Better blasts

Including a look at some of the interesting papers from the AusIMM Fragblast conference, John Chadwick examines some of the recent innovations aimed at better fragmentation

The Fragblast (see end) paper *A Simple Technique for Using High Energy in Blasting* was presented by Stuart Hawke, Project Manager – Blasting Solutions, **Orica** Australia, and Luis Dominguez, Supervisor – Blasting Services, Orica Mexico. They note that "numerous studies and independent modelling of the Mine to Mill process have demonstrated the potential for significant downstream productivity improvements from improved blast fragmentation. However, safety and environmental constraints associated with the blasting process usually limit the extent to which blast energy or powder factor can be increased.

"An effective blasting solution has been identified that enables the safe utilisation of powder factors several times higher than those used conventionally to provide significant improvements in fragmentation. The solution uses a static 'blanket' of broken rock overlying the blast to contain this increased blast energy and control rock movement. To produce this broken layer of rock, the subdrill in each blast is significantly increased to preblast (or precondition) the entire stemming region of subsequent blasts on the next mining bench."

This idea has been evaluated at a large open-pit polymetallic mine in Mexico. "Results from the application of this technique have shown significant improvement in run-of-mine fragmentation, with subsequent downstream productivity improvement indicated."

The authors make recommendations to steer ongoing research, development and application of this technique:

- The ongoing application of the preconditioning technique in varied production environments is required to further develop the 'best practice' application methodology for the technique
- Further evaluation of the technique is required to identify the long-term impact on drill consumable usage (i.e. drill string components) and drill maintenance requirements (i.e. cost and availability). To date, no adverse impacts have been observed
- The presence of groundwater was found to increase the likelihood of blasthole instability in preconditioned areas. The use of drilling fluids (e.g. drilling mud, foams and polymers) to stabilise the blasthole should be investigated to mitigate this risk.

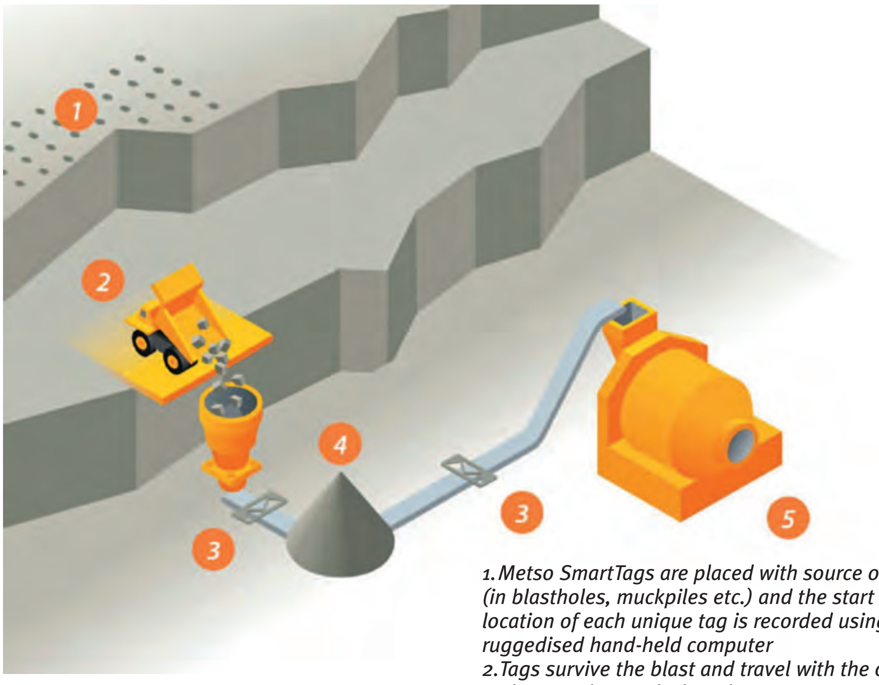
Orica's Ultra High Intensity Blasting technique (UHIB) has received much acclaim recently. Orica says "UHIB can be considered an environmentally friendly blasting technique that simultaneously enables a reduction in the total cost of mining while lowering the amount of energy used in comminution to consequently cut CO_2 emissions. It does this by safely utilising blast energies several times higher than normal in a completely novel design. The method is also used to reduce dust and vibration from blasting."

While working to UHIB designs, Orica technicians fire two separate layers of rock in a single blast event. The upper layer is blasted first using conventional powder factors. The broken rock is allowed to settle and effectively becomes a blanket that contains the lower layer of rock when it is fired at ultra-high powder factors. This has proven to effectively manage significant challenges associated with mining hard rock.

Speaking of the technique, Orica's Chief Mining Engineer Stephen Boyce said "In effect, the upper layer becomes a buffer to contain the energy in the lower layer, allowing for a more intense fragmentation in the ore. This improved fragmentation enables our mining customers to realise benefits during digging, hauling and most importantly milling".

