The mining industry is consistently told it needs to remove its ‘silo’ mentality and integrate downstream and upstream operations to produce the most productive, cost-efficient and safe results at mine sites.

Arguably, there is no better place in the mine to start such integrated thinking as on the bench in the open pit, or at the face underground. The placement of drill holes and explosives, and the initiation and detonation of these explosives, start off a rock reducing and refining process that has ramifications as far down the chain as the metal and mineral recovery stage.

Those with an interest in the explosives and blasting sector are aware of this, having developed solutions or partnered with companies in the supply chain to provide evidence of how its products benefit the overall mining process. Solutions such as FRAGTrack® and ORETrack® from Orica, and Tagnex® from Enaex were designed to collect valuable information at various points of the mining process to feed back to the drill and blast engineers.

Both companies have also partnered with OEMs such as Epiroc, MacLean Engineering, Magotteaux and others to further improve the benefits their existing explosives and blasting offering can have on the industry. These products and partnerships allow these engineers to become much more involved in the success of a mining operation. No longer segregated from the rest of the process, they can take pride when their optimised work results in higher recoveries or lower processing costs and take some blame should the expectant mill feed not be up to scratch.

These engineers are being armed with more solutions to help them increase accuracy, safety and consistency at their stage of the mining process.

Going wire-less

The removal of wires on explosives and blasting products is aiding optimisation of the process. Whether it be wireless detonation or initiation systems, those in the blasting game think the eradication of wires could act as a catalyst towards a more sustained move towards automating the drill and blast process.

Orica’s WebGen™ fully-wireless initiating system was launched back in early 2017 as a
“critical first stage in fully automating the drill and blast process”, Adam Mooney – Vice President of Electronic Blasting Systems, Wireless & Automation at Orica, told IM.

The system allows for groups of in-hole primers to be wirelessly initiated by a firing command that communicates through hundreds of metres of rock, air, and water. This eliminates the need for down-wires and surface connecting wires, enabling new mining methods and blasting techniques that are safe and reliable, Orica says.

Using low-frequency magnetic signals to communicate with each WebGen primer before a blast, WebGen is also the only commercial explosives product with a Safety Integrity Level (SIL) 3 rating, according to the company.

WebGen includes a state-of-the-art i-kon™ III plugin detonator, a Pentex™ W booster and a DRX™ – a digital receiver comprising a multi-directional antenna and a battery, which serves as the in-hole power source.

In the close-to-three-and-a-half years since introduction, WebGen has helped fire over 800 blasts in both surface and underground mines around the world, but, more than that, it has changed the relationship Orica has with mining companies.

“The elimination of wires through WebGen allows us to get involved much earlier in the mine planning and scheduling phases as we develop brand-new blasting techniques that enhance blasting efficiency and mine productivity,” Mooney said.

“By removing constraints forced upon customers with conventional products and methods, we are seeing significant value unlocked for customers in ways never thought possible.”

This has already led to the development and implementation of seven new blasting techniques, such as the Temporary Rib Pillar (TRP) method.

The results of using this new technique at Newmont’s Musselwhite mine, in Ontario, Canada, speak for themselves.

“The main ore of the panel at Musselwhite was blasted and extracted while the WebGen-enabled TRP held back the waste rock backfill,” Mooney explained. “This delivered a 34% reduction of waste dilution, increased truck fill factors, improved ore recovery, and improved mucking productivity by 20%.”

At the CMOC Northparkes underground mine, in New South Wales, Australia, meanwhile, sub level cave mining methods, enabled by WebGen, delivered a 75% reduction of drill and blast crew exposure time at the brow, a 96% cut in re-work, a 25% improvement in firing to schedule and a 37% increase in drawpoint availability.

Enaex Corporate Marketing Director, Gaetan Bachelet, thinks the company’s own wireless electronic detonator system has acted as a catalyst for automation.

He said the DaveyTronic® Edge wireless electronic detonator system “contributes to the path to tele-operated, then fully automated blasting operations”.

