Boot-less blasting

Manual, tele-remote or autonomous? Wired or wireless? Explosives and blasting innovators are answering the big questions, Dan Gleeson reports

Due to the risks associated with exposing personnel at the face (underground) and on the bench (open pit), the theme of automation and remote operations has always come up when discussing explosives and blasting practices.

All the major technology suppliers and innovators have automation on their roadmaps as a result, with **Enaex** having demonstrated significant robotic milestones, through its Enaex Robotics division, in the recent past.

Back in 2018, its Mine iTruck® robotic loading equipment, together with its Stemming-iTruck and RoboMiner, were used for the first full remote blast in an open-pit environment in history at the Anglo American-owned Los Bronces mine, in Chile.

This saw the RoboMiner, a humanoid unit mounted on four wheels, moor and prime the blast holes; the Mine-iTruck transport raw materials, manufacture explosives on-site and load them; and the Stemming-iTruck plug the blast holes with gravel.

Then, during April 2022, a world-first 100% remote, robotic and autonomous loading operation was carried out for development operations in underground mining with the UG-iTruck at Enaex's test mine in Chile.

This equipment is designed to load explosives in development tunnels, with the ability to measure the profile of each drill hole and clean them, if necessary; assemble boosters and detonators robotically; load emulsion; tram; and detonate without the need for tie-up since wireless electronic detonators are used. The UG-iTruck has a mechanised priming system and can manufacture Ugex Full Face®, an emulsion with a variable density that allows precision blasting and high performance, according to the company. The entire process, as was tested last year, is monitored from a remote control station or a centralised operations station.

Enaex has moved on from these milestones and continues to "set and push" the bar, according to Marco Ruiz, Enaex Robotics Manager.

"In a matter of years, we have moved on from testing our underground mine development automation process in our test laboratory, in our test mine and, now, at Codelco's El Teniente mine," he told ***IM***.

The company's UG-iTruck arrived at the mine – which will become one of the world's biggest block-cave operations when fully developed – earlier this year, set for trials in a new underground environment.

The new project portfolio at El Teniente includes the Andes Norte, Diamante and Andesita projects, making up an initiative that will allow Codelco to replace sectors of the existing El Teniente deposits that are in the process of depletion, while extending their productive life by 50 years and maintaining production levels at around 460,000 t/y of fine copper.

Yet, developing underground mines with more than 2,400 km of tunnels comes with issues, hence the reason the world's biggest copper miner is looking to remove personnel from the face wherever possible.

This automated loading testing is taking place on the "new levels" at El Teniente, according to Ruiz, with operators overseeing the automated operations from a truck positioned outside of the "red zone".

"We are in a ramp-up process where we started with more isolated parts of the mine in more 'controlled conditions', but the final goal is automated explosive loading activities in the main tunnels," Ruiz said.

Dyno Consult's Mike Kotraba is convinced the sector will move towards more readily utilising real-time data in its decision-making practices on the bench, instead of focusing on key performance indicators measured and reviewed after the fact

These tunnels will house underground conveyors or act as transport routes throughout the mine.

At the same time as the company plans to move its operators and UG-iTruck to mine developments areas, it also has plans to relocate the automation controllers to remote operation centres on surface.

This may not occur during trials at El Teniente, but it is part of Enaex's technology roadmap, which also includes the delivery of more prototype UG-iTruck units to be tested in South America and elsewhere.

"If we demonstrate this capability in a live mine development scenario, solving the industry challenge, the wider industry adoption for this solution will be very fast in my opinion," Ruiz said. "This is where the design criteria has to not only consider Chile, but also think about potential applications in North America and Australia.

"Fortunately, or unfortunately, the problem we are looking to solve at El Teniente is present at many underground mines all over the world. In this regard, we think we have a universal solution."

Ruiz says the company also has plans to adapt the underground automated loading process it is using at El Teniente for production blasting activities.

"A production scenario is very much on the roadmap, and we are working on adapting the existing solution for up holes," he said.

Above ground, the company is also looking to

Enaex expects to have a commercial open-pit autonomous blasting offering that involves RoboPrimer next year

refine its robotic offering, moving to higher levels of automation.

