically generating level development layouts to eliminate the tedious manual level design process."

Another significant improvement in GeoMine is the introduction of Dynamic Anisotropic Minable Shape Optimizer (DA-MSO), a new component in GeoMine-Stopemizer aiming to minimise dilution and maximise recovery while respecting basic geometric and geotechnical constraints. DA-MSO uses anisotropic rotation angles for defining stope shapes and orientations to minimise dilution and increase mining recovery.

"The new GeoMine-GSM and GMC modules are just two of the eleven fully integrated and individually licensed modules within ThreeDify GeoMine. The GeoMine product suite provides sets of powerful tools for resource modelling, optimisation, mine planning and design, as well as scheduling for both open-pit and underground mines.

Reaching the rapid modelling goal

Maptek has developed a new solution for evaluating projects, progressing from database to resource report in 30 minutes. Establishing a conventional ore resource report for a typical deposit can absorb weeks or months of geological effort. In response to the demand for faster results, Maptek™ has developed a new solution which unlocks huge potential for evaluating prospective projects.

After database validation and construction of block model geometry, the next phase involves interpolating grade into individual blocks. Commonly used grade estimation techniques include inverse distance, kriging (multiple variants) and conditional simulation (also with a multitude of flavours).

These have been developed and redeveloped, chasing the goal of better prediction of in-situ grades within ore deposits. "Mathematical techniques on their own cannot deliver realistic grade estimations,' said Product Manager Steve Sullivan. "The geologist provides an intuitive understanding of the deposit geometry, which is key to guiding algorithms to the ultimate goals."

Estimation algorithms have been deployed across industry in many software platforms. However, setting up an estimation for a single variable into a single geological domain using the inverse distance technique entails up to 190 decisions.

Likewise, applying ordinary kriging to a single variable/domain takes up to 170 decisions in preparation work alone, to determine appropriate parameter settings using variography and kriging neighbourhood analysis, followed by a further potential 220 decisions to carry out the kriging estimate.

Deposits rarely have a single commodity of economic interest within a single uniform geology. For example, one Maptek customer has approximately 900 variable/geological domain combinations. Applying kriging to estimation of the entire deposit requires about 35,000 decisions.

Little wonder that establishing a conventional ore resource report involves weeks or months of geological effort. Time constraints often do not allow the competent person responsible for the resource reporting process to validate each and every decision.

Through consultation with key customers, extensive R&D and testing with real datasets, Maptek has now developed a new solution to expedite resource modelling and reporting. The deep learning approach, powered by Maptek's machine learning engine, has already proven beneficial to the mining operation that partnered the development.

The geological database is uploaded into the deep learning system with several selected parameters. Data analysis leads to automated assignment of estimation parameter settings, followed by geological domain interpretation, grade interpolation and uncertainty analysis.
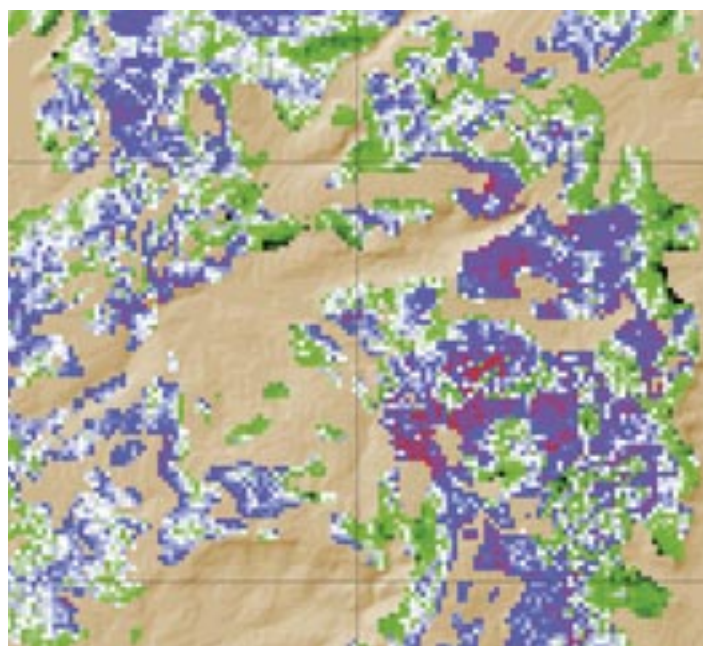
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The results are downloaded in standard Maptek block model format for resource reporting and collaboration with other users of the geological resource model, such as geotechnical, mine planning and mine scheduling engineers.

"The deep learning process models multivariable/multidomain data simultaneously. Input data is validated prior to modelling and results are validated with standard charting techniques. From geological database to resource report takes about 30 minutes, compared with weeks or months for conventional processes. This is a truly rapid modelling technique. Resource modelling using the Maptek machine learning engine will be available in 2019."

Minemax offers planners more control

Minemax told **IM** that it has continued to invest heavily in R&D, with a number of valuable new features now available in its mine planning optimisation suite. Its flagship product for integrated strategic schedule optimisation, Minemax Scheduler, now gives mine planners even more control through two key modelling features.

Firstly, Minemax has introduced cumulative constraints to enable planners to specify the amount of waste to be moved by a particular time in order to build critical infrastructure like tailings dams and roads. Previously, this was done through a trial and error approach by forcing quantities of waste to be mined in each time period. With cumulative constraints, planners simply need to enter the total material required up to and including a given time period. Minemax Scheduler then takes care of ensuring that enough waste is mined to be used in infrastructure construction while delivering the highest NPV schedule.

Secondly, fixed cost modelling is now available. "Mine planning engineers can now associate fixed costs with alternative processes that will only trigger if that process is used. The result is a more accurate financial model leading to a higher value mine plan."