Developed in partnership with IRT Nanelec and the CEA-LETI, a leader in micro and nano technology research, DaveyTronic Edge is the first electronic detonator enabling the removal of surface harness wires while keeping two-way communication, according to the company.

This is a crucial safety feature, according to Davey Bickford, the initiation brand of Enaex.

“This means that, from programming up until firing time, you can communicate back and forth with the detonator,” Bachelet told IM. “This feature provides information on the detonator location and identifies potential misfires, but, more importantly, reports on the detonator status at each stage of the blasting process.”

With no clipping step or cable deployment in the implementation process, crews spend less time on the bench, while the troubleshooting process is eased as each detonator has its own power source, according to Bachelet.

This means the setup time is shorter than a conventional electronic initiation system, thereby improving productivity.

DaveyTronic Edge can make use of drones to add another layer of safety to the initiation process.

“We are the first company to use a drone before the blast as a step of the initiation process,” Bachelet said. “It is a key enabler for this technology with multiple benefits.”

Here, drones are used to increase safety, operational efficiency and productivity, according to the Bachelet.

Operators program in a flight path for the drones factoring in the GPS locations of each blast hole. During flight, the drones autonomously assign the right timing to each detonator, according to Bachelet.

“One could think that automated operations may not be as flexible as ones performed by humans in case of modifications during the drilling process,” he said. “However, based on its available positioning data, and the integration of engineering information, the drone could adapt, in real time, to the situation based on the designed blast pattern.”

Tailor-made timing

The use of an electronic initiation system, whether wired or wireless, can help improve fragmentation through “more accurate, interactive, tailor-made blast timing”, Bachelet says.

BME’s AXXIS™ fully programmable electronic delay detonator system has something to bring to the table here.

The wired system – which offers the two-way communication Enaex’s Bachelet says is important for safety (between blasting box and detonators) – can, in tandem with BME’s range of blasting tools, help deliver improved fragmentation to miners, according to BME’s Global Manager for Blasting Science, D Scott Scovira.

Mines need accurate fragmentation assessment tools to understand their site-specific conditions, and to optimise initiation designs and loading of blast explosives, according to Scovira.

This is where BME’s BLASTMAP™ tool comes in.

The blast design software can specify explosive hole loads and assign hole firing times, with the latest version including a new design tool to heat-map initiation burden relief times.

Burden relief times are important factors in rock fragmentation and displacement for blast designers, according to Scovira, helping them achieve their specific blast outcome.

“BLASTMAP, therefore, provides valuable support in doing so,” he said.
The AXXIS system has initiated some of the world’s most significant electronic detonator blasts in recent years, including a 6,690 electronic delay detonator blast at a large copper mine in Zambia, one of BME’s largest blasts in the Southern African Development Community region.

BLASTMAP can also estimate blast fragmentation outcomes, based on standard geo-mechanical rock properties specific to any given blast design, the company said.

“With data from in-field fragmentation distribution measurements, the fragmentation distribution prediction tool can be calibrated to site-specific conditions and results,” Scovira said.

For blast initiation, the AXXIS design hole firing times can be downloaded from BLASTMAP into BME’s AXXIS Logger for electronic detonator programming. When the blast has been conducted, data from the AXXIS Logger can be used to effectively compare as-designed versus as-fired initiation information.

All of this helps reconcile drill and blast processes with actual fragmentation data, as Scovira explains.

“This integration of data will allow for easier interrogation of results, which will assist in better guiding the drilling and blast process to produce consistent, quality blasts,” he said.

The AXXIS system has initiated some of the world’s most significant electronic detonator blasts in recent years, including a 6,690 electronic delay detonator blast at a large copper mine in Zambia, one of BME’s largest blasts in the Southern African Development Community region.

In Queensland, Australia, meanwhile, a large coal mine was the site for an earlier world record blast where the AXXIS digital detonation system fired 5,665 detonators in 2,683 blast holes. Before that, the mine used AXXIS to initiate 4,303 detonators in a single blast successfully – a record event responsible for 2.8 million cu.m of overburden being broken.

These records were recently trumped by another world record blast when 7,350 AXXIS electronic detonators were fired at an Australian coal mine.