"We believe the adoption of the UHIB technique will increase as electricity costs rise and the cost of building new mineral processing plants increases. It is most applicable in regions where electricity supply is expensive; and for mines with hard rock or constrained milling capacity."

Work at another open pit was reported at Fragblast by David la Rosa (and colleagues), Mining Technology, **Metso Process Technology** and Innovation, Queensland Centre for Advanced Technology, in *Blast Fragmentation Impacts on Downstream Processing at Goldfields Cerro Corona*. At this copper-gold mine in Peru, the deposit has "heterogeneous



1. Metso SmartTags are placed with source ore (in blastholes, muckpiles etc.) and the start location of each unique tag is recorded using a ruggedised hand-held computer
2. Tags survive the blast and travel with the ore
3. They are detected when they pass antennas at critical points before milling
4. With no internal power source they can remain in stockpiles for extended periods
5. Physical ore properties in the mine can then be linked with time-based performance data from the plant

rock characteristics in terms of its mineralogical, geological and geotechnical properties.

"Blast design variations in these conditions directly impact the ROM fragmentation, which in turn influences downstream process efficiencies. In particular, when harder ore is processed, throughput and circuit performance may be limited.

"To evaluate the potential to increase throughput and improve overall plant performance by optimising blasting practices and comminution circuit operation, Gold Fields La Cima engaged Metso Process Technology and Innovation (PTI) to conduct a full process integration and optimisation project at Cerro Corona. Blasting, crushing and grinding processes were reviewed to identify the potential to achieve substantial improvements in productivity when treating the most competent ore types.

"Site-specific models of the blasting, crushing and milling processes were developed using SmartTag™ ore tracking technology for calibration and validation. Ore tracking permitted locations in the blast volume to be queried against the geotechnical block model to determine the hardness and structural parameters of the feed to the comminution circuit. They also ensured surveys were conducted when ore from the audit blast was flowing through the crushing and grinding circuits.

"The predictive models developed enabled PTI to demonstrate how changes in blast design influenced both ROM fragmentation and the performance of downstream comminution processes.

"Outcomes of the project suggested changes to blast designs and comminution practices, and these were partially implemented for a validation trial. The trial demonstrated a 14.8% increase in mill throughput for the specific ore selected for the study, and an average increase of 5.7% for all ore types."

Surface mine blasting application showing the six blasting objectives (Little, 2015)

Paul Klaric, Senior Technical Consultant, **Dyno Nobel** Asia Pacific, presented *Improving Drive Stability through Efficient Development Blasting Design and Practices* at Fragblast. As he commented, "drive stability is critical in block/panel cave mining. The production levels of these mines are required to remain operational for the entire life-of-mine which can be in excess of 30 years. It is therefore necessary to produce high-quality drives to ensure sustainable mine productivity."

In order to improve the quality of drives and pillars at a massive low-grade gold/copper operation, the mine instigated a project to optimise development blasting. "The initial aim was to reduce the level of overbreak in development mining, which was averaging approximately 18%. The benefits of controlling overbreak not only included an increase in the integrity of the drives but also a decrease in load and haul and ground support costs. Through focusing on the optimal blasting of the perimeter holes, overbreak was reduced to 4.5%. The project's focus then moved to drill and charge designs for development faces. In optimising these designs, it was anticipated that improvements in the development mining cycle would be achievable.

"The perimeter control aspect of the project was conducted in three stages:

1. Benchmarking of NONEL® LP timing with perimeter holes string loaded
2. Continuation of string loading, but introducing the precision timing of electronic detonators
3. Baseline measurement of full face electronic initiation.

"An integral aspect of the project was the use of string loading technology in perimeter holes. String loading provides a decoupled emulsion charge that is predominantly loaded in perimeter holes to reduce the localised explosive energy, hence reducing damage to the surrounding rock mass and the cause of overbreak. Ensuring string loading functionality on the DynoMiner® emulsion delivery unit was important for the outcome of the project."

In *Classification and Development in Grade Control Blasting for Surface Mines* (Fragblast), Trevor Little, Director and Principal Consultant, **Blasting Geomechanics**, explains that "the full range of grade control activities includes: reserve estimating, drilling/sampling, assaying, modelling, ore block design, blasting, ore mark out, excavating, stockpiling, processing and reconciling. Over the last 25 years, the grade control process has undergone significant improvements and this is in part due to the developments in grade control blasting."

He cites "two major technology initiatives. The first was the development of a method for the measurement and analysis of total displacement during the blasting process. Currently, the Blast

Movement Monitor (BMM®) is a practical tool that has been used around the world to improve the industry's understanding of 3D blast movement dynamics.

"The second technological enabler was the development of electronic detonator systems. The unique aspects of electronic detonating systems are their higher accuracy and that all detonators are activated at time zero (initiation). From a grade control blasting perspective these features and other improvements allow experimentation and, ultimately, more complex, multi-objective blasts to be designed and implemented."