The company has perfected its tele-remote robotic blasting process over the space of two years in a production environment at Los Bronces, leveraging the Mine-iTruck, Stemming-iTruck and RoboMiner, but the next step is to automate all activities.

"We need to advance this further for two reasons: first, there is enabling technology available today to do this and, second, there is the opportunity to be more productive on site," Ruiz said.

"RoboMiner is today considered old fashioned as it was designed to deal with wires. At the World Mining Congress, in June, we made public that we are developing RoboPrimer: a robot that can autonomously assemble explosives using wireless detonators."

This is where the robot will integrate with DaveyTronic® Edge, the company's semi-wireless initiation system. Developed in partnership with CEA-Leti, the solution removes the surface wire, generating a significant reduction of operations on the bench (connecting, troubleshooting), while ensuring two-way communication continues between detonators and blasting equipment.

Enaex expects to have a commercial offering that involves RoboPrimer next year, with plans to start testing at Los Bronces.

"We expect to be able to deploy this solution next year on a global basis, enabling the loading of explosives without people on site," he said. "Not only does this improve safety; it also allows the loading of explosives during the night to incorporate more productive hours into the operations."

These developments form part of the company's plans to expand further on a global basis, with Ruiz saying Enaex is planning a big push in both Australia and North America.

"Our aims of improving safety and increasing productivity translate to any corner of the globe, and we have the solutions in place that are both raising and setting the bar for the global blasting market," Ruiz said.

Pushing the boundaries

Orica is similarly looking to achieve major industry milestones with its own automation and digital advances.

Explosives and blasting may be the topic most associated with the ASX-listed company, yet it is focused on more than just the bench in the open pit, and the face underground.

For instance, in the upstream segment, the company's Design for Outcome service – which applies machine learning to in-field measurement sensor data and block model data to help automatically generate blastability domains – has recently been paired with its RHINO™ solution – an autonomous drill string-mounted seismic sensor that measures synthetic unconfined compressive strength while drilling – to make the most of drill-based sensor data coming off rotary drills used by several large surface mines.

The company's FRAGTrack™ fragmentation measurement tool, meanwhile, is assisting in the management and productivity of blast operations and downstream processes, with the latest additions, FRAGTrack GeoSpatial and FRAGTrack Front End Loader (FEL), continuing to offer customers increased visibility over fragmentation, while assisting in the management and productivity of blast operations and downstream processes.

FRAGTrack GeoSpatial significantly advances the understanding of blasting performance by offering georeferenced samples that correlate blast design and orebody information, according to Orica. By employing real-time fragmentation measurement and georeferencing technology, it accurately pinpoints the location of fragmentation samples, empowering customers to obtain fragmentation information at a blast or 'domain' level within a blast for continuous improvements in blasting outcomes.

One of the key advantages of FRAGTrack GeoSpatial is its ability to accurately geo-reference particle size distribution (PSD) samples, providing "unparalleled location accuracy" and facilitating high-fidelity correlation of PSD data with orebody information, the company says.

FRAGTrack FEL leverages advanced 3D machine vision and artificial intelligence technologies to capture autonomous measurement of loader operations, enabling customers to improve productivity through

Orica's latest bulk explosives system, 4D, is delivered through MMUs equipped with LOADPlus, Orica's proprietary in-cab smart explosives delivery control system that, it says, enables the ease of manufacture and accurate and efficient delivery of formulated explosives products to plan

fragmentation analysis, facilitating blast optimisation for downstream impact and provide fragmentation profiles of stockpiles to improve blending.

Angus Melbourne, Chief Technology Officer of Orica, told ***IM***: "By integrating FRAGTrack GeoSpatial and BlastIQ blast data in the BlastIQ Insights Blast Analysis Dashboards, users can effortlessly compare their blast designs with the blast's actual spatial particle size distribution. This capability allows for precise blast design tuning, enabling optimal blast performance on subsequent blasts within the relevant domain.

"It automates the association of blasting energy and fragmentation, enabling miners to easily calibrate fragmentation models to achieve better blast designs, improve fragmentation profiles and increase throughput."