Even with these achievements under its belt, BME is updating its AXXIS platform, with the AXXIS TITANIUM™ system recently undergoing final trials in South Africa. AXXIS TITANIUM, which features a three-in-one blasting box that can also be configured as a control box or repeater box, is expected to be launched later this year as a successor to the company’s GII version.

Fragmentation is only one value proposition for electronic initiation systems, according to Bachelet, explaining that they provided value for “wall stability, vibration and air blast control in sensitive areas, shovel productivity while increasing muck pile projection in case of cast blasts, through seam blasting, and many more” applications.

**Development advantages**

From an underground mine development perspective, there are many benefits to using an electronic initiation system, according to Dyno Nobel, one of which is a reduction in overbreak.

As Paul Klaric, Technical Manager at DynoConsult, Dyno Nobel’s specialist consulting division, says: “Companies traditionally see mine development as a means to an end. You just want to get it done to get to the ore.”

This short-term thinking – typically related to the need to improve a project’s...
In underground mines with challenging ground conditions where the initial drilling and blasting practices may have been lacklustre, this re-entry can create safety concerns.

“Companies are trying to mitigate any safety issues by working to remove people through automation and technologies such as wireless initiation – which is great – but we are of the opinion that part of the reason for these technologies is that the drives were damaged in the first place,” Gribble told IM. “If we can create competent drives with minimal damage from the off, then a lot of the issues that happen down the track – which we’re trying to mitigate against – should go away.”

This is where Dyno Nobel’s EZshot® electronic detonator comes in.

Offering users the benefits of accurate electronic timing without the complications that come with wired systems, it has been designed with underground perimeter blasting in mind. EZshot uses shock tube for signal transmission and has factory-programmed delay times ranging from 1,000 to 20,000 milliseconds, with long-period delay timing ideal for underground perimeter blasting, according to the company. This is helped by the electronic initiation unit inside the detonator, which eliminates scatter – an inherent property of traditional pyrotechnic systems – to ensure firing occurs at the pre-designated delay time.

These design elements all help confront the issue of overbreak in perimeter blasting, according to Klaric.

“A good measure of well controlled, smooth blasting is when you see ‘half barrels’ left behind, which are remnants of the holes that were blasted in the rock mass,” Klaric told IM. This is sometimes witnessed in competent, homogeneous rock masses, but rarely spotted in poor, challenging ground where there is faulting, jointing or discontinuities.

“In such ground, there is greater potential for overbreak and damage after perimeter blasting.”

Klaric explained: “Your profile might come out as designed, but there could be more damage beyond the perimeter. As you go to install your ground support, there is potentially an area of the drive where the ground support is going to prove ineffective.”

It is these challenging rock conditions where EZshot could provide the most value to miners, according to the company.

MAXAM is bringing its X-Energy application to the blasting sector to provide measurable total cost of ownership (TCO) benefits to the mining industry. From rock characterisation to an optimised blasting operation with a measurable downstream impact, X-Energy allows miners to maximise the use of energy through a mix of the “most advanced explosives” technology in the market (Smart RIOFLEX) and digital tools for optimised blast design and execution, integrated in the MAXAM Blast Center, MAXAM says.

“Recently started in the operations of selected customers, and thanks to its tailor-made, modular nature, X-Energy can provide a customised solution for each operation,” Vicente Huélamó, MAXAM Chief Technology Officer, explains.

MAXAM’s Smart RIOFLEX technology can instantaneously adjust explosive density to match a wide range of rock mass conditions, with one single matrix and sensitising unit, according to the company. Its “mechanical sensitisation” provides more control than chemical gassing, ensuring the exact product quantity at the right stemming length as well as operational time savings, MAXAM claims.

MAXAM Blast Center, meanwhile, is a cloud-based platform enabling the full digitalisation of blasting services.

The company explains: “It integrates a full range of MAXAM digital tools to design, plan and conduct the most efficient drilling and blasting operation, enabling selective energy application as per rock characteristics. MAXAM Blast Center is envisioned to include third-party data for downstream impact tracking and optimisation.”