In his conclusion, he makes five important observations:

1. There is value in classifying the range of grade control blasting strategies [see the paper for his blasting objective framework]. The concept of multiple primary blasting objectives is didactic and does not need to be confined to grade control application. It can be used for any blasting application on the surface or underground
2. There are an increasing number of strategies and parameters (limited only by our imagination) at our disposal to drive the results of grade control blasting. The need for them will be dictated by the primary blasting objectives and associated targets. Some strategies and parameters mentioned in the paper include:

- Selecting the appropriate blasting strategy (e.g. selective or bulk blasting)
- Orientation of the free face relative to the blasthole axes (e.g. vertical or horizontal)
- Selecting the blast shape and sequence (e.g. blast master design, location of ore in blast pattern)
- Adjusting burdens, spacing and associated powder factors (e.g. asymmetric, staggered, square, rectangular, even based on MWD, etc.)
- Adjusting the charge distribution within a hole (e.g. stemming height, decks or air decks, decoupling, etc.)
- Explosive confinement (e.g. stemming plugs, stemming length and type)
- Use of variable-energy explosives (e.g. diluents, variable density)
- Exploitation of the dynamics of the blasting process (e.g. initiation (timing, direction, sequence) and type)
- The point(s) of initiation.

3. As enabling technologies develop, so too do the ambitions of the blasting community and the expectations of downstream customers. Over the last 25 years, grade control practices have undergone significant improvements. These improvements have been enabled by technology innovations in the areas of: computing power, software modelling programs, EDDs, MWD systems, BMM systems, post-blast modelling and simulator developments
4. Grade control blasting and Mine to Mill concepts are merging, and this is catered for by using a multiple blasting objectives approach. This means that the blasting teams must be happy to work closely with both the geology and mineral processing teams. It also strengthens the geometallurgy links. In addition, it is interesting to note that the Mine to Mill concept is being extended into the areas of sustainability (energy efficiency and greenhouse gases)
5. Having a technical primary blasting objectives framework, combined with the classification system presented here, should assist practitioners and stakeholders with lateral thinking in regards to future technological innovations and grade control blasting strategies.

The Blast Movement Monitor (BMM) is a directional transmitter that is programmed and installed in dedicated blastholes and has the ability to transmit through 25 m of rock. "BMMs are simply targets that move with the rock during the blast and have been designed to withstand the extreme conditions within a blast, with far fewer losses than any other method," supplier ***Blast Movement Technologies*** *says. BMMs are supplied in a low-power state, giving them a long shelf-life. The Activator is a remote control device that provides the signal to turn a BMM on and program certain functions prior to installation into the blast. The Detector is specifically designed to receive and interpret the signal produced by the BMMs. This allows the user to quickly locate the peak signal that occurs directly above each BMM. This point is surveyed and the signal is recorded by the Detector for later processing by the software. The BMM Assistant software is built on many years of blast movement research*

"A final word of warning: the simplest method that achieves the primary blasting objectives is probably the best. The risk of having too many primary blasting objectives should be considered carefully."

Fragmentation Optimisation – Adopting Mine to Mill for Reducing Costs and Increasing Productivity by A. C. Silva et al is an interesting case study from Fragblast of the Anglo American phosphate mine located in the Brazilian state of Goiás.

Adjusting Initiation Direction to Domains of Rock Mass Discontinuities in Aitik Open Pit Mine is another interesting case study, by A. Beyglou et al. It presents a method for assessment of rock mass discontinuities and integrating it in production blasts.

"3D photogrammetric techniques were utilised to map discontinuities and distinguish domains of similar geologic structures in the pit. As a pilot study for a future campaign, four different initiation directions were tested through six pilot blasts in one of the domains. The results were compared in terms of swell and loading efficiency of rope shovels to identify the correlation between blast performance and initiation direction compared to major discontinuity families.

"It was established that in the trial domain, blasts initiated towards north or northwest yielded larger swell and better performance of loading. Comparing these blasts with discontinuity families show that there is a correlation between blast performance and initiation direction according to the dip and strike of these discontinuities. Such knowledge can be used for future blasts in the same domain to increase long-term operational efficiency through slight modifications in drill pattern and initiation design."

Another case study from Brazil, at a large iron ore mine was presented by R. Schaarsdmit et al - *Geological Modelling and Bench Face Survey to Improve Blasting Fragmentation*. "The understanding of the geological model integrated with a software system for bench face surveying and planning of blast layouts based on 3D images can help to achieve the fragmentation goals of the mine operation." The case study integrated these tools.

"The iron ore in the study area consists of hard and friable itabirites. More than three different ore types may occur on the same bench. Under these conditions, data integration becomes necessary to improve the results of blasting. A blasting plan was based on the generated geological model.

