

Driving efficiency with technology

Robert Pell examines the latest advances in mining software, tracking the trends across the value chain, and looking to the future

From open pits to complex underground workings – it is important to design a mine correctly at the outset, but include lifetime flexibility. During a time of fragile economic recoveries and shifting mining commodity demands, it has never been more important to have strong interactions and efficiencies between core planning, engineering plant production and geology teams. Today, the greatest advancements in interactions between different stages of mine development are achieved through software innovations.

New players in the mining software market such as **Bentley Systems** are looking to extend their knowledge gained from other industries into the mining sector whilst other companies are looking to enhance interoperability, allowing for greater comprehensive software solutions through the use of multiple software solutions. Another trend which has continued is industry consolidation, seen most recently with **Hexagon Mining** bringing together MineSight, Leica Geosystems, Devex and SAFEMine.

Strategic scheduling advancements

Maptek has further enhanced its offering for mining software with the development of two new solutions in the scheduling software space. **Gantt Scheduler**, released alongside **Vulcan 9.1** at the end of 2014, targets underground operations. The resource and activity based tools are integrated with **Vulcan** design tools,

With Gantt Scheduler and Evolution, Maptek is delivering integrated workflow between mine design and scheduling, avoiding silos of information and ensuring decisions are based on current data

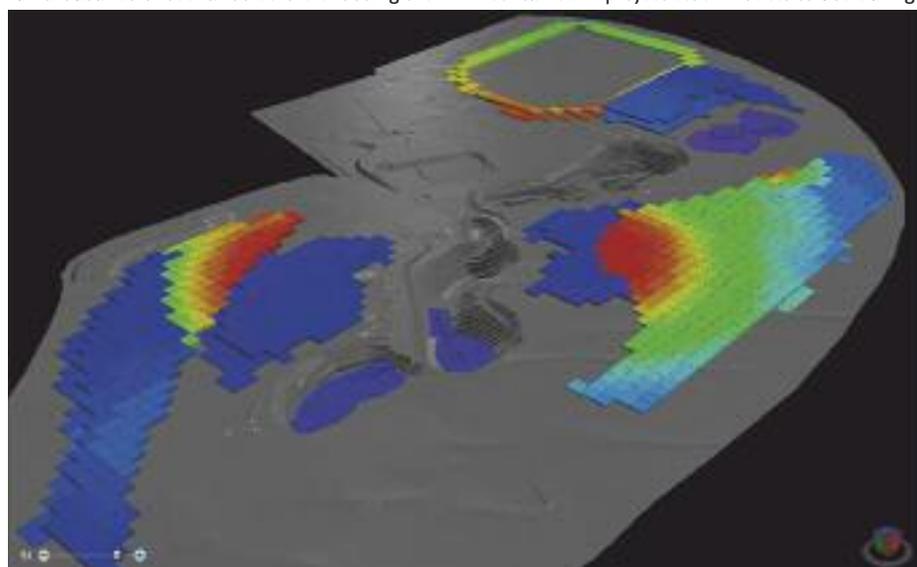
and are straightforward to set up and run. Attributes can be generated on the fly, allowing schedules to be seamlessly updated when designs are modified. Direct connection between mine designs and **Gantt Scheduler** allows selected or filtered activities from the Gantt chart to be displayed on screen. Users can run animations of designs for checking and publishing schedules. Resource levelling allows users to prioritise activities when more than one is available.

Maptek Evolution is a strategic and tactical mine planning tool acquired from Western Australian consulting firm **Oreology** in 2014. **Evolution** creates dynamic, cost-effective schedules from a resource model and employs a cut-off grade optimisation approach to ensure project value is maximised. Users can rapidly run thousands of scenarios before choosing the

Two excavators working together in a cut design strategy, modelled using MineSight MSSO

best options, run block-by-block scheduling to deliver granular information and holistic scheduling to fully exploit fleet and resources. Scheduling across planning horizons helps operations hit blending targets and meet customer product specifications. Different attributes can be combined to get the right mix for maximising values for any period.

Evolution's tactical approach produces a production schedule while optimising the haulage fleet and the overall shape of waste landforms. The result is the optimised allocation of haul routes with calculated cycle times, productivity and fuel burns. **Evolution** users have access to all of the relevant information contained in project block models to use during



scheduling. When the geological block model changes, the schedule is updated.

Maptek Manager Mine Scheduling, Steve Craig told *IM*: “Evolution improves productivity for any operation. Generating multiple schedules in a single run allows you to concentrate on developing the alternatives that add value. Holistic scheduling ensures optimised haulage routes and grade/tonnage consistency throughout the life of the mine. Mine planners and management can feel confident that they are making decisions that are based on profitability from the start of the project. Maptek development of Evolution will naturally involve integration with Vulcan. An early inclusion is phase optimisation – a much sought after tool which will give you the most practical phase design for the mining schedule. Further integration into the short term planning arena will see medium term tactical results being used by the Gantt Scheduler. As we continue to develop Evolution, our guiding principles are to maximise the value of your mine, taking into account the complexities you face every day. These include multiple resources, staged release strategies, fluctuating commodity prices, variable recovery and rehabilitation costs”, Craig concluded. “With Gantt Scheduler and Evolution, Maptek is delivering integrated workflow between mine design and scheduling, avoiding silos of information and ensuring decisions are based on current data.”

Breaking barriers between mining and processing

Dassault Systèmes has incorporated technology proven in other industries to improve productivity and control costs to the mining industry. The introduction of its Perfect Mine and Plant industry solution has assisted mining operations by allowing greater decision-making agility. The mining value chain is complex, interweaving people, processes, and activities which are highly interdependent. A problem that begins in one area, left unchecked, can have a compounding effect on those that follow, making mining to plan challenging. Perfect Mine and Plant breaks down the barriers between departments and introduces a new level of visibility about what is happening in mining and processing operations, including activities, tasks, personnel, and equipment.

Marni Rabassó, Vice President, Natural Resources, Dassault Systèmes told *IM*, “While the complete capabilities available in Perfect Mine and Plant are broad, mining companies can choose specific ones which are right for their individual needs. In the planning and scheduling domains, for example, companies can employ applications aimed at helping them



achieve planning and scheduling execution excellence. Integrated planning activities help ensure operations are consistently at the top of their game. With end-to-end visibility of all mining and processing activities, mining companies can make high impact adjustments to improve cost-per tonne and contain operating costs. By leveraging real-time data, they will also identify problems that would otherwise remain hidden and then react quickly to address them as they happen.”

Big data analysis is another area Perfect Mine and Plant makes possible. Mining companies generate a tremendous amount of data during mining and processing and from all the related support activities. Perfect Mine and Plant helps mining companies make sense of all this information and to put it to work in increasing productivity. Executives, managers and others have the information that identifies inefficiencies. They can then collaborate in the virtual world with their colleagues and use it in constructive and creative ways to enable superior process improvements or corrections. By sharing things visually, in 3D, everyone’s understanding of problems and potential solutions is increased.

With Perfect Mine and Plant, the latest data is available immediately, improving the quality of day-to-day plans. The incorporation of up-to-date data leads to more accurate plans which can support enhanced production output and greater equipment and staff efficiency. Thanks to ongoing review of performance to plan KPIs, they can make updates to the scheduled tasks and the assignment of equipment and people in near real time.