Other modules of the X-Energy application include RIOBLAST – an advanced, user-friendly updated blast design and simulation suite now integrating data from measurement-while-drilling tools; FMS (Fleet Management System) to plan, control and optimise MSU (loading units) operations; FDL (field data logger) to verify, correct and record data on the bench; and RIOTRONIC X+ an electronic initiation system and detonator to produce a broad range of precisely timed blasts.

Huélamó added: “MAXAM’s X-Energy application services unlock potential benefits by allowing the selective application of the explosive energy according to the rock properties, resulting in clear sustainable savings for our customers.”

The X-Energy application permits a mine to customise the design and execution of each individual blast and integrate it into the requirements of downstream operations.

The benefits in enhanced safety, reduced impact to the environment, optimised rock fragmentation, efficient use of energy, higher production, and reduced costs are helping mines become more competitive and sustainable, the company says.

In trials at an underground mine where variable ground conditions and temperatures were observed, a 12% overall reduction (from 22% to 10%) in overbreak was observed with a switch from NONEL LP to EZshot detonators, according to Dyno Nobel.

Operators witnessed visible half barrels in poor ground where they had never seen them and full profile half barrels in good ground during these trials, the company reported.

The benefits did not end there.

There was a measurable reduction in the volume of material scaled off the walls after using EZShot – thanks to the improved blasting profile – and initial calculations indicated a positive $/m benefit to development mining costs, according to the company.

“If you are starting to improve and get consistency in your blasting and the drives you are delivering, you can start to consider adapting your rock support measures,” Klaric said.

For example, removing six or seven roof bolts per heading due to the improved blasting profile could costs drop by A$3,000-4,000 ($2,085-2,780) per heading, he explained.

These benefits are applicable in all forms of mine development, but it is long-life operations set to reap the most rewards from a switch to EZshot.

“This could be your block cave, or panel cave type of operations where some of those drives might be in place for 30-50 years,” Klaric said. “If you get development right in these applications, everything else will be right down the line.”

Pain points

Enax is developing an electronic initiation solution of its own for the underground development sector, but it is also addressing other customer pain points below ground, exemplified by the work it is carrying out at two major block cave operations in Chile.

Safety in block caving – particularly in undercut levels – while guaranteeing productivity during production blasts is a major area of focus for the company.

“To address this challenge, we developed Ubex®One, an explosive loading truck with a tele-operated arm able to load holes from a safe distance up to 10 m away,” Bachelet said. “Associated with our range of underground emulsions, you can increase the productivity by almost 20%, reaching close to 95% of the targeted volume of rock to be blasted.”
The company also offers other products to boost safety and productivity in vertical up holes, including its Duoblast emulsion, which offers a high viscosity for both vertical production holes and horizontal development holes, according to Enaex.

Its X-Booster Up booster, meanwhile, is designed with a ballistic shape and equipped with the company's safe-lock system, which avoids any detachment of the detonator from the booster during insertion into the bore hole.

The combination of these solutions, plus the engineering capabilities from its Enaex Mining Technical Solutions teams, have led to “spectacular” results in both production and development, according to Bachelet.

“For example, in a new block caving mine site, where the mine engineers were expecting 4,500 sq.m/mth, we succeeded in reaching 9,000 sq.m/mth and blasted 21 drawbells, which is truly massive in this kind of operation,” Bachelet said.

In Australia, meanwhile, RUC Cementation Mining Contractors helped Davey Bickford Enaex achieve a new blasting first with the DaveyTronic electronic detonator blasting system.

The contractor implemented “Safety First Firing” with DaveyTronic to allow it to fire blasts over the established communication system at one of its contracted operations, using the existing fibre-optic network at the mine to set-up a secure blasting system underground.

Orica, which says its WebGen wireless initiation technology can speed up development rates in all underground operations, has, in partnership with MacLean Engineering, been addressing another industry pain point.

It has combined WebGen with MacLean's Automated Explosive Loader (AEL) to form the first fully mechanised drawpoint hang-up blasting solution.

Mooney explains: “Hang-up blasting is a major challenge for block and sub level cave mines where up to 30% of all drawpoints can be unavailable due to oversize material.”