"The methodology helps understanding the factors that can interfere in the fragmentation process, allowing defining actions that can improve the blast design in those places that fragmentation wasn't achieved. This condition is important for a continuous improvement of the drilling and blasting operation. In comparison with the previous blasting carried out at Itabira mine, which did not take into account the geological model, substantial improvements in fragmentation were observed, eliminating the need for secondary blasting."

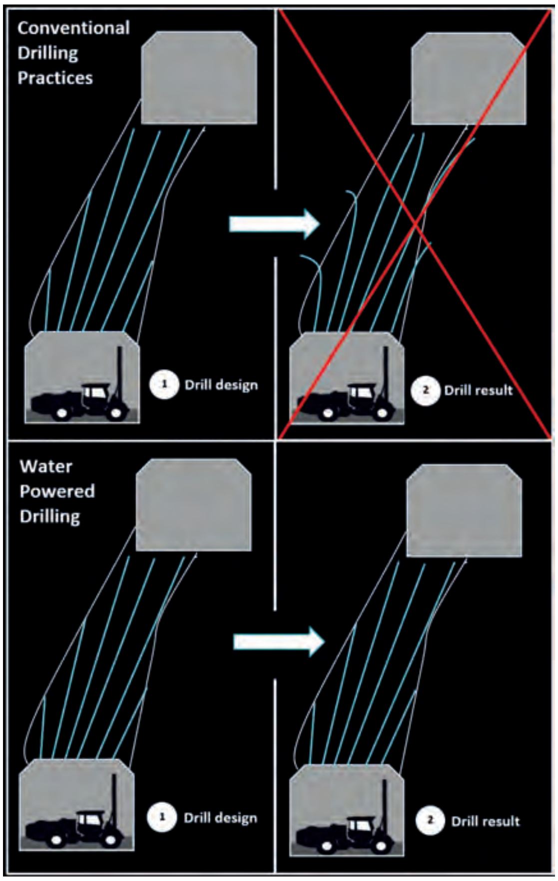
A. C. Torrance, Consultant, **Kilmorie Consulting**, and Andrew Scott, Consulting Mining Engineer, **Scott Mine Consulting Services**, provide good advice about velocity of detonation (VOD), in *What is Relative about Energy?*

"Standard technical data sheets provided by explosive manufacturers to describe the properties and performance of their products do not enable a meaningful comparison of the potential merits of particular explosives to blast any given rock mass. In particular, the values quoted for explosive energy may be based on quite different definitions and the VOD values quoted cover a wide range of blasting conditions.

"Despite impressive developments in the theoretical modelling of explosive-rock interaction in recent years the objective of being able to reliably estimate the VOD and effective work done by a particular explosive when blasting a particular rock mass remains beyond our current capability.

"The strength or energy content of an explosive is a fundamental input into most blast design, fragmentation or performance models, but the energy values quoted by different manufacturers may be derived from different assumptions. This means that the models need to be tuned or calibrated to suit the data being used if misleading outcomes are to be avoided.

"Analysis of successful blasting practices in a range of rock types indicates that quoted values of explosive energy do not correlate well with blasting requirements or performance. The authors contend that knowledge of the in-hole density and actual VOD of a proposed explosive in a given rock type provides the best basis for selecting an appropriate explosive for any given blasting task. At this stage this information needs to be acquired through field measurement."



Control drilling deviation

The position of the blastholes is a key factor in achieving the desired fragmentation. Blastholes and charge columns are designed at an accuracy of decimeters in order to achieve the desired blast and fragmentation.

"However," explains **Wassara's** Fredrik Gransell, "with conventional drilling practices it is very challenging to actually turn that carefully [prepared] drill and blast design into reality. Deviation of several percentages for holes over 20 m in length has almost become acceptable in the industry – hence redundancy for deviation is also taken into consideration while the drill and blast design is being designed. Fortunately there are drilling methods that can deliver the same accuracy as the drill and blast designs themselves."

The Wassara DTH hammer was developed by the Swedish iron ore producer LKAB more than 20 years ago. It is a water powered DTH-hammer which enables exceptionally high drill hole accuracy. "Since water is a non-compressible media, unlike air, it will yield in much lower velocities of the drill cuttings and the overall volume that has to leave the hole.

"This will cause much lower wear on the hammer. Due to this guide ribs can be used on the outside of the hammer case. These guide ribs will enable a very tight clearance between the hammer and the wall, as close as 1-2 mm." Gransell also notes that in addition to high drilling accuracy, the characteristics of the Wassara hammer will also improve fragmentation from a blast perspective. "When the water leaves the hammer the host rock will not get pressurised since there is no change in volume of the water. If the host rock get pressurised by, for example, compressed air there is a great risk that existing faults gets extended. While charging the blastholes there is a risk that explosives such as emulsion enters the faults. During the detonation process there will be a higher risk of having an interrupted blast sequence." That will have a severe negative impact on the fragmentation produced by the blast.