Input into long and medium term plans is also improved with Perfect Mine and Plant. To adapt to changing conditions at the mine and in the

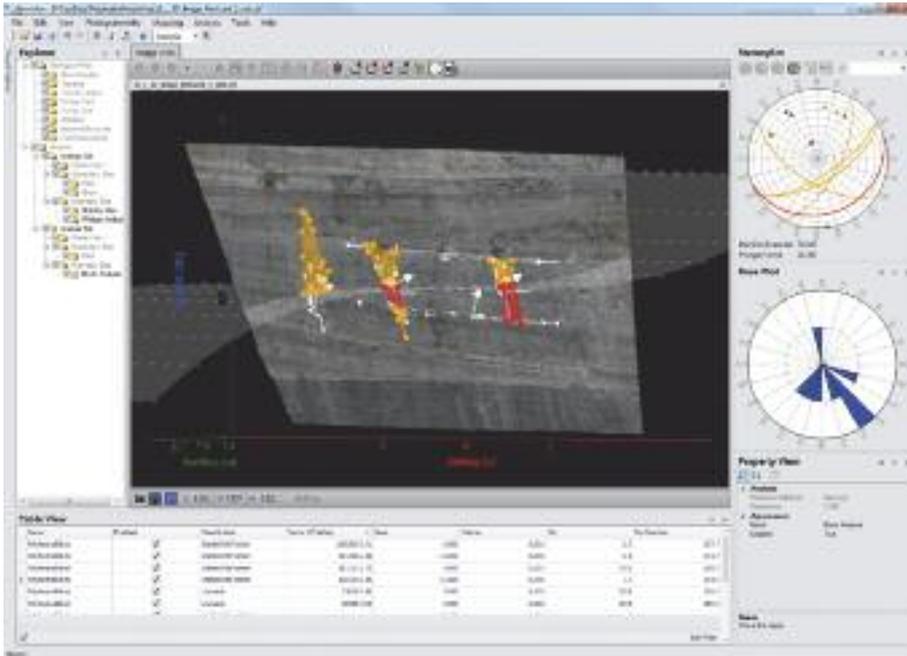
The introduction of the Perfect Mine and Plant industry solution from Dassault Systèmes has assisted mining operations by allowing greater decision-making agility

market, mine planners can leverage advanced optimisation and simulation to account for a wider variety of factors such as such as equipment performance, geotechnical data, and site logistics.

Perfect Mine and Plant’s operational modelling and simulation capabilities allow mining companies to try out and validate hundreds of ideas in the virtual world before implementing the right one in the real world. Coupling Dassault Systèmes advanced simulation with mine planning applications allows mining engineers to automate the execution of strategic and tactical design and planning activities. This allows for the selection of better designs and mine plans from a much larger number of scenarios. In turn, this leads to improved operational plans which have the potential to realise lower costs and higher revenues.

Datamine Sirovision 6

Sirovision from Datamine has grown in demand from the global mining operations and geologically consultancies since its development in 1994. It was created by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) at the Queensland Centre for Advanced Technologies in Brisbane, Australia, but in 2006, Datamine Software became a reseller for Sirovision and in June 2011 signed an exclusive licence agreement with the CSIRO giving Datamine Software exclusive rights to market and sell Sirovision to the global mining industry. Since 2011, both parties have worked together to research and develop new technology for the open-pit and



A Datamine Sirovision 3D model showing an imported curved structure and automatically detected unstable blocks

underground Sirovision photogrammetry systems.

The fifth major release of the software in 3 years is scheduled for February 2015. Sirovision 6 sees the expansion of the Slope Stability Analysis tool by introducing more sophisticated polyhedral block analysis in addition to the existing tetrahedral analysis which detects simple wedges. The availability of tetrahedral and polyhedral analysis techniques enables users to detect all types of unstable blocks in their excavation.

New functions include the ability to map or import multiple domains and enable input of geotechnical characteristics such as rock density, cohesion and critical friction values for each domain; import and display Pore Pressure grids; import and display non-planar or curved complex structures; and run polyhedral analysis to automatically detect blocks and toppling hazards in addition to tetrahedral wedge analysis. It can also analyse the interaction of minor and major structures; and run analysis on all digitally mapped structures simultaneously, not just two orientation sets at a time.

Final analysis considers all of the above to produce a Factor of Safety, physical location, mass and volume and stability classification of all unstable features including wedges, blocks and toppling hazards detected on the rock wall.

Sirovision 6 also adds automated ore body mapping to enable the user to select an ore body sample. The software scans all selected 3D models and automatically maps all occurrences of the ore. As the Sirovision model is accurately scaled, the software can output ore body surface area data which can be used to estimate ore volume.

Other new features include a simplified graphical interface, a new image and spatial data resolution reduction option for faster processing and improved file size management. This as well as the option to merge image files to enable large scale analysis across multiple large scale 3D mosaics, and improved plane mapping functionality for 3D mosaics.

Bentley enters the mining software market

Bentley Systems has launched its first mine life cycle product with the assistance of Cyst Technology. Together they launched MineCycle software in South Africa, following two years of development from syndicate development sponsors. The mine-planning tools which have been developed around the deep South African gold and platinum mines are now looking to be extended to a range of open pit and underground mines around the world.

Gary Lane, Managing Director, Cyst Technology, said, "The new mine planning

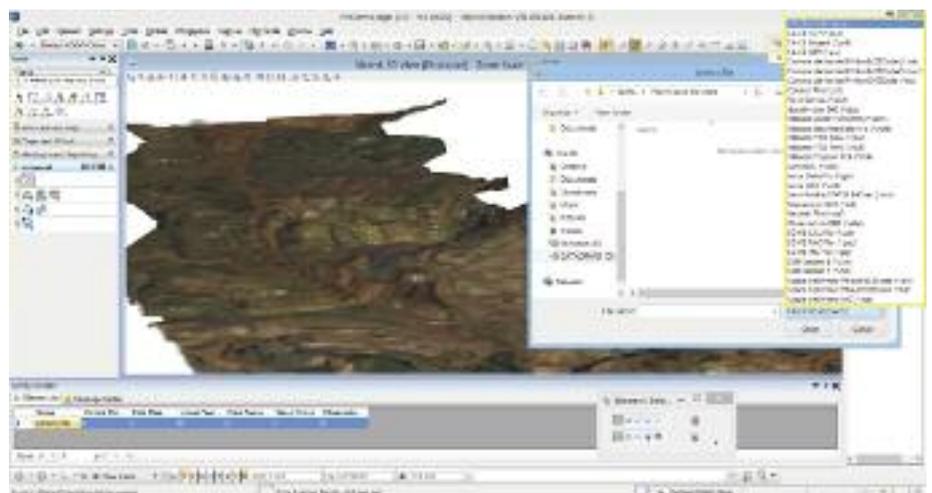
solution developed by Bentley Systems and Cyst Technology will radically change the way in which mine planning is done in the industry. By applying new innovative approaches to planning and scheduling, mine management can now test different production planning options to understand the impact on the economics and, thereby, derive a more optimal plan that meets the strategic objective of the business. A more optimal mine design and production schedule leads to more effective execution, which will increase return on capital through increased productivity levels and reduced unit cost. Cyst Technology and Bentley Systems have a strategic vision of developing a solution set that will result in a quantum change in the mining industry."

The MineCycle software applications was designed to address some of the mining industries most pressing challenges, including the need for a continuous rather than intermittent mine planning cycle. Bentley's new MineCycle products, which include MineCycle Designer, OpenRoads, MineCycle Survey, and MineCycle Material Handling, are the first Bentley products to be created through syndicated development, which gives industry participants direct input into the software's definition and design.

The MineCycle Designer and MineCycle Survey syndicate development sponsors were Anglo American Platinum Limited, AngloGold Ashanti, Lonmin, and Royal Bafokeng Platinum. The MineCycle Material Handling syndicate development sponsors were Hatch, GHD, and PDC.