In addition to functional improvements, performance improvements mean that strategic mine planners can now optimise scenarios even faster, enabling them to provide more timely input into corporate investment decision-making.

Minemax's newly redesigned Tempo product for detailed mine planning has also received R&D attention through performance improvements of its fast Bienstock-Zuckerberg (BZ) algorithm. Minemax is touting BZ as a potential game-changer for mine planning as it seems to leave traditional optimization approaches in the dust regarding solve times.
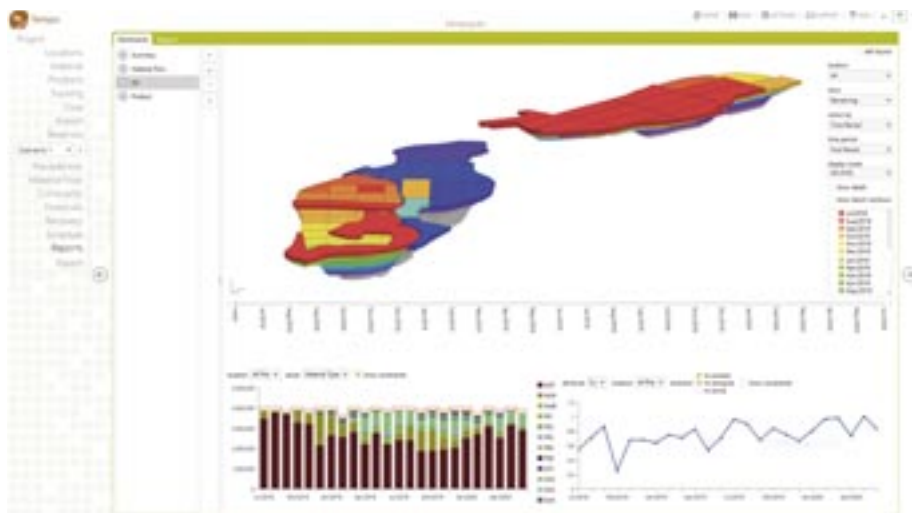
Tempo has also seen the introduction of products and associated product constraints. A product is typically the final product a mining operation produces after all processing steps are completed. In metals mining, this can be the extracted metal itself. In iron ore, it can be lump and fines products that come from a crushing operation. In coal there can be different products of specified ash content produced either through washing or by bypassing the wash plant. Constraints on products are required if a mine plan is to be practical for the operation. Tempo's new product modeling enables mine planning engineers to easily define products and associated constraints to achieve even more detailed and implementable mine plans.

The most recent significant development can be seen at SME and PDAC in February and March: Minemax will be releasing an initial version of their Haulage solution. According to Richard Diaz, Product Manager for Haulage, "Customers require integrated haulage when they do detailed mine planning to get accurate plans that respect the capacity of their truck fleet." The first release will be integrated into Tempo and there are plans to subsequently incorporate it into other Minemax planning and scheduling products.

Micromine 2018's new online licensing platform

New underground mining precision performance software, which uses machine learning to refine and enhance loading and haulage processes, is set to be launched by global mining software company, **MICROMINE.**

The solution will be released in early 2019 as part of MICROMINE's fleet management and mine control solution, Pitram. Using the processes of computer vision and deep machine learning, on-board cameras are placed on loaders to track variables such as loading time, hauling time, dumping time and travelling empty time. The video feed is processed on the Pitram

Minemax's newly redesigned Tempo product for detailed mine planning has also received R&D attention through performance improvements of its fast Bienstock-Zuckerberg (BZ) algorithm

vehicle computer edge device, the extracted information is then transferred to Pitram servers for processing and analyses.

MICROMINE Chief Technology Officer Ivan Zelina explained the solution intelligently considered the information gathered to pinpoint areas of potential improvement that could bolster machinery efficiency and safety.

"Pitram's new offering takes loading and haulage automation in underground mines to a new level," Mr Zelina said. "By capturing images and information via video cameras and analysing that information via comprehensive data models, mine managers can make adjustments to optimise performance and efficiency. It also provides underground mine managers with increased business knowledge, so they have more control over loading and hauling processes and can make more informed decisions which, in turn, improves safety in underground mining environments. This can contribute significantly to the overall optimisation of underground mines, which we believe have a lot of room for improvement."

MICROMINE trialled the new technology in Australia, Mongolia and Russia throughout 2018 as part of a research and development pilot program. The initial concept was on the back of a trial project in partnership with the University of Western Australia. One of the Masters students from the university was subsequently employed by MICROMINE to help drive the company's development of machine learning projects across its global business.

"This advance is another demonstration of how MICROMINE is operating differently to other software providers by extending our products well beyond simple built-in machinery automation to artificial intelligence," Zelina
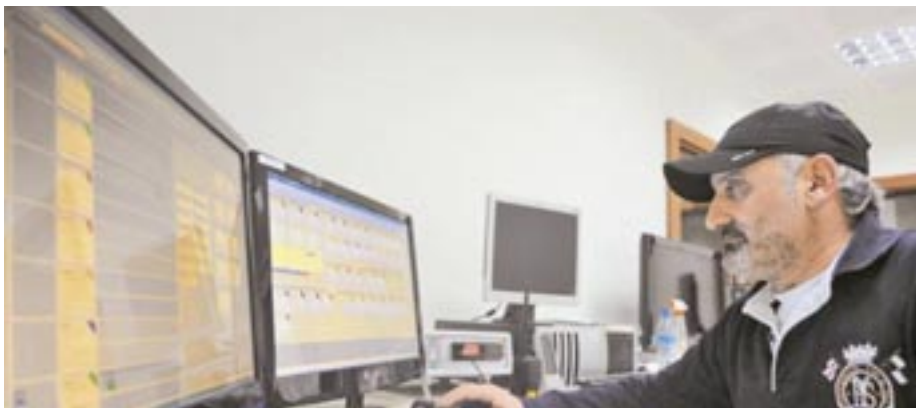
Pitram's Shift Planner reflects the dynamic nature of a mining operation

added.