Stemming

One of **AEL's** most recent innovations is InstaStem, a technologically-advanced range of non-detonating, self-stemming rock breaking cartridges. These produce no shockwaves which means they are safe and ideal for use in vibration-sensitive areas. Furthermore, the non-detonating nature of this range of products ensures safer operations because they provide no over-break detonation damage in the drift roof or floor.

With these products there is no risk of auto-ignition and they have a shelf life of 18 months.

AEL InstaStem cartridges

Under South African legislation, and similar opportunities exist in other countries, InstaStem cartridges do not require transportation by an explosive truck for quantities less than 250 kg because they are classified as UN:0323 cartridges, power device, Class 1.4S.

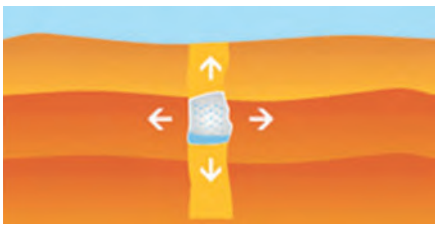
"InstaStem operations are also suitable in areas of low-ventilation as the blasts emit only harmless gasses which are quickly diluted even in low-ventilation areas and there is a minimal gas re-entry time of about 15 minutes."

As there is no stemming or required change of existing drilling patterns, these products provide "drop-and-go" ease-of-use and do not impact on support infrastructure. Therefore, there is no interruption or downtime necessary because there is no need to remove equipment or staff.

InstaStem is also highly accurate, delivering no overbreak in the visible barrels left behind after the blast, coupled with a reduction of commodity loss in fines and dust.

PR Polymers Kool Kap® gas bags are self-inflating bags that, when activated and lowered or dropped down a blasthole, will seal off the hole giving an effective deck for loading explosives and/or stemming. The manufacturer says "they save time and money. When using air decking for pre-splits, you can significantly reduce your use of explosives.

"You'll also reduce noise and ground vibration, backbreak and backshatter by reducing excessive powder factors. You can also use gas bags to block off wet and dewatered holes, eliminating the need for using expensive and less effective emulsions. They are also great for standing off coal beds to stop coal shock and for decking holes that have varying layers of rock hardness,



Blastholes are not perfectly cylindrical, differing internally in shape and form, which can lead to slippage. Kool Kap gas bags use a patented anti-slippage mechanism that means they will deform and brace within non-uniform holes

so you don't waste energy on already soft ground. "Kool Kap gas bags have the lowest failure rate of any gas bags on the market." A failure costs time and money and increases the risk of injury. The patented activator cap cools during operation, reducing misfire and making them ideal for both hot and cool conditions. They have been tested in the Colorado winter and up to 65° C in the Australian summer, making them ideal for all conditions.

MTi Group says its Duraline™ "significantly reduces blasting costs by eliminating the need to use expensive water-proof explosives in favour of cost effective ANFO." One size fits all (230 mm–270 mm), Duraline features seamlessly expanding side gussets. These eliminate liner twisting and breaching assisting high-speed deployment and reliable loading.

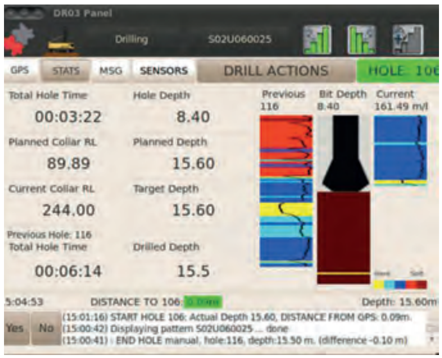
Duraline is constructed out of lightweight, rip-stop and high tensile, impact and abrasion resistant material. It is convenient to handle rolls marked at 1 m increments for practical on-bench sizing, cutting and sealing. The Duraline SMART all-weather welding machine allows liners to be cut and sealed to length easily on-site.