Many oversized rocks can be dealt with by preparation loaders or rock breakers, yet a number require explosives where workers need to access the area to perform the wiring up of each respective conventional explosive being used.

The mechanised drawpoint hang-up blasting solution safely brings down blocked drawpoints in these mines, with recent trials at Newcrest Mining's Cadia underground operation proving this.

Newcrest explained the method: “This AEL can drill a hole in a rock and push the wireless explosive inside the hole, without the operator leaving the cab of the drill rig. The operator can then remove the drill rig, leave the area and remotely detonate the explosive, using a wireless device manufactured by Orica.”

According to Orica, this WebGen-enabled process can see up to eight blast holes charged remotely, improving safety dramatically with no need to tie-in detonators and no boots on the ground.

Trials were successfully completed over a 30-day period in March of this year, with Cadia Acting General Manager, Aaron Brannigan, saying the testing met the key objective of trialling machinery that eliminates human interactions on foot while working near an active draw point.

The next step will be a more comprehensive trial in a real-life production environment to further assess the safety aspects and productivity of the secondary break system, Newcrest said.

Outside of Cadia, several new units are being manufactured by MacLean to introduce to sites across Australia and Chile by the end of the year, Mooney added.

AECI Mining's underground autonomation strategy is still being finalised, but it is addressing another industry pain point with the development of an emulsion vertical delivery system that, it says, frees up cage time, reduces emulsion transport and provides an on-demand source of emulsion.

This will see emulsion delivered to underground areas via bore holes with underground silos and distribution, according to Carl Joubert, Engineering Manager at AECI Mining, explaining the technology has already been proven
up to 980 m depth with an intermediate tap off, and the next step was to install systems to depths of around 1,500 m.

"With an on-tap source of emulsion underground, the risk of losing blasts decreases, while additional blasting can be carried out at short notice," Joubert said.

Accelerating automation
A partnership of another kind involving Orica is looking to end manual activities at development headings in underground mines.

This time it involves mining equipment major Epiroc, WebGen 200, the next generation of Orica’s wireless initiation system, and a plan to develop a semi-automated explosives delivery and charging system.

Mooney explained the project rationale: “We’ve listened to our customers and the broader industry, and are developing this solution in response to customer requests to move operators away from the face where some sites have a safety issue with rock bursts or slabs falling from the walls and face.

“WebGen 200 is just one of the enabling technologies in the solution, whereby the WebGen system has been designed for mechanical assembly and handling, enabling automated encoding and charging at the development face.”

A prototype of the system, which will enable the mechanisation of wireless explosives charging at the development tunnel face, is currently being developed for the underground mining segment, with the partners hoping it sees the light of day by the end of the year.

As for WebGen 200, the new generation wireless initiating system is due to be released in early 2021.

This system will harness digital technology to allow advanced reprogramming and digital inventory management, offering mine operations an integrated user interface with improved quality assurance, according to Orica.

“The reliability of each blast is further improved with the new generation WebGen 200 system designed to endure even greater shock resistance,” Mooney said. “These significant product improvements and new features will support innovative and complex mining operations, opening new market applications and opportunities.”

It will come in four product variants, with an opportunity to enable the first stages of blasting automation in the large volume surface market, according to Mooney.

Enaex has also been responding to customer requests in its own pursuit of removing personnel from the explosives and blasting process.

The company’s automation developments started all the way back in 2014 when, after receiving reports from customers about the inability to operate in certain areas of the mines due to safety reasons, it established the Enaex Robotics department.

It entered partnerships with Stanford Research Institute (SRI), a leader in robotics with dexterity capabilities, and, later, Autonomous Solutions Inc (ASI), a key player in ground vehicle automation, to speed developments along.

Enaex Robotics also worked closely with Godelius, an engineering company that is part of the Sigdo Koppers Group, the majority shareholder of Enaex.

After some years of research, development and testing, Enaex Robotics performed its first teleoperated blast at the end of last year in a mine in the north of Chile.