"The ability for mining companies to increase their knowledge of mining processes through automated data collection and analysis is endless and this is just the start of the work MICROMINE is doing with our mining software solutions. We're striving to help companies optimise their mining value chain and we believe enhancing one of the most fundamental and critical underground mining assets – loaders – is a great place to start."

Members of MICROMINE's Perth office also recently participated in The Newcrest Crowd, an industry-leading, crowdsourcing and partnership platform that challenges innovators around the world to solve specific mining problems through online competitions.

The "Get 2 the Core" competition focused on core tray photography and how companies can derive the value in historical core tray imagery. Core tray photography is currently underutilised due to the arduous process of capturing, processing and analysing core tray photography. With so much rich textural, mineralogical and geotechnical information contained in core tray photography, there is a lot of value in optimising current processes.

Photographs taken on Newcrest sites are mostly standardised, but they have millions of historic core images from 10s of thousands of drillholes. As technology evolves, image analysis techniques are becoming more powerful and prevalent within exploration and mining industry. These large image repositories will eventually become rich sources of quantitative data.

"Get 2 the Core" asked participants to build an algorithm that could determine and map the spatial extents of the core tray and then the individual rows contained within. The successful participant was awarded a prize of $10,000, with a separate prize to be awarded for solutions that also solve the problem but do not exactly fit the scoring requirements.

MICROMINE's Wojciech Slabik commented: "The Get 2 the Core was an exciting project to be

involved in. We have been working with Machine Learning techniques to solve mining problems on our Pitram team and we immediately noticed that we could apply these methods also to the problem presented by Newcrest."

Provided to participants was a training dataset of images and completed masking instructions – the ground truth. The test data set consists of images only, for which the participants needed to predict the masking instructions via a CSV file. The solution needed to be able to perform on inconsistent photography where:

The MICROMINE team applied machine learning skills using the relatively new Mask R-CNN technique. Wojciech adds: "We utilised a

technique known as Transfer Learning, so our Mask R-CNN learned very quickly to deal with the core tray data. Using Transfer Learning meant that we didn't need thousands of labelled core trays to be able to train the machine. To generate the core bounding box, we then used more traditional edge detection techniques that used the mask from the Mask R-CNN.".

The competition aimed to achieve the result of reducing the man hours required to manually

review and analyse core tray photography. Due to the manual mark up, the labels may not be perfectly consistent across the entire dataset, however, these labels represent the kind of work required to produce an outcome which is time consuming and labour intensive.

Wojciech added: "The results we got in only few hours were much better than what we have initially expected. Future development will be focused on training the network to generate not just the bit mask outlining the drill core, but also the full bounding box."

Leapfrog EDGE one year on

Seequent's new resource estimation solution Leapfrog EDGE has just celebrated one year in the market. During this time two product updates have seen Leapfrog EDGE advance to version 2.2. Mike Stewart, Technical Domain Expert at Seequent comments: "The industry has really taken to Leapfrog EDGE. Users appreciate the strong link between data visualisation, analysis and parameter choice. It's streamlining workflows, eliminating implementation errors and has effectively brought dynamic updating to resource estimation."

Designed for today's resource estimation challenges, Leapfrog EDGE "is a dynamic

Designed for today's resource estimation challenges, Leapfrog EDGE is a dynamic solution that seamlessly integrates with Leapfrog Geo's geological models, enabling stronger emphasis on robust domain modelling

solution that seamlessly integrates with Leapfrog Geo's geological models, enabling stronger emphasis on robust domain modelling to underpin the estimate. This delivers major benefits in how users can manage change as they continue to interpret geology and make use of the latest information. The result of extensive industry consultation, Leapfrog EDGE includes intuitive and highly visual tools within a streamlined, flexible workflow and has been thoughtfully crafted to improve productivity and reduce training time."

Nick Fogarty, General Manager Mining and Minerals at Seequent adds: "Leapfrog EDGE builds on the success of Leapfrog Geo, whose

fast, dynamic and intuitive capabilities sparked a paradigm shift in the geological modelling world. Together, Leapfrog Geo and EDGE create a fully integrated workflow between the geological model and the resource model. This not only facilitates easy updating but also allows users to stay in the very visual and dynamic Leapfrog environment they love."

In a study carried out in 2018 by leading precious metals mining group Polymetal International, Leapfrog EDGE was proven to achieve the same results as a major competitor. The study also revealed EDGE's distinct advantages.

Natalia Utkina, Senior Geologist of Polymetal's Exploration Department - Mineral Resources Management, who carried out the comparison, remarked: "EDGE's distinctive features are enhanced geological interpretation capabilities and the connection with the Leapfrog structural model. Leapfrog EDGE stands out from other similar products with its excellent visualisation at

Entering the enterprise era

IM sought views from Maptek on key trends in mining software in terms of development and functionality in the digitalisation era. The company stated: "There is growing demand for enterprise level solutions that embrace the science of machine learning and big data as well as integration across mining 'disciplines'. Maptek believes that integration philosophies within automatic and autonomous frameworks will appeal beyond technical users of design, survey planning applications to IT and management. Generic (rather than proprietary) data upload formats and output can make results compatible for third-party systems. Using this approach, mining companies won't need prior interaction with a specific vendor; the only dependency will be having data ready to upload into the system."

In terms of achieving the mining factory, Maptek says that the machine learning approach, such as that being developed in Maptek for grade estimation, leads into automated grade modelling and mining. Data can be collected from autonomous drill rigs with onboard analytical capability and fed direct into the machine learning engine for grade estimation followed by automated grade control optimisation. The results can then be uploaded into fleet management dig control systems for mining. The technology already exists for this complete mining process cycle to be implemented in open cut mining operations.