Blast design and modelling

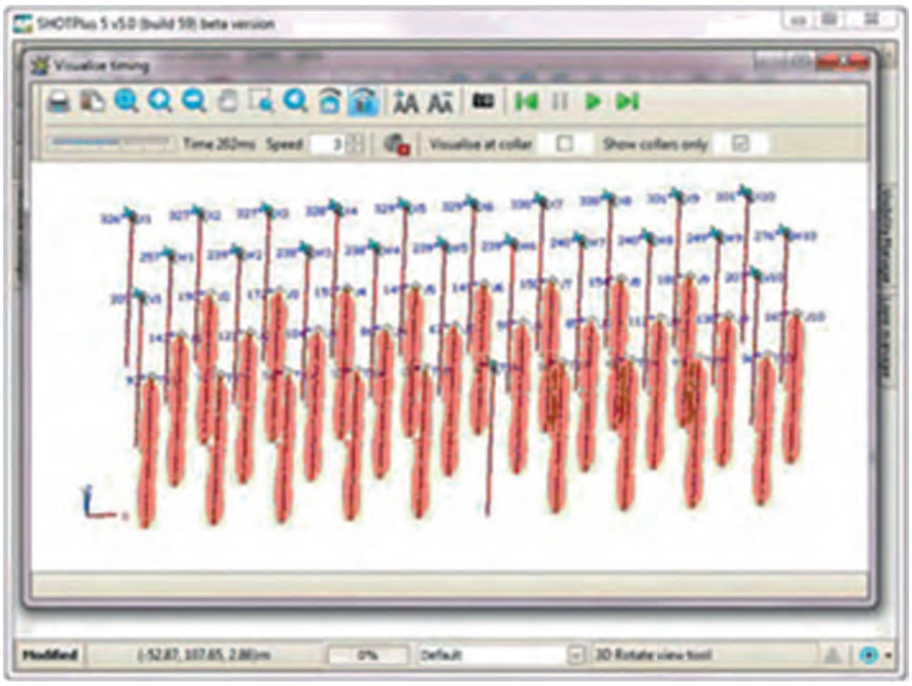
Orica's new SHOTPlus™5 software (available in many languages) has extensive blast initiation design capabilities and supports Orica's pyrotechnic and electronic blasting systems. It offers blast design in a full 3D environment and automatically assigns electronic blasting sequences based upon user defined burden relief and firing directions. Other features include:

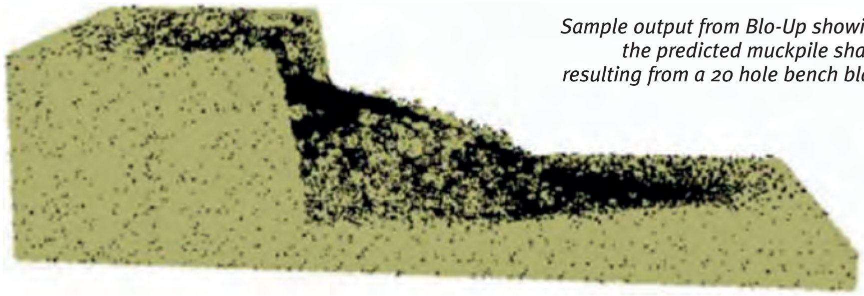
- Auto-adjust electronic delay timings to meet desired firing windows for vibration control
- Simulating timing sequences in real time, allowing any problem areas to be highlighted before firing
- Importing blasthole layouts generated from other mine design packages
- Export charging design data to create loading sheets in Microsoft Excel or other packages
- Creation of import and export templates to streamline routine data transfers between software packages to maximise design process efficiency
- Creating loading rules defining specific blasthole charging parameters that can be quickly applied to selected holes or to the entire blast
- Full integration with Orica's i-kon™ and uni tronic™ electronic blasting systems to maximise on-bench efficiency
- Print initiation plans and reports to allow effective blast hook-up on bench
- Generate blast-material quantity reports for reconciling blasted inventory
- Links to the Advanced Vibration Management (AVM™) online tool.

As **Hexagon Mining** notes in its latest edition of its *Insight*, "depending on the conditions of the hole (dry or wet) or the hardness of the ground, an



Leica J²drill displays hardness bands displayed to the operator





Sample output from Blo-Up showing the predicted muckpile shape resulting from a 20 hole bench blast

appropriate explosive product will be selected to place into the holes. A different product may be required for different holes, or even down the same hole if hard bands exist in the strata. Technology contained in Leica J^2drill can help here. Using Measurement While Drilling (MWD) techniques, the hardness down the hole can be determined and the data used to vary the explosive product in the hole, or pack areas in the hole that do not need to be blasted. The down-the-hole profiling data can also be used to detect coal seams to adjust the mine model, or to perform through-seam blasting. The system can also identify hard bands to change the loading design.

"Once the blast design and relevant simulation activities are completed, load sheets for the blast holes can be created. These load sheets show the blast crew what material and how much material is to be added to the hole."

Itasca's Blo-Up, uses a unique combination of continuous and discontinuous numerical methods to represent the key processes occurring during blasting.

Briefly, Blo-Up is a three-component coupled model of rock blasting; a coupled modelling approach was chosen because no single numerical technique was found to adequately describe all the physical phenomena occurring during blasting. The three components are (i) a continuum geomechanics model for the early-time detonation and near-field crushing; (ii) a brittle discrete element model for stress wave propagation, fracturing and burden movement; and (iii) a gas product model for burden acceleration by gas expansion, fracture flow and atmospheric venting.