The tele-operated fleet included the RoboMiner®, a cutting-edge robot developed with SRI that manipulated boosters and detonators, thereby assuring the priming phase. This tele-operated unit also stayed on the bench to support the Mine-iTruck, a 20 ton (18 t) teleoperated mobile manufacturing truck, to pump or auger explosive into the bore hole.

On top of this, a tele-operated Stemming iTruck was used alongside a tele-operated gauge robot to measure bore hole conditions.

The trial appears to have gone well, with Bachelet saying the company is already operating a similar solution at one of its customer’s operations as part of a commercial contract.

“In the short term, the next steps for Enaex Robotics is to improve the speed of execution in the open pit and to bring tele-operated solutions into the underground, particularly to solve secondary breaking challenges,” he said.

“In the mid- to long-term, Enaex Robotics aims to go from tele-operated to fully autonomous functions, associated with artificial intelligence technologies.”

In South Africa, AECI Mining is also readying an autonomous program alongside digital twin developments in surface mining.

According to Joubert, the company is taking an advanced process control-type approach to this work focusing on continuous improvement with the result being full integration of the blast plan, drilling, charging and blasting.

This will leverage wireless detonator integration, with detonator GPS positioning/tracking and detonator “intelligence”, Joubert said. Deployment will involve autonomous bulk explosives charging and an autonomous initiating system.

“The approach is to have sub phases to build up to a fully autonomous solution,” he said.

These sub phases include the development of a mobile manufacturing unit (MMU) able to record what is delivered and send information through electronic means. This capability is already in place, according to Joubert.

The next sub phase would see the MMU receive information regarding the holes drilled and the quantity of explosives required per hole (desired type and quantity). “The MMU delivers as per plan with capability to make changes on the bench,” Joubert said, explaining that this ability has been in place at AECI Mining for some time, with a proof of concept already completed. “Recent client requests have resulted in an update of technology and a roll out is now in progress to clients,” he said.

The next sub phase would see such information linked with GPS coordinates on site (planned and verified). “The capability is in place, but centimetre-hole accuracy technology is still relatively expensive,” Joubert explained.

An integration into various third-party software would be needed as the fourth sub-phase, according to Joubert. “Front-end software with capability to integrate has been developed and deployment is anticipated in the near future,” he said.

A robotic arm deployment of the initiating systems is currently being developed by AECI Mining, as is an MMU that can be remotely controlled, Joubert added. This will be followed by automated control of the MMU, with positioning and charging based on set coordinates, blasting plan and confirmed hole positions. Such control will be developed in concert with automated route planning, according to Joubert.

An autonomous supply chain including “intelligence” on-site silos, automated route planning for explosives distribution and automated ordering request is also being explored by AECI Mining.
**Safety benefits surfacing**

The success of WebGen in underground mining has led to an increased adoption of the technology in surface mining, according to Orica, with the company having completed successful surface blasts using the wireless system around the world.

Hexagon's holistic approach to drill and blast incorporates solutions to improve yield, fragmentation and dilution.

Incorporating technology ranging from blast design and high-precision drilling to post-blast analysis and optimisation, the approach empowers mines to take back the purchasing power on their bulk commodity explosives, according to the company.

“A well-designed blast pattern and the effective execution of the blast plan using high-precision drills are an important part of an effective drill and blast operation,” the company said.

Hexagon's MinePlan portfolio features HxGN MinePlan Blast, a comprehensive software utility for drill and blast reconciliation.

“Rather than risking high-wall stability problems, uneven blasting, poor fragmentation, unnecessarily high energy costs, and dangerous working conditions, MinePlan Blast incorporates charge and blast design templates that are based on sound engineering principles and methods proven in mines worldwide,” the company said.

The MineOperate portfolio, meanwhile, features machine guidance for drills (as well as dozers and loading equipment), with the OP Pro HP solution ensuring drilling is performed to the right position and elevation.

“It provides accuracy and instantaneous feedback, meaning improved loading times across the fleet, less mis-routed material, fewer hours of rework on ramps, roads, and benches, and fewer over- and under-drilled holes,” the company said. “It is proven to improve both the quality of material produced and fragmentation with precise drill hole placement and depth.”