Devlin Andersen, Section Surveyor, Anglo American Platinum said: "The Bentley and Cyst Technology teams have, over the past two years, led us all in a journey of discovery, which has culminated in a set of programs that will push the boundaries of our current way of doing

A new mine planning solution has been developed by Bentley Systems and Cyst Technology



business into the 21st century. We have collectively given input regarding our various operating requirements in our fields of expertise to Bentley and Cyst over the past two years. This information has driven them to produce a product that not only looks and functions as we intended but has exceeded our expectations. Whether it is mine surveying or mine planning, the solutions that have been created will allow us to function more efficiently and effectively. They further allow users to have one point of contact in terms of software that will give them all the functionality they require to perform their work to their absolute best. It is my belief that the products that have been developed will not only change the way we do work in the particular fields but also allow us to improve it.”

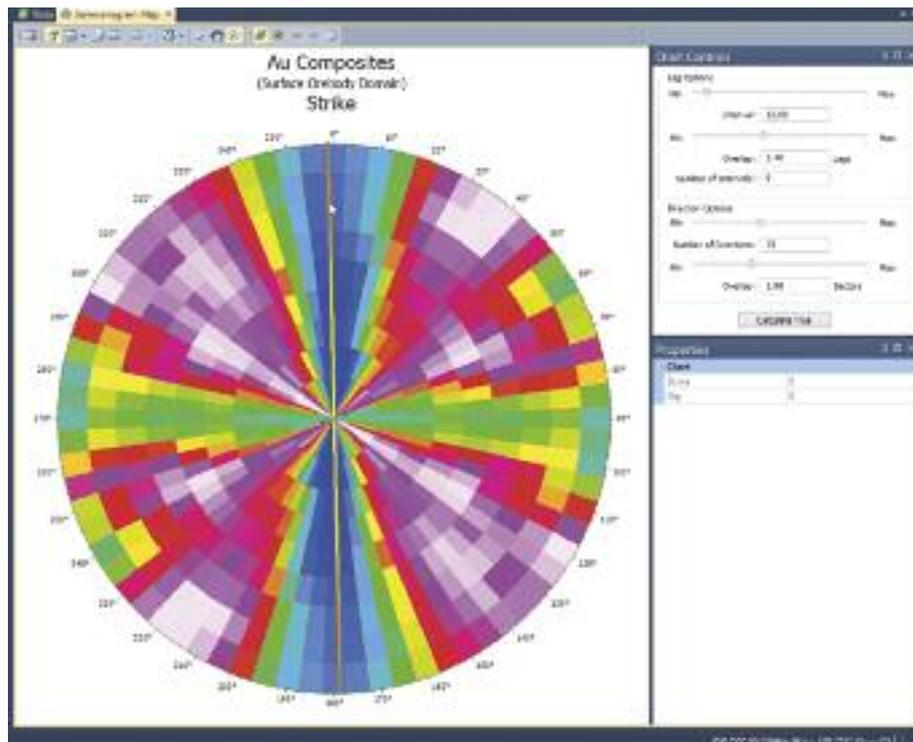
Traditionally it has taken weeks or months to complete mine planning and mine survey iterations, preventing consideration of other mine planning options, and often meant that strategies were out of sync with changing mine and market conditions. The development of MineCycle’s optioneering allows for mine operators to examine a range of operational alternatives, allowing for greater quality decision making and enhanced mine performance.

Robert Mankowski, Bentley Vice President, Simulation Product Management, said: “We are very excited about our new mining offerings and the powerful optioneering benefits they bring to the mining industry. This ability to quickly assess operational planning and engineering alternatives was one of the ‘musts’ that our syndicate development sponsors identified. Our collaboration with strategic software partner Cyst Technology was also instrumental.”

He continued, “I would particularly like to thank the syndicate sponsors who participated in MineCycle’s development. This innovative approach provides industry leaders with a unique opportunity to mutually influence the definition and design of new products. Thus, the mining industry is now ensured of solutions to high-priority business challenges, and Bentley has been able to mitigate risk and accelerate time to market.”

More from Micromine

Micromine provides software solutions through all stages of the mining process, from geological exploration through to mine production. Over the years Micromine has maintained its strong reputation by regularly releasing new software versions which build upon the strengths of its applications, allowing for Micromine to continue meeting evolving user needs and industry conditions. Micromine has released Geobank Mobile 2, the latest version of their geological field-logging solution. Geobank Mobile 2 allows users to confidently collect and work with



geological field data. The solution ensures accurate data capture through real-time validation and rich data input controls that minimise errors at the point of entry. It also maximises efficiencies through customisable calculation fields, in-built data approval and transfer mechanisms.

Commenting on the latest release, Geobank Operations Manager, Derek Vincent, said: “The Geobank Product and Development Team has invested a significant amount of time and effort into Geobank Mobile 2. I am incredibly proud of this latest release and based on the positive experiences of our Beta Testers I am confident that it will be very well received by the market. The application’s new and enhanced features continue the company’s tradition of producing easy-to-use software solutions which enhance user productivity and efficiencies. Geobank Mobile 2’s most significant new feature is the synchronisation of collected data and logging profiles with SQL Server, enabling communication between devices and head office. Data collected on field-deployed Geobank Mobile devices can be seamlessly uploaded into central databases in the office. Synchronisation will increase productivity through more efficient workflows, increased data confidence, and improved access to data. It will also save time through the simplified distribution and updating of logging profiles, and by allowing database administrators to more easily gather and distribute data. Geobank Mobile 2 also includes a new centralised screen which groups all validation errors and cross references them to data records. This will help to enhance data accuracy and user productivity, and introduce cost savings through

The most significant enhancement within Micromine 2014 is the major update of statistical functions and the inclusion of new graphing functionality

faster and more efficient validation processes in the field.”

In addition to these new features, Geobank Mobile 2 contains many efficiency enhancements. These include improved memory optimisation, more options for exporting logged data, enhanced execution parameters, and improvements to the Schema Editor.

Reflecting on the series of releases, Vincent comments: “Geobank Mobile 2 closely follows the launch of Micromine 2014, the latest version of the company’s exploration and mine design solution, and will soon be followed by the release of Pitram 2015, the upcoming version of MICROMINE’s mine operations system. These releases, all introduced within five months of each other, are testament to the company’s commitment to the ongoing enhancement of its software across-the-board. We are as dedicated to our exploration clients as we are to our mining ones”.

Micromine 2014, which allows users to capture, manage and interpret critical data, is relevant to all stages of the mineral extraction process. Micromine provides an in-depth understanding of a project so prospective regions can be targeted more effectively, increasing the chance of a project’s success. It also provides easy-to-use modelling, estimation and design tools to simplify day-to-day production tasks.

Commenting on the release, Micromine Product Manager, Daria Lvova, states: “The

Micromine Product Management and Development Teams worked tirelessly to release Micromine 2014 only a year after the previous version, Micromine 2013, and to ensure that the application and its developments exceeded client expectations. MICROMINE is renowned for its timely and frequent releases, and is already working towards the next release. Over 310 new and enhanced features specific to both exploration and mining were included within Micromine 2014 to satisfy all users, from GIS specialists and geologists through to mine engineers. Micromine 2014 also continues the company's commitment to producing easy-to-use software solutions that are intuitive and allow users to enhance productivity and cost efficiencies."

Lvova adds: "By re-investing a significant percentage of annual revenue into the company's Research and Development (R&D) Program, Micromine ensures clients benefit from the latest technological advances with frequent, timely releases and updates that reflect their needs. In addition to the company's ongoing R&D Program, which has been supplemented by the largest ever grant awarded to a mining software company by the Australian Government, the Micromine Product Management Team manages an incredibly robust Beta Testing Program."