"At an enterprise level, an event-driven communications system between service-oriented applications allows users to make a request without needing to know which applications can supply the data or in what format it is provided. The system takes care of the routing, orchestration, choreography and transformation."

Maptek is also developing safer more autonomous outcomes for mine measurement systems to communicate the key parameters affecting successful implementation of a mine plan. Mining companies are seeking increased emphasis on rapid turn-around through greater field capability to acquire, process and publish results, including registration, notation and markup, volumetric reports and design conformance.

"Real time conformance to design and reconciliation of material being mined and stockpiled is a key driver for productivity improvements. This real-time data feedback to plan approach might see data streamed from a laser scanner mounted in the field to be compared to the design. Data connectivity from fleet management systems then provides the capability to direct material movement in real time. Adding more data connections will reveal digging information concerning the correct grade of material and allow the haul cycle to be directed to the correct ROM."

Extending connectivity to the short term scheduling system then allows real-time adjustments to grade control for adjusting the ROM on the fly. Integrating Maptek products into a single solution enables continuous real-time feedback to design conformance and material grades being mined and stockpiled.

There is a lot of discussion about Artificial Intelligence in mining. Maptek states that mature applications such as Maptek Vulcan and PointStudio already contain dedicated tools and built-in smarts to deliver analysis and reporting functionality in survey, geology, engineering and scheduling spaces. These are developed with appreciation for the 'ontology' of the mine, and pay attention to the processes upstream and downstream in terms of output, applicability, and interoperability.

"Context-aware data and processes are critical for mining, which is a complex, non-linear ecosystem. There will always be the need for surveyors, geologists, mining engineers and geostatisticians whose inherent understanding of their technical discipline enables them to analyse and report on correlations and anomalies to inform decision making. AI can deliver gains in automating laborious, time consuming tasks, freeing up time for analysis. Fast generation of multiple scenarios and iterations of a problem helps operations hone in on economic, workable mine plans. Speed and ease of use are the main benefits of machine learning. Another bonus is that the application workflow becomes embedded inside the system, ensuring consistent outcomes. The mine manager is no longer at the mercy of having the right skills or the right number of people."

In the design and planning stage VR offers a low risk way of simulating the various stages of a project. High impact visualisation and data interaction, or immersion, allow all stakeholders to easily understand concepts and impacts of project development on the environment for example.

In August 2018, Maptek announced collaboration with augmented reality experts LlamaZOO to bring digital twinning and advanced 3D data visualisation for interaction with technical and operational mine models. Viewing live data, such as trucks and shovels, loaded train cars and material stockpiles, in real-time and displaying real-time grade control data over scheduling activities provides critical information in context. Live and interactive simulation of scenarios via a digital twin of the real mining environment can provide a virtual risk-free mode for decision-making.

In terms of potential collaboration approaches between software providers, considerations around commercially sensitive IP will limit collaboration between software vendors. But alliances with equipment providers for MWD data from drill rigs, specialists such as LlamaZOO for augmented reality and niche software developers offer great possibilities.

"SDKs and APIs allow third-party developers to write functionality that streamlines the exchange of data between their applications, services or algorithms and the Maptek software application. This enables the transfer of data types in/out of the Maptek app and development of new solutions that operate on that data."

Overall on the key mining software developments, Maptek states: "The bigger mining companies have defined mine intelligence strategies as they look for new and better ways to control and optimise the mining cycle. Investment of R&D dollars is best spent on systems built from the ground up which consider integration and holistic intelligence and support a range of levels in a mining operation. These will acknowledge a mining operation as a non-linear dynamic complex system (rather than a supply chain) that needs dynamic, optimising decision-support and embraces automation and autonomous systems. Maptek is perfectly placed to build on long-term industry relationships, with our quality globally supported systems, strong foundations in system intelligence and solid commitment to research and development. We continue to develop mature technical applications. We are developing world's best capabilities in Machine Learning and Artificial Neural Networks, as well as genetic algorithms and intelligent multi-agent systems."

all stages of deposit modelling. The crucial point is that this visualisation helped me to carry out many operations more meaningfully."

Last year was a big year overall for Seequent – with **IMDEX**, a global leader in real-time subsurface intelligence solutions, it announced an ongoing partnership to deliver a real-time 3D visualisation solution for the mining and exploration industry to dramatically improve the speed and accuracy of decision-making for drilling projects.

Seequent and IMDEX are collaborating to integrate IMDEXHUB-IQ™, which provides access to sub-surface data and Central, Seequent's centralised model management solution for visualisation, tracking and management of an organisation's geological data. The integration will allow live 3D data collected in the field and synced to IMDEXHUB-IQ™ to be linked in real-time to the same project in Central, enabling 3D visualisation of downhole survey and structural geology data.

Seequent also acquired **Geosoft**, the Canadian geoscience software company headquartered in Toronto with offices around the world. The acquisition brings together Seequent's Leapfrog 3D geological modelling software suite with Geosoft's subsurface geoscience and exploration dataset technology – to create an unparalleled subsurface offering for the mining, civil engineering, energy and environmental sectors.

Shaun Maloney, Chief Executive of Seequent, says: "The acquisition allows two strong geoscience brands, Leapfrog and Geosoft, to join forces to offer a greater range of solutions for our customers around the globe. Together, we are better equipped to deliver on our commitment to enable better decisions about some of the world's biggest earth environment and energy challenges."

Tim Dobush, CEO of Geosoft, said: "There is exciting synergy between our two companies, and together we can deliver new and enhanced value to our global customers. We share the same vision and passion for making a difference, and empowering knowledge from geoscience data is at the core of what we do. By bringing our people and powerful technology assets together under Seequent, we're able to help customers solve their ever-larger geoscientific challenges across all disciplines and industries."