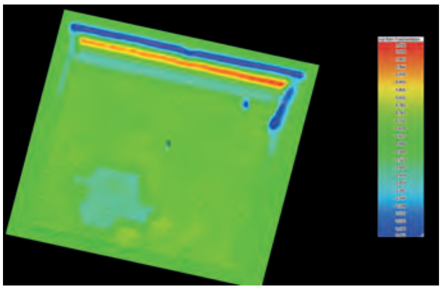
Itasca is currently involved in the HSBM (the Hybrid Stress Blast Model project) Validation Project, which seeks to prove the quality of Blo-Up model predictions in real world blasting. Field-scale bench and underground blasting tests currently are being used to validate and improve the model. The goal of the software is to provide blasting engineers a high-quality predictive model of blast outcomes. Application areas include mine to mill optimisation, grade movement predictions and pit wall damage studies.

BlastLogic blast accuracy and management system from **Maptek** manages the data being collected at every stage of the drill & blast process so operators can focus on improving performance. The company says BlastLogic provides a reliable platform for achieving optimal fragmentation for every blast. Unique blast-by-blast analytics allow comparison of blasts across the mine to analyse performance for reducing downstream processing costs.

"Better fragmentation has been linked to shovel improvement of around 9%. That's worth its weight in whatever you are mining," said Mark Roberts, Manager of Blast Accuracy Solutions at Maptek.

"Instant data connection and visualisation allows engineers to easily correlate design, execution and results. Optimal and consistent fragmentation improves digability through easier handling and processing of excavated material. BlastLogic looks at the big picture of the entire comminution process, and provides the means to measure and track drill and blast performance relative to crusher and milling throughput."

Fragmentation modelling in BlastLogic outputs a distribution curve and coloured grid for simple



Blast analysis by colour variation using Maptek BlastLogic

identification of variation across blast. Designs are quickly validated and refined. Performance is tracked. Comparison to as-charged data provides the supporting data engineers need to make improvements in blast design and processes.

Linking blast designs directly with the geological model and field measurement enhances precision in blasting and impacts on downstream processes.

BlastLogic can quickly relate fragmentation results back to blast and geology parameters. The BlastLogic frag modelling tool helps engineers advance future designs and better inform operations of expected post-blast ground conditions.

"BlastLogic effectively provides a live window to what's happening in the field. Immediate access to production data, analysing results in real time and making changes on the fly mean all teams are working in sync. Getting the fundamentals of any process right each and every time is a key which unlocks endless opportunities to improve profitability," he concluded.

Blast monitoring

MREL says its SpeedTrap™ Velocity Recorder "is the world's most modern discontinuous (point-to-point) velocity recorder. It is used to instantly display and save the velocity of all types of industrial explosives. It is the ideal recorder for instant infield determination and display of the velocity of energetic products. For example, to take a sample of bulk explosive at a mine and test the sample's average velocity of detonation (VOD) prior to allowing the explosives truck to load blastholes.

Vision™ from **Instantel** is a new cloud-based data hosting application for vibration monitoring data that makes it simpler to satisfy even the most demanding reporting requirements. Vision allows users to:

- Store event monitoring data securely in the cloud
- Share information with stakeholders
- Access data at any time, from anywhere
- Immediately see vibration and overpressure trends
- Set alarm and warning levels for each project
- Locate monitoring units on a map or image
- Add comments to and print event reports
- Control what level of information each user can see
- Upload photos for a record of the latest progress.

Motion Metrics says PortaMetrics "is the first portable, Windows-based, stereo vision device designed for outdoor environments

Blast watching and analysis

Motion Metrics' latest technology, PortaMetrics™, with its portable capabilities, provides detailed rock fragmentation analysis of a desired scene in seconds. With much worldwide interest in underground applications, last November the PortaMetrics team headed to an underground mine in British Columbia to put the system to the test.

Up until then PortaMetrics had not been trialled underground due to the lack of light. The device doesn't incorporate its own lighting system and given poor lighting conditions underground, shadows have the potential to reduce accuracy. In the underground trial, portable LED flood lights were used to light the underground drives. Spaced several metres apart with the PortaMetrics device placed between the two, the tablet was able to capture a clear image, report accurate fragmentation results and remain unaffected by shadows.

The LED lights proved successful in combination with the device and the results were very promising, the company reports. "Going forward, our PortaMetrics team is working diligently to address specific underground concerns including ensuring the device is water tight, ensuring the device is intrinsically safe and adheres to underground explosive safety guidelines to ensure the device will not cause ignition and incorporating greater battery longevity."

On surface, PortaMetrics is a point and shoot 3D machine vision tablet that provides fragmentation analysis without the need for any reference scaling object. A 3D imaging sensor is combined with a powerful processing unit to provide accurate fragmentation information in a matter of seconds.