Then there is the upcoming launch of OREPro™ Hub to consider, an open-pit-focused product that, when integrated with OREPro 3D Predict, enables the tracking of material from resource model to the final destination in a digital twin format. Melbourne added: "OREPro 3D Predict enables users with the game-changing capability to confidently and accurately model each blast without walking on hazardous muck piles or maintaining expensive hardware. OREPro Hub will then capture and store all blasted inventory and its depletion, providing unique reconciliation via our volumetric digital twin."

Orica has been able to expand its reach throughout the mining supply chain by developing flagship products that have a tangible impact on safety, productivity and efficiency at the mine face.

One of the key enablers of late has been WebGen, the company's fully wireless initiation system.

This system has had a significant impact on the way mining companies conduct blasting operations, leading to the creation of many different mining techniques that were simply not possible with wired initiation systems.

"The impressive statistic of over 176,000 units fired underscores the widespread adoption and effectiveness of the technology," Melbourne said. "While some mines may initially have reservations about adopting wireless blasting as a potential replacement for traditional initiating systems, the actual experiences of sites that have implemented WebGen paint a different picture."

The benefits derived from reduced development, faster cycle times, improved recovery rates, increased production flexibility and decreased dilution provide significant value to operations that outweigh the associated cost increase, according to Melbourne.

He added: "In fact, what we have observed is that mines gradually increase their utilisation of WebGen over time."

XPLOLOG allows mines to monitor their block progress in real time and to continuously improve the quality of blasts, according to Ralf Hannecke

Now in the process of rolling out additional WebGen 200 platforms – the second iteration of the initiation system – across surface and underground mines, Orica is in receipt of dozens of success stories at mines owned by major mining companies such as Vale and Newmont.

The development of WebGen 200 has also accelerated the automation and mechanisation of explosives charging through Avatel™.

A fully mechanised development charging system developed by Epiroc and Orica, Avatel is now operating at Newcrest's Cadia Valley Operations in New South Wales, Australia, with the first shot fired in May 2023.

Avatel is being usurped in the automation level stakes by the company's fleet of 4D™-enabled Bulkmaster™ Mobile Manufacturing Units (MMU™s) in surface mining and Maxichargers™ in underground operations.

"Our recent efforts have primarily centred around automating the digital flow of information and decision-making processes," Melbourne explained, saying one of the key areas is the automation of the bulk explosives loading process these units.

Orica's latest bulk explosives system, 4D, allows customers to access a wider range of energies and the ability to adjust energy levels within a blast pattern based on geological considerations and desired blast outcomes – all at a push of the button, it says.

The explosives are then delivered through MMUs equipped with LOADPlus™, Orica's proprietary in-cab smart explosives delivery control system that, it says, enables the ease of manufacture and accurate and efficient delivery of formulated explosives products to plan.

"The integration with Orica's suite of digital technologies, including BlastIQ and SHOTPlus™, further enhances customers' ability to leverage seamless digital workflows for blast designs, quality assurance and control, and digital insights for continuous optimisation of blasting outcomes," Melbourne says.

The implementation of these automated processes, supported by the algorithms in the LOADPlus system, has led to notable improvements in achieving desired densities and energies in the blasting process, according to the company.

"Our efforts in automation represent significant progress towards automating the entire hole loading process, bringing in increased accuracy and flexibility that were not achievable manually," Melbourne said.

The company has now got to the point with this automated hole loading platform that it is talking about commercialisation in the Australia-Pacific region in the March quarter of 2024, with subsequent regions, including North America, Latin America, Asia, and Europe, Middle East and Africa, soon after.

Melbourne concluded: "As we anticipate the future, we are excited to introduce a line-up of upcoming products that will push the boundaries of explosives and blasting technologies, setting new industry benchmarks."

Safety, supply chain and sustainability

When it comes to using alternate electronic initiation systems outside of the traditional wired variant, **BME** is looking beyond just wireless solutions.

The company's General Manager of Technology & Marketing, Nishen Hariparsad, says BME's AXXIS™ platform is the key area of focus for such developments.

AXXIS was originally designed for open-pit mining blasting as a fully programmable, accurate and easy-to-use electronic delay detonator system. In 2018, its functionality was expanded to cater to the underground sector and, since then, the company has developed the AXXIS Titanium™ and AXXIS Silver™ offerings.