Geosoft's Oasis montaj® technology platform is an industry standard within the geosciences, supporting advanced analysis and understanding of the Earth's subsurface and subsea environments. The company's Target for ArcGIS software is the market-leading geological

Paul Moore spoke to RPMGlobal's Anthony Fraser, Customer Engagement Director and Michael Baldwin, Executive General Manager – Product Strategy and Marketing about the evolution of mining software as part of a fully integrated mine solution

Q Traditionally mining software has been delineated into distinct functionality areas such as planning, design, mapping, surveying, scheduling etc with some mining method specific packages for things like block caving. With ever greater digitalisation of mines, to what extent is it now possible to link packages where there is relevance for crossover and overlap?

A There is now an enormous amount of data that is available to be used for integration across what have traditionally been specialist systems. Traditionally these specialist systems have been desktop based where data sits in silos making integration with other systems close to impossible or a manual process at best. The other issue that held back integration was lack of reliable communications for the exchange of real time data. With reliable comms now available through WiFi, 802.11 and technologies like LTE becoming commonplace, the transfer of data is now quicker and more reliable. This has opened the door to Enterprise solutions (such as those of RPMGlobal's) that utilise any data that is available. These solutions are able to take real time data from SAP and Fleet Management Systems, for example, and utilise the data in planning, financial and even maintenance solutions.

Q Equally, what about integration and crossover between areas like the mine plan and optimisation packages on actual mining equipment?

A Optimisation should always start with the mine plan as it is critical that you start with a plan and then are able to measure performance with actuals. RPM has partnerships and integration with fleet management providers and Original Equipment Manufacturers where the solutions on the actual mining equipment are continually providing data back to the planning systems. Planning of any systems needs to start with the reality, so it is important, from a planning perspective, that the most accurate and up-to-date data is used. A very simple yet good example of this is where actual excavation information is sent from MineWare and Modular Mining Systems to RPMGlobal's XECUTE short term planning to provide what has been achieved in relation to the last plan and from where the next plan should commence.

Q With the greater use of sensors (such as ore being automatically scanned during drilling or being scanned on the belt after extraction), are we now getting to a position where no manual input of datasets is required at all and where many software packages are automatically being updated in the mine (just as they already are in say the mineral processing plant)?

A Automating the sending of data between systems is achievable now and is the aim for most operations; however, you need to have trust in your data and what is being sent. RPM already does with many systems such as SAP and ERP solutions, but for the systems in the field this has been slower for the mining industry to adopt which has mainly due to the issue of not being able to fully trust the data being captured and also the format in which each data set is captured. RPM's MinVu solution solves this problem with validation tools that look at the captured data and flags erroneous data before transferring to other systems. Once that data is captured it then puts the data into a common format so that it can be used across systems.

Q Are we anywhere near being able to talk about Artificial Intelligence in mining? Presumably the core software packages will still be at the heart of any such developments given that they still hold the fundamental data in terms of design and planning as well as the latest grade information?

A Absolutely we can be talking about artificial intelligence. The mining industry has been generating and collecting huge datasets for many years. Take a haul truck, for example, the major manufacturers have had systems onboard recording speeds, pressures, temperatures and a number of other parameters for decades. Both Caterpillar and Komatsu equipment catch hundreds of channels on a machine. For a long time we have recorded so much data that we are not quite sure what to do with it so everything was saved, stored and archived over the years. What has probably been lacking in general is the process and discipline around what data should be kept and the quality of the data that we have recorded.

Q Equally is VR being used in day to day operations as much as it could be? Has the proliferation of remote operations centres for mining accelerated to use of this type of technology in conjunction with the relevant software?

A There are, certainly, some cool applications for the technology, but few seem to be using it as much as they could. There are companies that are investing heavily in this, and we will soon start to see the results of all the R&D of that some suppliers have been working on, some in conjunction

application for Esri, delivering essential workflows for geoscience and GIS professionals working on the ArcGIS platform. With its release of VOXI Earth Modelling, Geosoft pioneered the use of high performance geocomputing and 3D geophysical inversion modelling in the cloud.

Geovariances simplifies resource estimation and ore control

For over 30 years, Geovariances has imposed itself as a major worldwide actor in geostatistics. It told *IM*: "Thanks to well tested and proven algorithms and an exclusive 30-year partnership with the Center of Geostatistics of the French school Mines ParisTech, the company is recognised by the industry for the reliability and scientific rigour of its products. Its leading-edge software solution Isatis is tailored for any use in geostatistics and is the software of choice for mineral resource estimation. Some independent consultants in charge of due diligence assessment or project auditing even say that this is the only package they trust 100%."

Building on its strong expertise, Geovariances decided to develop a new software solution aimed at meeting the requirements of operational mine sites that need to quickly and accurately estimate and update block models with new data. "Minestis was first released in 2015 to offer a solution that simplifies mineral resource estimation while ensuring the quality and the performances of the geostatistics Geovariances is known for. Using Minestis, professionals who are not necessarily familiar with geostatistics can generate resource models with a high level of rigor while providing a fully auditable process."

Minestis is based on a sequential and efficient workflow that covers the best practices in resource modelling and ensures that any critical phase in the resource estimation process is reliable and not missed. "In fact, the background routine checks are so powerful that it is almost impossible to deliver an absurd result. The software is easy to use and walks the user through every step of the resource estimation project: data validation, Kriging Neighbourhood Analysis, estimation, classification and recoverable resource reporting. Software use is further facilitated with an automatic data-driven parameter setting. Those who use Minestis say that estimates are produced in a record time and that the software lets them focus on the technical aspects of resource estimation rather than wasting time in learning how it works."

This year, with its new module for ore control, Minestis Geovariances told *IM* "is to an even greater degree the software par excellence for

with mines, however, we are not sure of many that are using it in day to day operations – yet.