OP Pro HP integrates with Hexagon's operational management hub, MineEnterprise, for a single source of reporting and support, the company says.

Then there is fragmentation data to consider.

Here, Blast Movement Technology (BMT) is an integral part of Hexagon's drill and blast solutions, providing accurate ore location information for open-pit mines. BMT, via sensors and software, provides blast information used to recover a mine's resources. It ensures that, post-blast, the mine retains a full vision of where its orebody moved to.

Hexagon's Split Engineering systems are used to automatically monitor different areas and processes along the operation, such as in shovels, excavators, loaders, haul trucks, crushers, conveyor belts, mill feed and screen decks, providing a unified approach to fragmentation management, Hexagon says.

Monitoring trends in size at each point in the comminution circuit enables operational adjustments in real time, while alarms can be created for oversize events, reducing the downtime from inefficiencies caused by blockages and broken screen decks.

Its fully wireless capability presents an opportunity to overcome one of the industry's most persistent limitations – a physical or wired connection to each primer in a blast, Mooney says.

“Wired systems have a large physical presence and are susceptible to damage at every point along the connecting line,” he explained. “The potential for misfires due to downtime damage has commonly led to the application of redundant initiation systems and can impede the loading of adjacent blast patterns due to flyrock damage.”

Like other surface wireless systems, WebGen for surface, removes priming, loading, stemming and tie-in activities, in addition to reducing the time employees spend on the bench.

With increased flexibility in pit planning and blasted inventory, mine operations enabled by WebGen can also prime and load larger single blasts as well as eliminate firing window variability, according to Mooney.

The lack of wires can also eradicate potential hazards caused by weather events.

“Due to the conductive characteristics of wires, lightning storms pose one of the primary challenges in surface mining around the world,” Mooney said.

Typically, in the event of approaching lightning storms, a mining exclusion zone is placed around the loaded blast or, in some cases, the blast is cut short and immediately fired.

This does not happen with WebGen blasts.

“As WebGen does not require downlines and surface wires, lightning production costs and the risk of unplanned initiation of loaded blast holes can be eliminated, while production constraints from exclusion zones are completely removed.”

At a depth of 3 m below the collar of a blast hole, WebGen units are protected from the hazards of lightning, according to Mooney.

“The absence of lead wires in this scenario prevents current transfer,” he said. “Additionally, the magnetic field induced by lightning is not able to activate a WebGen unit to fire.”

Mooney is confident some of these characteristics will lead to new, WebGen-enabled blasting techniques surfacing.

“For example, with WebGen, it is now possible to allow traffic to safely flow over a loaded blast in surface operations, providing full flexibility in pit access and availability as well as significantly improving vertical advance and efficiency across the load and haul cycle,” Mooney said.

“This can dramatically optimise sequencing in surface coal strip mining and drop cuts in surface metal mining.”

Another example of “surface mining reimagined with WebGen” is multi-stratum blasting, Mooney says.

“This method involves drilling and loading multiple benches in a single pass, providing stemming decks in between the loaded benches,” he said. “A single deck is fired and dug before firing the next deck, reducing cycle times and bench preparation costs, while increasing the overall rate of vertical advance, fleet utilisation and safety associated with operating around highwalls.”

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**HxGN MinePlan Blast is a comprehensive software utility for drill and blast reconciliation, Hexagon says**
Paul Moore looks at key developments including the use of pumpable resin with bolts & SDAs for rock reinforcement

There has been a big move in the ground support industry in recent years to offer pumpable resin systems for underground rock bolting, delivered via dedicated mechanised bolting rigs. Orica-owned Minova told IM that it is introducing its UniPass Bolting Technology – described as an innovative ground support system for one and two step rock bolting, which combines Minova hollow bolts and self-drilling anchors with its patented bulk injectable resin, CarboThix. By combining these two products, Minova says it has created “a unique rock bolting solution that has been engineered to suit even the most demanding requirements of hard rock underground mining and tunnelling environments.” The use of pumpable resin and hollow bolts is quickly gaining traction in underground operations due to the ease of use, clean operating environment, improved safety, and the ability to provide instant ground support, enabling the miner to move faster.