The most significant enhancement within Micromine 2014 is the major update of statistical functions and the inclusion of new graphing functionality, providing improved visuals and increased user interactivity. New functionality, including box-and-whisker plots and a new semi variogram map, ensure users can easily produce what they need with minimal effort, saving a considerable amount of time. Although all users benefit from improved workflows, they are most pertinent to exploration and resource geologists who use statistics on a daily basis. Micromine stereonet display has also undergone a re-write, and is now more visual and advanced. Through new options it is now easy to summarise structural orientations.

To ensure the solution adheres to latest technology trends, Micromine 2014 has been converted to a full 64-bit application. This builds on the hybrid 32/64-bit framework of the application's last few releases, and will allow clients to use all available memory on their computers and work with more data than ever before. Many underlying systems such as wireframes and drillhole databases have also been modified as part of this update.

Micromine 2014 offers enhanced pit design tools, new road and switchback options, and new surface road design tools. Other CAD enhancements include new snap modes which allow users to easily create a string that follows a surface wireframe, and a dynamic input mode

that allows specific numbers (such as a gradient or distance) to be entered in the middle of a graphical editing session.

Micromine 2014 features new block model display options, including interactive block visibility. Users can now display or hide blocks in the model by dragging sliders on a histogram of data values. These data values can be coloured using the same colour set as Visex, making it easy to relate visible blocks with the slider positions. Additionally, new drillhole aligned hatches provide more visually appealing results by aligning patterns to the drillhole traces. The application's Plot Editor functionality has been further enhanced, a process which was initiated a few releases back. Users are offered a more streamlined use of Plot Editor through the ability to easily and quickly edit properties of plot features with a single click, saving time.

Connecting long, medium and short term planning

MineSight, an industry leader in developing mine planning and mine modelling software, is now part of Hexagon Mining. Hexagon says it "is the first global technology integrator to build a true mining vertical, with a span of technologies from exploration to operation." MineSight's capabilities in planning, scheduling and operational software are a great fit with Hexagon Mining's other technologies: fleet management and high-precision guidance from Leica Geosystems Mining, underground asset control from Devex and operational safety from SAFEMine.

Goldcorp is one of the largest gold producers in the world with projects in South, Central and North America. Goldcorp's flagship operation is Peñasquito, a worldclass, polymetallic deposit that started production in 2010 which is one of the largest mines in Mexico. Since the early stages of the project, Goldcorp has used the most advanced technologies available to maximise its value. However, the implementation of optimum mine plans has been challenging to put into practice. This is due to the fact that the mine operation involves more complexity than the plans usually reflect. This challenge is an industry wide issue that presents opportunities for improvement.

Mine planning methodologies and procedures that connect long, medium and short term planning strategies are essential in bridging the gap to produce optimum mine plans that can be practically implemented in the field.

The Peñasquito mine is a typical open pit truck and shovel operation located in Zacatecas, Mexico. The ore deposit contains mineralisation of gold, silver, lead, and zinc hosted mainly by two breccia pipes: Peñasco and Brecha Azul. The oxide ore is delivered to the heap leach from

which gold and silver doré bars are recovered. Similarly, the sulphide ore is delivered to the crusher and mill circuit from which lead and zinc concentrates are produced. There are three main dump locations to store the waste mined. The waste dump facilities have a combined storage capacity adequate to handle the amount of waste mined over the expected life of the project. It should be noted that a portion of the waste material is discharged directly into the dumps by the haul trucks.

However, some of the waste is delivered into a crusher that feeds a conveyor belt system which transports the material into a stacker which places the waste mined in the dump facility. In addition to that there is a tailings storage site that was designed as a zero discharge facility in accordance with environmental standards.

Mine planning studies at Goldcorp Peñasquito assist management with the evaluation of multiple mine planning alternatives from which those that are most viable and aligned with the company's objective are selected, refined and implemented. This process is cyclical as the mine plans are constantly updated to adjust to the changes in the business environment.

The long term mine plans are prepared in collaboration by a team of engineers that consists of corporate staff engineers, onsite engineers and consultants. The information is communicated across Mexico, The United States and Canada in English and Spanish. In addition to that, there is diversity on the tools used to complete the mine plans. Historically, most of the cutting edge mines planning tools available in the market have been tried at Peñasquito. Therefore, the validation and data translation from one software to another and from one team to another one is an inherent part of the process. Each team member that participates in the process along with the corresponding tool used to complete the required task or analysis adds value to project and complements the mine plan.

The first task for the mine planning engineers is to calculate the economic pit limits at the selected evaluation price and corresponding costs scenario. The pit optimisation results are calculated based on the block value stored in the block model.

The net smelter return (NSR) model used to determine the value of the block is quite complex and includes the metal revenues minus the smelter recovery/payables, treatment/refining charges, penalties, freight costs, etc. It should be noted that multiple scripts with alternative logics are used to calculate the value of the block under different assumptions. This allows the engineers to evaluate worst/best case scenarios under different model assumptions in order to manage the risk and help management with the decision making process. Similarly, these scripts are

continuously updated and modified to reflect new information as it becomes available.

After the economic pit limits are determined and the corresponding reserves are estimated, the next step is to sequence the pit. For this purpose a series of incremental pit shells are created which follow the best economic mining direction and satisfy certain design parameters and constraints. Initially, the incremental pit shells are scheduled at a high level to determine the best mining sequence. Then, the more feasible alternatives are refined and detailed pit designs are completed using the optimised pit shells as a guideline.

The detailed designs are used for reserves reporting and scheduling. The haul profiles are created to ensure feasible material movement and determine the equipment requirements for the life of mine studies. Similarly, waste dumps are designed and sequenced to ensure proper storage of the waste material and minimise the haul hours.

The life of mine plans created by the long term planning engineers, serve as the guideline for the medium and short term plans to ensure a cohesive mine planning strategy. Traditionally, most of the long term planning scheduling tools, provide analytical schedules that identify the pushback bench reserves that need to be mined by period.

However, for medium and short term planning more detail has to be added to the plan in order to define how the bench mining cut sequence will proceed. This requires direct input not only from the planning engineers but also from the operations personnel to ensure a feasible excavation pattern. At this stage access into the bench has to be considered not only for the excavators but also for the drills and the mining trucks. Adequate operating space must be provided and safety considerations have to be observed during this process. Similarly, other factors have to be considered such as construction or removal of high voltage electric posts and the associated cables that supply the power for the electric shovels. Additional water management considerations must also be taken into account to ensure proper drainage of storm water runoff via spillways, culverts, ditches, berms, dry wells, submersible pumps. Similarly, geotechnical considerations have to be observed and monitored for safety reasons which may limit the areas available for blasting and extraction. If the shovel is digging in a confined area, it may be necessary to remove the shovel before the blast and bring it back afterwards. All of these factors have a direct effect on mine production which the medium and short term engineers have to reflect in their extraction plans.

Therefore, the strategy dictated by the long term plans are not always achievable but provide

a reference for the medium and short term engineers to use as a guideline. It should also be noted that additional discrepancies between the exploration and production models introduce deviations to the plan. Lastly, the engineers must provide the operators the precise location of the mining extraction areas and the operators must conform to it in order to minimize the deviations from the plans.

The mining polygons provided by the long range plans are usually subdivided into finer cuts that represent excavation paths subject to minimum minable widths to fit the equipment. These cuts are designed to meet specific plan objectives and can be designed in more or less detail to meet tonnage and grade targets as shown below.