Q As the amount of data continues to grow and the complexity increases, does it mean we are getting to a point where it has become impractical to have major software packages from more than one supplier at a site? In the past several legacy systems plus new systems would have been operated side by side – is it now the case that mine operators are looking for one comprehensive solution?

A I think it is unlikely that one supplier could ever provide everything required to plan and operate a mining operation. The mining industry is so varied with so many methods, commodities, geographies, legal and statutory requirements that differ from operation to operation that it is not practical that one supplier could provide everything for everyone. There are certainly software providers that can make it easier for integration with packages that complement each other, however, the true to key is to have standards across the industry for data transfer, as exist in other industries. Think of the finance industry and the ability to transfer monies between banks. The mining industry needs to adopt standards and work towards a common platform such as ISA95. RPMGlobal has been working closely with a number of suppliers to drive forward this common platform.

Q Where they may have preferences for different packages are there situations now where different mining software companies will work together in a collaboration to offer a customised but unified set of packages?

A This has certainly been our experience and we have been working closely with a number of providers to offer a unified solution. Mining operations have also opened up more to allow providers to deliver a solution by providing open dialogue with vendors as to a problem then allowing them to solve the problem together.

Q How has the accessibility of mining software to staff been improved in terms of removing layers of security and enabling data manipulation and interpretation more rapid and smooth?
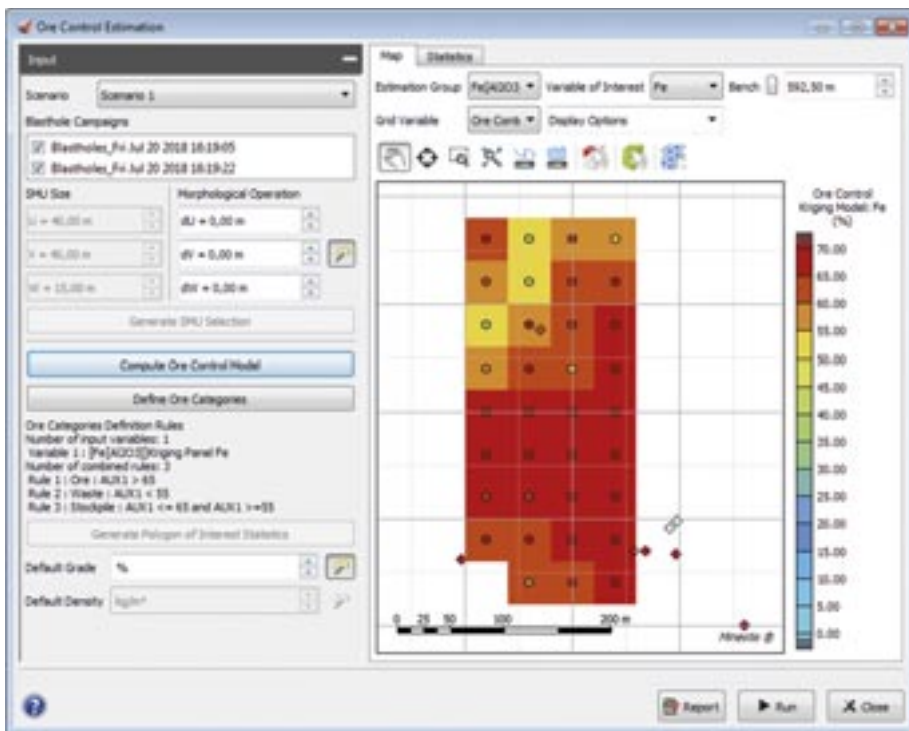
A Mining software has come a long way as far as accessibility goes. With subscription and cloud-based options now available, accessibility to software has never been easier. The accessibility to data is also now highly efficient. Consider a mine planning department, for example, with Enterprise solutions, the minute that a schedule is saved, it is accessible

to anyone with access – anywhere in the world. There are a number of examples where schedulers at specific mining operations can share information/data with planning specialists and/or business improvement people sitting at different geographical locations, sometimes in another country or even continent. The same goes for finance; forecasts and budgets can now be turned around very quickly where multiple departments have access to the parts they need, without having to wait for emails and spreadsheets – much less room for error or bottlenecks. Clearer visibility with higher reliability = more efficiency and accuracy in decision making = true profitability.

Q As a company what do you see as the key developments in mining software in recent years and what is most exciting about current mining software capability?

A The key developments in mining software would be Enterprise solutions and communications technologies. Data and access to that data has been critical to moving the industry forward and that can now happen immediately and seamlessly without the need for email and physically transferring data. As communications have been upgraded and improved, data access has also evolved. Once you have the data, then you can start to make decisions with your eyes open – with Ai and VR, we will soon be able to do this confidently even with our eyes closed!

Minestis for ore control

mineral resource estimation, offering the complete workflow geologists need on sites. With this new module, users can quickly assign a destination to the mining polygons based on various criteria. The software capitalises on the long-term model to quickly generate short-term and ore control models from production data, here again in a fully transparent and auditable way. Therefore, practitioners can be confident that consistency is ensured throughout the whole model life."

Strengthening underground design

Coupling fragmentation and break analysis tools will enhance the drill & blast process and facilitate a feedback cycle for continuous improvement. Collaboration between Maptek and the developer of Aegis is set to close the loop on underground drill & blast design and measurement, boosting quality assurance and

control in this key mining process.

Canada-based **iRing Inc** is the developer of Aegis software, which is revolutionising underground drill & blast design and analysis. Vice President of Development at iRing, Troy Williams recently visited Australia and was excited by the potential for fragmentation analysis in Maptek™ PointStudio™ when used in conjunction with the new Aegis Break Analyzer.