Users can easily access critical information such as rock size distribution; individual rock size and distance, real-time range measurement and instantaneous slope measurement. In the case of the latter, it uses a large number of 3D points to estimate the slope for a desired scene in real-time. No assumptions are made about the shape

Using Instantel's proprietary Auto Call Home technology, vibration data uploads to Vision immediately after it is collected, not hours-or even days-later. Once the data uploads, Vision provides secure, encrypted web-based access to the latest information from any desktop, laptop or tablet with access to the web

WipFrag 3 for iOS instantly provides accurate particle sizing results that can be outputted to Excel, PDF, or emailed to colleagues. This safe, easy to use method allows operations to benchmark blast results and optimise future blasts

of the scene or the angle between the camera's line of sight and the scene.

WipFrag, a leading product in fragmentation analysis for desktop computers is now available for tablets and smartphones in the Apple App Store. **WipWare** says "WipFrag 3 for iOS is the most economical portable blast fragmentation solution available. It's perfect for instantly analysing blast pile particle sizes in open pit and underground locations using an iPad. The new WipFrag app puts fragmentation at your fingertips."

To use it, "simply open an image of your blast pile taken with a tablet or another camera device. Then analyse the material using industry-leading edge nets and output a distribution curve based on 17 customisable size classes."

Along with precise fragmentation analysis, WipFrag 3 for iOS includes the unique BlastCast KCO fragmentation prediction module that lets you apply WipWare data to achieve better breakage.

The WipFrag app also serves as the control interface for WipWare Photoanalysis Systems monitoring moving vehicles or downstream conveyor belts providing continuous real-time particle size data to your portable device 24/7.

The WipFrag 3 for iOS demo is now available for download from the App Store. WipFrag 3 is also available for Windows computers and tablets on the WipWare website.

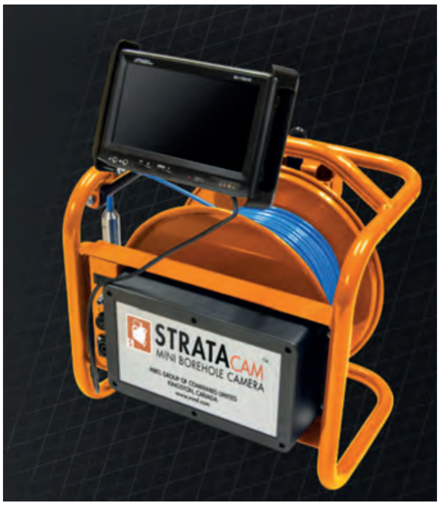
At Fragblast, David Adermann et al warn, in *High-speed Video – An Essential Blasting Tool*, that "the low frame rates of a standard video camera; essential data is frequently missed as it occurs when the shutter is closed between frames. The use of high-speed video for the research, development and monitoring of the performance of blasting procedures is a well proven but under-utilised practice.

"The recent development of low cost, easy to use high-speed digital cameras and user friendly software can deliver a capability into mine management as a day-to-day production tool that can greatly improve blasting performance and reduce costs.

"Digital high-speed video and image analysis software can accurately quantify each blast. Analysis of the images can facilitate the identification of causes of variance from design, geology changes, errors in blast practice and areas of poor performance. The use of high-speed video greatly enhances the audit and review processes so that future blast design can be quickly and appropriately modified to deliver improved blasting performance and reduced costs."

Three videos of open-pit blasts demonstrate the differences between standard video and high-speed video and the detail that can be obtained from them. "These videos can be used to identify blast performance variances. Capturing images at 1,000 frames per second allows the analysis on a millisecond timescale where detonator timings, fragmentation, venting, fume generation and flyrock can be accurately identified."

Adermann is Director Technology and Research, **Measurement and Analysis Camera Systems**. MREL is another specialist company in this field, offering a digital video camera with the light sensitivity, speed and resolution to accurately capture blasting events: the Ranger II™ Lt High Speed Camera. "It is a complete high speed video recording system with an easy-to-use operator interface."



The StrataCam™ Mini Borehole Camera is another aid to blast design introduced recently by MREL. It can clearly view and accurately record the physical location of geological strata, weak/strong boundaries, ore/waste boundaries, coal seams, top of coal, free-surface of water or ingress points, in-situ fractures, cavities, and irregularities

MREL says it "is a portable, affordable alternative to expensive high speed digital video cameras. Multiple cameras at distances of up to 100 m from the Ranger II™ Lt Controller can be easily networked and time-synchronised providing the ability to record events from multiple camera angles for accurate 3-D motion analyses using the optional ProAnalyst® 3-D Professional Edition software available from MREL."

AOS Technologies' high-speed video provides quick review so that blasts can be modified to deliver improved blasting performance and reduced costs. Battery operated, the cameras (compact and sealed) provide HD resolution (1920 x 1080) to 2000 fps with a large viewing screen, operating at an extended temperature range. Analysis software is available.

Fragblast

The Fragblast material referred to in this article came from the 11th International Symposium on Rock Fragmentation by Blasting, Sydney, Australia, August 2015, organised by the AusIMM (www.ausimm.com.au). *IM*