Certain mining considerations have to be implemented into the medium and short term plans in order to make the schedules practical. For example, the number of open benches has to be limited to prevent the shovel from moving from one bench to another. Similarly, vertical separation among phases may be necessary for safety reasons. The schedule has to be checked period by period graphically and analytically to ensure that the excavators assigned can be physically and timely moved from one mining area to another one from period to period subject to the excavation rates and other constraints. The mining rate for each phase may vary by elevation depending on a number of factors such as the space available. In some benches there may be enough room for two or more excavators while in other levels there may only be enough room for one excavator.

Detailed haul profiles are designed to reflect the available routes for each period from the mining cuts to the existing and future destinations such as waste dumps and stock piles. The cycle times for the truck fleets are calculated based on the detailed haul profiles and calibrated against field observations and data obtained from the fleet management system. The creation of the mine plans is monitored and updated on a regular basis to make sure that the operation stays on track and that production milestones are achieved according to plan. For example, the rolling plan forecast is completed and updated every month.

This allows for monthly plan corrections and reconciliation between the extraction plan and the actual mined out areas. Therefore, the creation of plans and the continuous supervision of its implementation go hand in hand to make sure that the operation stays on target, so the mine productivity and profitability can attain its maximum potential.

A range of people and software is used for the preparation of the mine plans. Every mine planning tool has its strengths and limitations,

thus the application of multiple tools helps to assure that the problem has been approached from multiple angles in order to get the best possible results. However, there are some challenges with the translation of data from one platform to another one, each one with different assumptions and levels of details. For example, the long term plans may assume full and partial bench reserves while the short term plans may be based on production polygon cuts. Therefore, it may be difficult to reconcile plans prepared with different assumptions and levels of detail. However, as new technologies and software become available it is possible to close this gap and provide an integrated mine plan. "The traditional approach followed by Mintec over the last 40 years is to develop a series of tools to help the mine planners complete their tasks and produce a robust mine plan. This has led to a complete suite of mine planning software which assists the engineers and management with the strategic analysis, decision and implementation of the business plan. However, with the evolution of mine planning software there are new tools such as MineSight Schedule Optimizer (MSSO) which can be used for long, medium and short range planning. In the case of Peñasquito, the short term plans used to be prepared with MineSight Interactive Planner (MSIP). However, this was a manual process and very time consuming. In April of 2012, Goldcorp implemented the use of MSSO at Peñasquito to generate and optimize their short term schedules. The first task was to reproduce with MSSO the schedules previously produced with MSIP. The second task was to find opportunities to improve the mine plan and optimize the schedule. The successful implementation of MSSO for the rolling plan forecasts lead to its application for medium term plans as well. In 2012 and 2013 there were significant developments in MSSO such as the ability to schedule on partial cuts, equipment/haulage integration, multi-period optimisation and scheduling. These developments among others enabled MSSO to be used for long term planning as well. Early in 2013, the long term schedules generated with MineSight Strategic Planner (MSSP) and other third party scheduling tools were validated and reproduced with MSSO. Thus, MineSight Schedule Optimizer became essential not only for short term plans but also for medium and long terms plans. There are many advantages associated by using the same tool for long, medium and short range schedules. For example, the integrity of the data is kept under a single database, therefore the validation of data and the time required to import/export data formats is kept to a minimum. With MineSight Schedule Optimizer (MSSO) the plans can be refined and additional levels of detailed can be

added within a single interface. The results can be quickly visualised in MineSight 3D and mining rules can be added dynamically for user control. Also, the software training required for mine engineers to transition from short to medium or long range planning is kept to a minimum.”

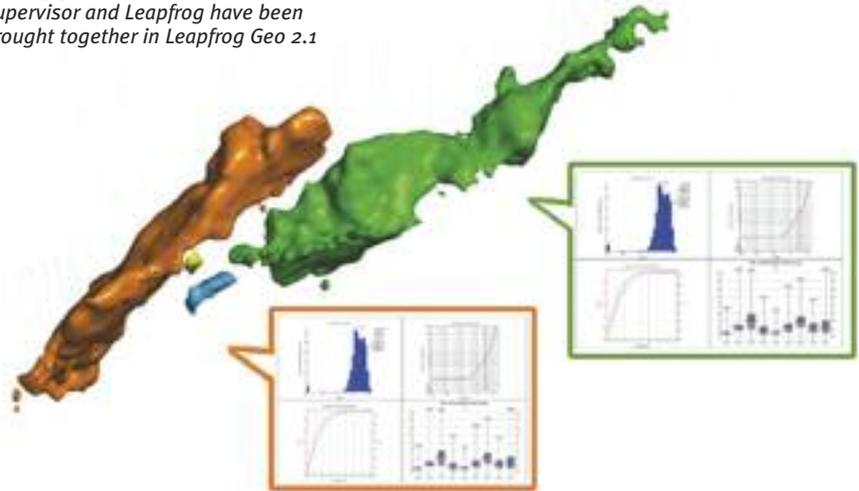
The information gathered from the long range plans is transmitted seamlessly to the medium and short range engineers. Similarly, the information gathered from the medium and short range plans are retrofitted into the long term plans to make them more representative. The end result is a strategic business plan in which the first periods are broken down by month according to the rolling plan forecast, followed by quarterly and yearly forecasts in which long and short term planning strategies are integrated and perfectly aligned.

Assembling a project team in which the members understand how their work connects to each other and serves the long and short term goals of the organisation is key to producing and implementing an integrated mine plan. “Ultimately, mine planning philosophies have to align with mine operations so the mine plans can be realised in the field. Therefore, the performance of the mine must be monitored and measured to ensure that the business objectives are met according to the strategic vision of the organisation. Similarly, the mine plans have to be flexible and adaptable in order to respond to changes in the conditions of the operation and the business environment.

Introducing Atlas and Blast

MineSight’s latest new releases include Atlas 1.9, in direct response to requests from mine planners. “We are dedicated to ensuring our clients get more time to make decisions while MineSight takes care of details,” said Glenn Wylde, MineSight Vice President-Technical. “Short-term planning in particular is fraught with pressure so Atlas is designed to make life easier for mine engineers.” Atlas 1.9 adds a whole new world of CAD design. Gone are the days of countless click-click-clicks to design mining cuts. Atlas’s automatic activity designer builds mining activities straight from a centreline, and clipped to a limiting boundary, allowing you to easily adjust the swath and target tonnes or volume. Quick hotkey adjustments can revise the swath and all automatically built cuts can be pushed to the activity model and be assigned to a resource. “We want the user to be able to spend more time refining the schedule than perfecting CAD skills,” said Wylde. Atlas 1.9 further integrates MineSight Axis for grade control. Axis users will now be able to build their daily dig mining blocks directly from Atlas or MineSight Planner. You can quickly build remaining stocks of block-outs from fleet management dig-points. Improved Gantt printing,

Leading geostats tool, Snowden Supervisor and Leapfrog have been brought together in Leapfrog Geo 2.1



simple to configure rolling reports and the automatic ability to complete tasks by a given date are also included in Atlas 1.9. Since being introduced last year, Atlas has been adopted by planning departments in some of the world’s biggest mines.

Finally, MineSight has added precision and dependability to one of mining’s most challenging steps with a new drill and blast management utility. MineSight Blast improve the process of design and execution of drill and blast plans from within MineSight 3D. Within a single interface, you will be able to design drill patterns, apply blasting parameters to holes and do the tie-in of a shot. Mark Gabbitus, MineSight Product Manager-Operations said: “MineSight Blast will redefine blasting. A bad blast can undo all of the good work done by geologists and engineers to develop a robust block model and mine plan. So it is vitally important that the blast design and execution minimises error and interprets the effects when things do not go to plan.”