"The Maptek fragmentation approach is light years ahead of anything else we've seen. Using 3D point clouds instead of 2D image-based photogrammetry provides a distinctly superior result for fragmentation modelling."

Aegis Break Analyzer allows engineers to design blasts based on the first principles of rock mechanics and uses geotechnical data collected on site every day to inform ongoing blast design.

Fragmentation analysis, available for customer trial in PointStudio 8, uses laser scan data to automatically identify individual rock pieces, enabling better analysis of blast results. "Maptek laser scanners and PointStudio software will be fundamental to measuring the fragmentation," said Williams. "Aegis will provide the front-end software and prediction tools to custom design every blast to ensure it meets the fragmentation specifications."

Williams said that combining the prediction and analysis tools will help achieve the goal of

Maintenance software: misconceptions on predictive maintenance

DINGO says that after working with mines from around the world for over 25 years, it has heard quite a few concerns – and misperceptions – about predictive maintenance. DINGO's asset health software, Trakka® 4.5, captures predictive health information automatically from each mining machines, reports on performance, and if problems are found, schedules a service request in advance to prevent equipment failures. It maximises the data the mine already has – including preventive maintenance data so an issue can be addressed before it becomes a problem.

The company argues that implementing predictive maintenance isn't predicated on doing traditional preventive maintenance well – or even at all. "DINGO's goal is to shoulder all the heavy lifting and maximise your current processes, so your team can focus on its tasks while we implement predictive maintenance for you. Routine maintenance is usually triggered by breakdowns and fixed factors like time, age, service recommendations, and meter readings. The downside to preventative maintenance is that it's easy to miss something if it occurs outside the scheduled maintenance window. Conversely, predictive maintenance is based on the actual operating condition of your equipment so it's continually assessing if everything is functioning well."

Some mines rely on sensor data to understand which equipment needs attention. The downside is that sensor data is only part of the story – according to Dingo's maintenance experts, over 80% of all problems are found via other condition monitoring sources.

Another challenge is that the amount of data gathered is often overwhelming and nearly impossible to analyse manually. On average, less than 1% of available data in the mining industry is being used – if that data was being intelligently utilised, it could prevent costly and time-consuming equipment breakdowns.

"DINGO's Trakka 4.5 ingests, curates, and analyses data from almost any source while recommending actions to remediate issues. By using predictive analysis and machine learning, Trakka can 'learn' from patterns and make intelligent predictions based on the data." DINGO also believes that data analysis alone isn't enough – human expertise also needs to be applied to troubleshoot and diagnose issues. Its team of Condition Intelligence experts reviews condition monitoring data daily to proactively identify issues and recommend corrective actions. They will also continue to monitor open issues until equipment returns to a normal operating state.

The company also argues that most mines don't realise just how well they could perform if they had the right technology in place. Nearly every mine has room for improvement: based on data compiled from more than 50 mining operations across the globe, 33% of major components are regularly operating in a warning state and more than 11% are running in critical condition. "Inside each of your machines is a wealth of information. Predictive maintenance and asset health software is about listening, searching, locating, and acting to fix impending issues before they become major problems." The cited typical payback with DINGO is greater than 4 to 1 within 12 months, says the company.

Collaboration between Maptek and the developer of Aegis is set to close the loop on underground drill & blast design and measurement

turning a mining operation into more of a manufacturing operation with repeatable processes.

While many areas in mining are repeatable, others are based on skill, experience and intuition. The aim is to capture that learning so that any drill & blast engineer can perform their job successfully. This will add value at the mine level and also downstream in the mine-to-mill process.

Williams said quality assurance and control was virtually non-existent in many underground drill & blast processes and sites would benefit from more scientific rigour.

"We see the future is in blast analysis, treating blasting like any other underground process, not as a dark art where one skilled individual knows the mine by feel and can decide what the blast pattern is going to be regardless of the available information," he said.

Aegis and Maptek solutions can also work together effectively during the early stages of the drill & blast process. Aegis streamlines underground ring design, and laser scanning validates that drilling matches the plan, without interrupting production.

"You'd be amazed how many operations don't know exactly where the drillholes are located," Williams says. "With Maptek technology a scan of the working drift could reveal collar locations as a byproduct of a general scan." The ability to quickly measure as-drilled information can be the largest contributor to more reliable drill & blast.

When Williams met with Maptek, greater data integration between Aegis and Maptek software was high on the agenda. Maptek Mining Engineer, Mike Winfield said that streamlining data use across Aegis, Maptek™ Vulcan™ and PointStudio would enhance the user experience

and deliver better outcomes for mines. "Triangulations and block model information could be loaded from Vulcan straight into Aegis for design work and then the data can return to Vulcan or go through to PointStudio," Winfield said.

"Aegis has proven in some cases to speed up blast design up to 25 times. I can see its analysis tools having a huge impact for underground drill & blast processes when used alongside the Maptek capabilities."

The Maptek Technology Roadmap points to the potential for exciting outcomes for underground mining through collaboration with other developers.

Hexagon Mining's improved geology suite

Hexagon's Mining division last year introduced an improved geology suite for exploration and resource geologists. The HxGN MinePlan Geology Suite (formerly MineSight 3D, Geology CAD, Torque, QAQC, Logic, Drillhole Correlation, Sigma and GeoLogic) empowers users to store, manage, and analyze drillhole data, perform geological interpretation of deposits and generate accurate block models.

The release allows customers to access and

deliver drillhole results while conducting more geostatistical studies. Drillhole data storage is more robust and easier to access with an SQL server. Customers can quickly and easily check out their data, work on it, and merge it back into the original master data.

"The improvements are designed to increase the usability of a robust data model that meets the needs of all customers, from consultants to mines. Clients with data outside of Hexagon products can work with any type of ASCII format."