Mines are extracting ores deeper than ever before, resulting in higher rock stresses, potential increase of convergence, dynamic events, and rock bursts. There is an increased demand on ground support applications, the products used and the safety of operators. Existing rock reinforcement solutions can be prone to limited ductility, installation difficulties, especially in broken ground and limitations on the efficiency and productivity of installation processes. Minova's Peter Assinder, Global Head of Sales, Marketing and Technology comments: “Mining companies are looking to decrease such risks and increase productivity by speeding up the bolting cycle and introducing mechanisation and further automation options. OEMs and their contractors are also looking to enhance the quality of materials used in mines to deliver installation consistency.”

For the last eight years, Minova says it has been developing a solution which it says provides answers to the requirements for increased automation, greater mine mechanisation, improved productivity and moving miners away from the working face. “Working with a major OEM of mechanised bolting equipment, Minova further developed their industry leading pumpable resin CarboThix and self-drilling hollow bolts to enable single pass installation of ground support, which Minova has termed UniPass.”

The OEM company that Minova worked with to develop the UniPass system is Epiroc, with the system designed to work with its Boltec M and Boltec E models. Last year Peter Bray, Global Product Manager, at Epiroc, had this to say: “An important factor to achieve a workable rock reinforcement solution is to have a system where the bolt design, bonding agent and bolting rig all work together to provide a robust and reliable bolt installation. To this end, Epiroc has worked hand in hand with a leading bolt and chemical supplier to create a bolting system that addressed the issues faced with long-term bolting in poor ground conditions.” The result of this work is an integrated pumpable two-component resin system that can be used with a Self-Drilling Anchor style bolt in tougher ground conditions or, alternately, with a one-step or two-step hollow bolt in both hard and moderate rock.

A major part of any new development process involves extensive laboratory and mine site testing. Minova was the material supplier for the ground control work package of the EU funded Horizon 2020 Sustainable Intelligent Mining Systems (SIMS), a 3-year program from 2017 to 2020, to demonstrate new technologies for the mining industry. Minova's hollow bolt and pumpable resin technology was extensively and successfully tested on Epiroc Boltec machines at LKAB's Malmberget mine in northern Sweden as part of the SIMS work.

Assinder comments: “The results surpassed the benchmarks set by the work program in terms of number of bolts installed per shift. The work undertaken during SIMS further allowed Minova to develop and fine tune the bolts and resins and installation accuracy and consistency, including optimum mixer units for the resin across a range of operating environments and approved greases to flush the bolting system after each bolt installation.”

The company adds that it is important to note that supporting materials and processes are almost as important as the bolt and grout materials, to ensure consistent quality of installation. “Minova's static mixers and greases ensure that the two-component resin is mixed and installed correctly for every bolt installation. Additionally, an extensive testing program, including on mine environmental monitoring and laboratory testing provided extra confidence concerning the structural and environmental stability of the resin.”

A series of dynamic drop tests undertaken in Europe and Canada further proved the performance of the hollow bolts in dynamic environments for a number of bolt and resin configurations, thus providing confidence to the mine customers that Minova's new technology is appropriate for their operations. Minova's portfolio comprises Static, Yielding and Dynamic Hollow Bolts and three main CarboThix resins (Standard, Fast and Rapid) to provide an all-in-one bolting system that has been engineered to suit the most demanding requirements of underground mining and tunnelling environments.

The products offered are designed to improve installation times and to address hole collapses when used in fractured ground. It is a flexible system that features a load-bearing hollow bolt that is encapsulated by a resin grout body. All bolts are available with or without welded sacrificial drill bits to allow for both one step and two step bolting processes. The welded on drill bit has been specifically designed and manufactured to allow a reduced borehole annulus, lower resin consumption, improved load transfer, shortened drilling time and guaranteed performance (no bits breaking or spinning-off during installation) whilst providing additional anchorage capacity.

Minova manufactures a wide range of grout solutions for rock bolting applications. UniPass bolting technology introduces CarboThix, its...