Incorporating a modern design interface, MineSight Blast will design and manage drill and blast patterns interactively on screen while storing all of the design (and actual) information in a SQL database. Direct links to drill fleet management and explosive vendor systems will enable easy automation of data transfer between the design tool and the operators. See what’s happening in the pit in near real time and make intelligent business decisions. MineSight Blast will link directly to MineSight Atlas so mine planners can update their schedule based on actual drillholes and lengths to get more accurate times.

Several factors affect the quality of a blast. The geology and geotechnical characteristics of the rock are unchangeable, but the blast pattern parameters, such as hole spacing, depth, diameter and amount/type of explosive used, can be modified. The ability to change these

parameters dynamically in response to as-drilled information is critical to achieving good fragmentation. Future releases of MineSight Blast will include blast simulation, analysis and optimisation to reduce the workload on drill and blast engineers and enable them to change or optimise blasting parameters at critical stages.

Starting later in 2014, MineSight Blast will be released in a phased approach with Version 1 set to include enhanced drill pattern design features, such as offset rows, volume of influence solids and naming rules. Versions 2 and 3 will see the addition of blast design tools, pattern tie-in options (manual and automatic) along with simulation and optimisation options.

Geological modelling from Leapfrog

Since 2003, the Leapfrog suite of 3D, geological modelling packages from ARANZ Geo, have been used by some of the world’s leading mining companies. Leapfrog’s latest release, Leapfrog Geo 2.1 along with Leapfrog Partner Program, allows for greater interoperability with leading partners such as geostats tool Snowden Supervisor, geographic mapping and analysis application MapInfo Discover from Pitney Bowes and geographic information system Esri ArcGIS.

Shaun Maloney, ARANZ Geo’s CEO says: “This release is significant as it delivers more interoperability for our users, enhancing efficiency and improving workflows. We’re committed to extending interoperability through Leapfrog’s partner program so users can work seamlessly with a wide range of packages.”

Leading geostats tool, Snowden Supervisor and Leapfrog have partnered together to give Leapfrog Geo 2.1 combines the speed and power of the FastRBF™ Leapfrog engine for grade interpolation, with the confidence that geostatistical analysis offers. Variograms can be modelled in Snowden Supervisor using Leapfrog Spheroidal variogram structures. These models can be output in Leapfrog format and loaded

directly into an interpolant model in Leapfrog Geo.

"Snowden's software has a great synergy with ours," says Maloney. "We share a real emphasis on innovation and our software similarly has a well thought out and intuitive interface. By combining the power of the Leapfrog engine with the confidence that Snowden Supervisor offers our users will have a clearer understanding of the deposit. Improving accuracy allows greater resource recovery and ultimately delivers more revenues, so it's a real win for customers."

David Cormack, Snowden's CEO agrees: "We are excited about the synergy created from bringing together two innovative, user friendly software packages to improve productivity by allowing quick, efficient and accurate analysis of a deposit."

Leapfrog Geo 2.1 has new workflows for integration of GIS data which removes the manual steps and opportunity for errors. Entire batches of GIS objects can be moved into Leapfrog in one go from either MapInfo Discover or Esri ArcGIS. MapInfo Discover have developed a purpose built Leapfrog exporter to create a robust and effortless workflow. New support for 2D data grids means 2D data such as geophysical grids can be viewed alongside 3D models and wireframes.

Neville Panizza, Data Systems Manager at First Quantum Minerals (Australia) says: "MapInfo and Leapfrog are two major components in our exploration software tool kit. Having the ability to quickly incorporate our GIS data with our 3D Leapfrog projects, irrespective of file formats or projection types, is fantastic. The interoperability will allow us to move from a 2D to a 3D environment with ease and streamline our process flow for handling multiple data formats. Not only will this be great for existing projects it will also allow us to evaluate new data packages quickly, moving us to a decision point faster."

Leapfrog Geo 2.1 includes a new processing engine which scales to multiple-cores to meet geologists' needs to deliver more complex outputs by harnessing more of the computers power. New 'priority engine controls' give users the flexibility needed to 'run' only the data required, resulting in less waiting when iterating through many small edits.

"We've demonstrated a continuous modelling workflow software prototype at the annual Deep Exploration Technology Cooperative Research Centre (DET-CRC) conference in Adelaide. The software is designed to work in conjunction with ARANZ Geo's 3D geological modelling software Leapfrog® to provide a continuous modelling workflow which can be used in operational environments such as drilling campaigns."

ARANZ Geo's Product Manager Brennan

Williams, who is leading the project says, "We're very pleased with the response from conference participants and deep exploration experts who are here to look at research and innovations to transform the workflow of mineral exploration. We'll be carefully evaluating this feedback to ensure the final product exceeds expectations and maintains our position as an industry leader."

The DET CRC was established in 2010 under an Australian Government program to address the most significant challenges to the future of the minerals industry. The annual conference provides an opportunity for participants to learn of the progress made by CRC research projects and other new industry innovations.

ARANZ Geo's continuous modelling workflow prototype replaces the repetitive manual tasks involved in importing new data, updating models and generating refreshed comparisons with existing interpreted geology to enhance efficiency and increase productivity.

Williams says: "By cutting down manual and repetitive tasks geologists have more time to apply their expertise to the understanding of the geology and mineralisation leading to more informed decisions in a shorter timeframe. The value of collected data lies not only in the information that can be obtained from it through analysis and interpretation but also in the elapsed time between data gathering and the use of that information to support decisions."

Continuous modelling workflow results in agile decision making as geologists can visualise and extract information from geological models that are continuously updated with newly acquired data.

Williams adds: "IT/OT convergence should include rapid resource modelling. The prototype builds on Leapfrog's core dynamic modelling feature but also provides a level of management that further improves decision-making. It is hoped, that the prototype, as yet unnamed, will initially target mining's exploration market."

BHP Billiton's Senior Manager Technology Development, who saw the demonstration said: "What a difference a day makes. With this continuous modelling technology now you can see how much your model changes due to new drilling data from dinner last night to breakfast this morning."

ARANZ Geo's Research Director Richard Lane states: "We pride ourselves on developing solutions that solve real problems in the market. The prototype is in response to industry demand for more efficient ways of operating. A recent mining productivity survey found that productivity decreased as operations became larger. It was recognised that each part of the business needed to be optimised by finding new solutions to existing problems using data and

technology. Innovation was identified as a game changer."

RungePincockMinarco expands its offering

RungePincockMinarco (RPM) acquired the rights to the Mine2-4D design software from MineRP in August 2014. The acquisition of a non-exclusive right to the code will allow RPM to develop its own mine design products and offer integrated design capability with its market leading scheduling and simulation products.

Richard Mathews, CEO at RPM said: "This acquisition is really exciting and accelerates our plans to expand our capability across the mining value chain. The Mine2-4D product is well known in the industry and by using this existing foundation we have a low risk, fast track approach to getting mine design on our software roadmap and delivering a more holistic offering to our customers."

The Mine2-4D design product has recently undergone a complete rewrite, using next generation development tools to allow superior levels of enterprise integration and processing capability. Under the terms of the acquisition, RPM has acquired unrestricted rights to rebrand, commercialise and exploit the software code and any successor products developed by RPM.

RPM has historically provided export/import functionality for design tools of multiple third-party vendors allowing feedback between the design and scheduling processes and it will continue to do so. The full integration of an RPM specific design tool with RPM's scheduling and simulation applications will however, greatly enhance the mine planning process.