"By listening to our customers, we have improved our geostatistical solution to meet their needs," said Ian Blumel, Planning Product Manager. "Building a suite fully integrated with our system allows more time for analysis rather than moving and conditioning files."

Hexagon's Mining division has also released an improved mine planning solution. HxGN MinePlan 3D (formerly MineSight 3D) now features full virtual reality, bringing a new and compelling dimension to visualising and sharing mine plans.

MinePlan 3D users can visualize their mine plans and geological models in complete virtual reality. They can then share and showcase their designs to all key stakeholders, using the same medium.

The release responds to customer feedback, and includes improvements to the application's time and efficiency. MinePlan 3D now automatically generates more accurate solids, easier-to-condition surfaces, and quicker-to-design ramps. The solution speeds up design and evaluation time and delivers unique tools to validate geological models.

"We are the only general mine planning application with true virtual reality embedded directly within the application," said Ian Blumel,
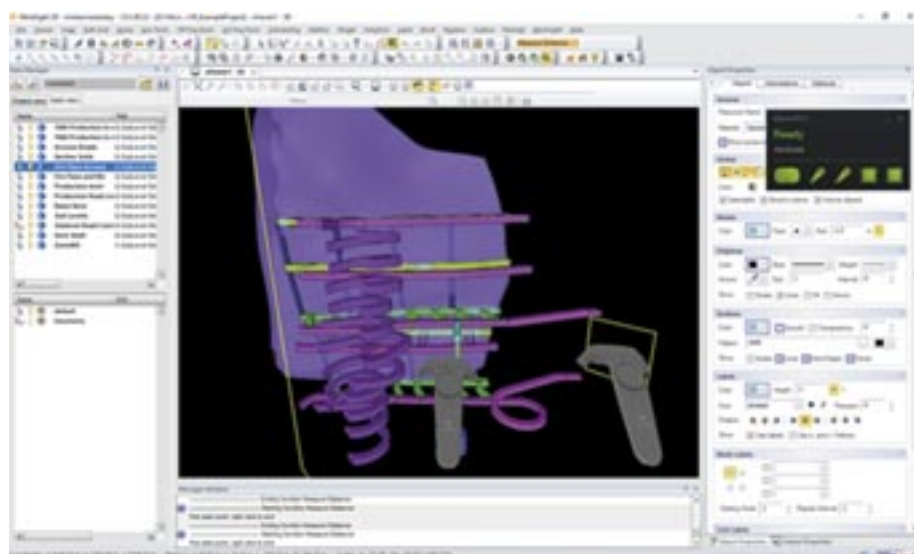
Hexagon's Mining division has introduced an improved mine planning solution. HxGN MinePlan 3D (formerly MineSight 3D) now features full virtual reality, bringing a new and compelling dimension to visualizing and sharing mine plans

Planning Product Manager. "Imagine stepping into a model to validate that the geology is more accurate, that scheduling makes sense, and that the design is sound. MinePlan 3D users can do that! We have listened to customer feedback and delivered improvements that allow users to obtain mine designs faster."

Ore control software advances at Peñasquito

Ore control technology from Hexagon has helped Goldcorp's Peñasquito mine in Mexico to meet the challenges of a declining metal production profile. Processing time for ore control has seen an average reduction of 75% while monthly reconciliation processing time has been reduced by approximately 80%. Located in the northeast corner of Zacatecas State, Mexico, Peñasquito is Mexico's largest gold producer, consisting of two open pits – Peñasco and Chile Colorado – containing gold, silver, lead and zinc. Mining (pre-stripping) began in 2010 and full production in 2011. The open pit mines feed both a sulphide concentrator (mill) and a heap leach pad. Peñasquito's project is owned by Goldcorp, Inc and is a poly metallic deposit with gold, silver, zinc, and lead being recovered as payable metals.

Due to expected lower grade ores with advancing mine-life, Peñasquito is facing a declining metal production profile. The requirement of the ore control system to accurately predict ore feed characteristics is critical to maximising metal recovery at Peñasquito, while the ability to accurately route materials from the ore control system is critical to site success. These challenges have been overcome by the adoption and implementation of a new ore control (OC) technology from Hexagon's Mining Division.

The solution has improved geomodelling, material routing and model reconciliation. The technology's implementation has also significantly improved selectivity, performance and data management, while reducing the variance between planning and execution. This has helped to drive overall improvement across the operation.

This project requires managing blasthole data, model interpolation, and model calculations, among other modelling-related tasks. Also required are the creation of new ore control databases to manage material routing, daily mining, model reconciliation and the communication with third party systems at the mine. The implemented solution uses the blasthole database as a primary input while also serves as material routing input for the fleet management system, and as a source to generate various reports. The OC system data is turned into information that supports the

decisions and evaluation-making processes at the mine.

The process used by Peñasquito's ore control team to update the OC model was beset with issues: a lack of knowledge of the intermediate steps from the users, the excessive number of steps, and the ability to troubleshoot when there were errors in the process. These issues prevented Peñasquito from running a robust ore control model that could be accountable for the new needs of the mine. The team sought greater confidence and reliability in the model.

This process was replaced with a newer, standardised workflow that allows the users to trust in the results and to make informed decisions with higher confidence. Using HxGN MinePlan Operations (formerly MineSight Axis) a new workflow for Peñasquito's OC was designed and implemented. The new workflow includes the use of different tools to resolve the issues that ore controllers had faced using the previous process.

"Thanks to the new process, we have increased the reliability of the model, which leads to higher confidence in our reserves," said Juan Barrios, ore controller for Peñasquito. "We have also reduced the working time to process a blast polygon, and now we can visualise and report the results almost on real time."

The implementation of the new ore control system from Hexagon's MinePlan software narrows the gap between what is and what should be; and helps to not only shape smart change, but also to unlock and realise significant improvements in the OC process. **IM**