"Having our own design tool will mean we can provide our customers with a complete planning solution. With design functionality, geological reserving, and operational scheduling, a fully integrated offering will enable customers to immediately evaluate the impact of changes in the physical environment on scheduled activities. The product also comes with a new graphics engine at its core, which is based on leading visualisation technologies. Our client base is increasingly looking to use the visual representation of geospatial data to validate plans, simulate and analyse alternatives. We will be embedding these new technologies across our existing products to greatly enhance the user experience and take this visualisation capability to the enterprise level."

It is expected that the first release of the new RPM design product would be available in the second quarter of FY2015. RPM also launched the latest version of their haulage and loading simulation software, HAULSIM. Updating for greater capability for modelling the haulage network for underground hard rock mines

“Focusing on underground capabilities for the release of HAULSIM 1.1. is in response to the overwhelming feedback and interest we have received from the industry since we launched earlier this year”, said Craig Halliday, Director of Software at RPM. Underground haulage can be incredibly complex, so by adding the ability to configure more sophisticated road rules and haulage network features like passing bays and ore passes, this latest version of HAULSIM will provide an extremely accurate reflection of actual haulage networks. This allows our clients to run simulations that best reflect reality”, adds Adam Price, Product Manager for Simulation at RPM.”

Following its release in February 2014, HAULSIM has been used by RPM advisory consultants on a number of projects including mine expansion and equipment efficiency studies at a number of underground and open cut mines.

One client that has already seen the benefits of using HAULSIM is Iluka Resources. “We implemented HAULSIM as a tool to model how our pit will operate day to day, and answer the ‘what if’ questions that are asked during the feasibility process. We are impressed with how quickly and easily the simulations are to set up and maintain, given the complexity of our models”, commented Stephan Esterhuysen, Manager Innovative Mining at Iluka Resources.

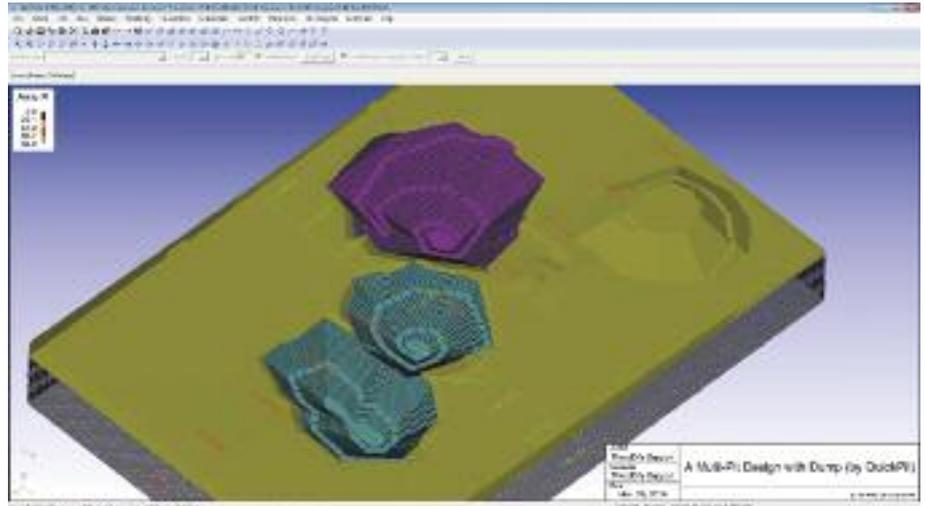
“Thanks to HAULSIM, we are able to optimise haulage systems, evaluate challenging mining strategies and visually communicate outcomes to stakeholders in a reliable and accurate 3D interface. We have been demonstrating this new product to clients across the globe and the level of interest has probably surprised even us, we knew we had a great product but we are excited about how quickly clients are seeing the benefits that HAULSIM can deliver to their operations”, says Halliday.

“Every week our teams are coming up with new applications for HAULSIM and solving a wider range of problems for our clients. I look forward to telling even more good news stories about HAULSIM in the near future”.

HAULSIM 1.1 also provides the ability to group certain equipment together for example, locking bigger trucks to certain loaders and smaller trucks to other, more appropriate sized loaders which allows the user tighter control over the simulation.

These updates and a range other smaller performance enhancements will be made available to existing HAULSIM clients in the coming weeks.

RPM has also released the latest version of Open Pit Metals XPAC Solution (OPMS). Alun Phillips, RPM’s Product Manager – Scheduling, said “This release is really exciting for two key reasons, firstly we have added interactive scheduling capability - which allows users to get



A 3D pit design using ThreeDify QuickPit with legend and drawing identification

right down to the intricacies of the extraction schedule. Secondly, we have now given users complete flexibility to schedule with blocks of any shape and size to suit their planning timeframe”.

Phillips explains that interactive scheduling allows mine planners to pick and choose which materials and equipment to manually schedule, and which to leave to the automatic scheduling functions of OPMS.

“Having the ability to select any subsection of the plan to work on in more detail allows users to create a very precise schedule. Mine planners can choose to work in detail for critical tasks but leave the more tedious tasks to the automated features of OPMS including the Autoscheduler, Advanced Destination Scheduler and Product Optimiser. OPMS allows for a seamless transition between interactive and automatic scheduling so the planner has complete control”.

Another key enhancement to OPMS is the ability to schedule with blocks of any shape and size, to suit the scheduling timeframe. Whilst large regular blocks are fast and efficient for long term scheduling purposes, irregular block shapes are more common for budget and shorter term schedules which require more flexibility and precision. OPMS now supports any combination of these.

“The way we create our mining blocks now provides the best of both worlds, quick when it needs to be and more detailed at the pointy end. These new features are the result of extensive consultation with our clients since the initial release of OPMS. Coupled with the recent developments of RPM’s Operational Mining Integration (OMI) platform, OPMS is the clear choice for enterprise wide mine planning”.

The OMI platform manages the direct connection of RPM’s scheduling and financial modelling software products and allows for integration of these products to ERP systems, such as SAP.

“Our OMI platform has brought together our

scheduling and financial products so that they can share data quickly and seamlessly, giving more control and auditability over the whole mining process. The feedback we have received so far indicates that this is really meeting the needs of the industry” concludes Phillips.

ThreeDify continues stope optimisation

In terms of ongoing take up of software in the mining industry, Nancy Liu, **ThreeDify** VP Operations told *IM*: “The business of mining is not getting easier. As grades decline and ore bodies are depleted, companies continue to move into increasingly remote locations with correspondingly harsh conditions, pushing costs to unsustainable levels. The passion for innovation in the mining industry has not been lost. New innovation can be a productivity game-changer, especially with ore grades declining around the world. Many of these excellent innovations of the past ten years or more have offset the adverse effects of mineral-resource depletion over time. The mining software packages have been improved by taking advantage of current parallel-processing technologies to provide real-time planning, visualisation and data analysis. Processes that used to take weeks or days to complete are now to finish in hours or minutes. Now that low commodity prices and high production costs are the norm, it is time to optimise mine plans and close uneconomic developments. With the effective mining software solutions, companies can determine which mines have the capacity to generate the economic output. This equips them to prioritise investments so that funds are directed only to those projects that promise optimal returns.”

ThreeDify says it is committed to providing “leading edge software tools to help mining companies identify key cost levers they can pull

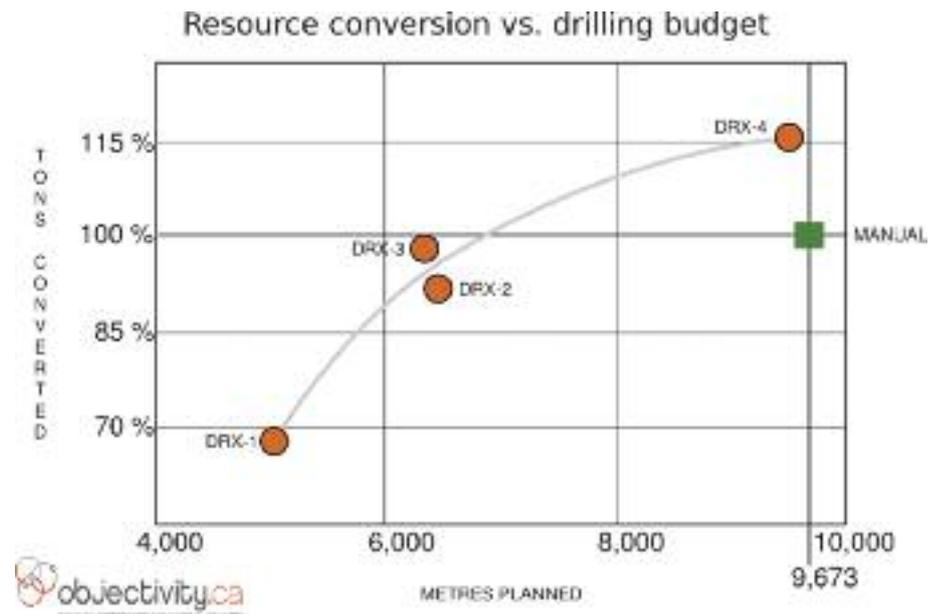
to improve productivity and optimise return on investment.” ThreeDify’s strategic mine planning and design tools include FlowPit, an ultra-fast 4D pit optimiser and Life of Mine scheduler, which takes full advantage of today’s multi-core CPUs to determine the optimum final pit within two to three hours for huge block models (with 50 to 100 million non-air blocks) without super-blocking. QuickPit is a rapid open pit mine design software that allows mine planners to build a complete pit or dump design with ramps in a matter of minutes; and Stopemizer is a stope optimisation software for strategic underground mine planning. The stope design created by Stopemizer is not only optimum for a given stope layout, but also practical for engineering use as it produces optimal mineable shapes in respect of important geotechnical and geometric constraints.

Liu comments: “To help mine planners to create effective mine plans and make more informed decisions on the most advantageous investment opportunities, we consistently evolve our products based on clients’ feedback. The newly released FlowPit V6.2 generates evenly-spaced nested pits, which makes it straightforward to create smooth life of mine schedules. A new pit reconciliation module has been added to QuickPit V1.2, which allows for comparison of any pit design with the Lerchs-Grossmann pit. QuickPit also has a new feature that enables the pit slope of each increment to vary by sectors and by levels. In addition, the newly released Stopemizer v2.6 includes two powerful modules: an automatic mineable shape generator that incorporates sub-blocks and a stope reconciliation tool that compares and reconciles stope designs with as-built stopes.”

Commenting on challenges associated with developing new products for the mining industry, ThreeDify highlights the fact that there are now many software vendors serving a relatively small pool of highly technical users in mining along with the well known industry conservatism, reflected in a reluctance to invest in new technologies, especially in the current economic down turn.

“There’s no doubt the mining industry is experiencing tremendous pressure on costs, but the cost constraints should lead to innovation. However, to fully realise the value of any software package, the current models may require system and operational redesign. This will present both challenges and risks. Also many mining companies are striving just to survive until the next mining boom. An additional challenge is a high turnover of staff and lack of staff, especially those experienced in focusing on driving efficiency.”

Moving into 2015, ThreeDify says its R&D focus will be on streamlining workflow for its



underground mine planning, design and scheduling packages, as well as continually enhancing current tools to help its clients work more effectively. Liu told *IM*: “In the first quarter of 2015, ThreeDify is planning to release iScheduler, a calendar-based interactive 3D activity and resource scheduler for surface and underground mines. It features a fully undoable activity and dependency editor, integrated activity and resource Gantt Charts, PERT charts and Network Diagrams, a fast Resource Leveling algorithm, and ability to animate a schedule. Also included is a powerful sub-module that auto-generates and optimises practical push-backs for open pit mines. iScheduler is designed to leap-frog its competitors with a single unified “unblocking and reactive” interface that seamlessly integrates all tasks of the complex mine scheduling process in a highly interactive 3D workspace.”

Objective resource drilling

The foundation of any mine plan is the underlying resource model that is used to define the shape and the value of the ground targeted by the mining operations. The process of generating the resource is still dependent on drilling and geostatistical interpretation. Sudbury, Canada-based Objectivity.ca uses data analytics, simulations and learning algorithms to increase the speed with which resources can be drilled.

The company evolved from providing the design and implementation of large scale visualisation systems, and research associated to understanding how humans work with complex data. The visualisation systems were used for the analysis of complex geological and engineering data sets. These datasets included both 3D and 4D (time varying data such as stress fields and hydrogeology datasets).

Objectivity’s core product is DRX, short for

Drilling, Reporting and Targeting (X marks the spot), which is a drill hole program planner and optimizer. Objectivity President Andrew Dasys tells *IM*: “DRX is quite different from the current process of requiring a geologist to individually lay out drill holes one at a time. Instead, the algorithm provides the detailed hole layout having been given the expected budget, the target volume, possible setup locations and a number of constraints that limit how holes can be collared and drilled. We can apply analytics and optimization algorithms to drill planning because resource drilling is quite different from early exploration drilling. By the time you are quantifying the resource there has already been a significant amount of geoscience and discovery work done. Modern drill layouts are evolving to drill off-section to increase resource sampling and to better define mineralization shells. This shift in best-practice is developing thanks to the availability and acceptance of implicit modellers, such as Leapfrog, allowing shell interpretations to be completed without sectional drilling. The user determines how aggressive the out of section drilling can be whilst DRX determines the detailed placement of each drill hole to maximize resource generation and classification.”

The company states that the real value that DRX generates is the production of a number of technically correct drill plans based on varying budgets. The attached graph allows management to make objective decisions about the trade-offs between expected return (expected resource conversion) vs. investment (drilling budget). “This graph, and the underlying fact that each of the DRX solutions meets all technical constraints, completely changes how resource development budgets can be allocated - it brings a level of objectivity, repeatability and auditability to every decision. The ramifications are even greater when you consider that the current market slump will

have an effect on the number of seasoned professionals that will be willing to come back to the market when resource prices pick up for another upward swing in our market cycle. Having the means to make objective decisions, based on computational results, will help offset the lack of experienced professionals available in the next market upswing.”

Dasys states that drilling meter reduction is 10 to 40% with equivalent volume of ground being converted or alternatively 10 to 50% improvement in volume of ground being converted to a given classification for a given drilling budget. An open pit study trade off analysis is shown in the accompanying figure.

In terms of the future Dasys states: “Currently in beta our plans are to release a Software As A Service (SAAS) browser based interface to DRX to our clients in mid-2015. The recent advances in web based rendering make it possible to not only perform the expected pan/zoom/rotate of the holes, shells and block models, much like Datamine's Summit release, but also to improve collaboration between exploration, engineering and production departments. This collaboration will be helped by developing a number of visual metrics to help assess drill plans with strategic objectives.”

In terms of the states of the market, although funding has basically stopped most of the greenfield drilling and the remaining juniors are hanging on with few funds to do anything other than survive, there are a number of late stage projects that are continuing to drill their resource to complete pre-feasibility and feasibility studies. In many cases, continued drilling is the only means that companies have of generating value and speed to market is critical. Objectivity works with those late stage players that are time-pressed to bring a resource to the financial markets or with companies that have operating mines that need to keep the resource, reserve and production cycle going. **IM**