Hariparsad told ***IM*** that the future AXXIS roadmap included a series of feature upgrades

that deliver more efficiency, larger blasts and limit customer pain points through the blasting process.

"As such, one of these feature upgrades and solutions in our roadmap includes alternate electronic initiation solutions, which is not limited to just a wireless initiation system," he said.

BME Managing Director, Ralf Hennecke, added to this saying that the company is already working on bringing new updates to the market outside of AXXIS Titanium and AXXIS Silver.

"This is the same approach that we take with all product categories; for example, we have recently released a new version of our popular XPLOLOG system for capturing and analysing data on blast holes and decks," he said. "XPLOLOG allows mines to monitor their block progress in real time and to continuously improve the quality of blasts. The performance of this version is enhanced with design and application code built from the ground up, and with a new and upgraded database using Google's Cloud Services."

More generally, BME's R&D is underpinned by the foundation of safety, a secure supply chain and a focus on sustainable production through rolling out renewable energy generation at its facilities.

When it comes to the ongoing safety of its products, Hennecke was keen to go back to the properties of the company's AXXIS Titanium platform for a reference case.

"Safety in blasting has less to do with automation, and more to do with strict safety protocols supported by the best technology available," he said. "For example, our latest generation of AXXIS Titanium once again raises the safety bar by incorporating a Swiss-designed application-specific integrated circuit chip in our detonators. This gives the system more internal safety gates against stray current and lightning, enhancing safety levels and allowing for inherently safe logging and testing."

The company's digital technology also allows for more controlled blasting, which prevents risks like vibration and fly-rock.

"Electronic initiation, for instance, staggers the energy release of a blast – and lower charge mass per delay can lead to lower vibration levels," Henneke said. "For example, we were able to safely initiate a blast of 766 detonators just 34 metres from a building, on a recent urban construction project in Gauteng."

The integration of more controlled blasting, sophisticated blast design software – like BLASTMAP™ – and the introduction of a global online technical services and solutions platform to enable explosives users to consult with experienced explosive engineering professionals is also helping BME's clients quantify and keep track of the downstream impacts of its upstream blasting processes.

Hennecke said: "This technology plays a role not just in planning and initiating blasts, but in assessing how well a blast plan was executed. Measurement techniques include real-time tracking of emulsion volumes being pumped into blast holes, to the use of drones, 3D photography and global positioning systems to profile blast results.

"The data lends itself to ongoing cost optimisation, and to ensuring that there is no wastage of resources in achieving the optimal blast result."

This is also translating to a reduction in upfront costs for clients, according to Hariparsad, with machine-learning algorithms interpreting data for optimisation opportunities.

Machine learning and artificial intelligence also come into the company's automation efforts where solutions such as XPLOLOG and XPLOCHARGE™ can automate aspects of blast hole charging, including the real-time tracking of emulsion volumes being pumped on the bench by smart trucks.

Hariparsad explained: "These volumes are monitored by on-vehicle equipment, which compares the planned volumes with the actual volumes required. This data can then be transmitted wirelessly to be stored and analysed in cloud platforms."

Smart trucks, or 'Smart MMUs', are regularly mentioned in the explosives and blasting sector to remove people from the bench and distribute accurate and tailored explosive solutions to individual blast holes.

BME's concept of a 'Smart MMU' is aligned with its strategy of delivering innovating technologies that position the business to deliver global mining solutions, according to Hariparsad.

"They are designed to capture data, monitor product information and record delivery of bulk emulsion according to defined chemistries and formulations," he said. "This allows our customers to benefit from greater insights and decision-making capabilities with each loading and blast cycle."

Beyond the basics of digital data capture, the Smart MMUs are designed with remote connectivity to BME's cloud servers for real-time data transfer of loaded product, as well as digital telemetry through Internet of Things devices that measure truck performance.

"This information can be used for productivity gains, maintenance control, product quality and asset utilisation, offering a more efficient and reliable solution for our customers," Hariparsad said.

Added digital functionality is available through the aforementioned XPLOCHARGE, BME's dedicated MMU operating system, which can connect to XPLOLOG, the company's blast data management system.

"This ensures the most up to date hole design and loading data is available to the MMU operator and the blaster while blast holes are being charged," Hariparsad said. "BME's smart MMUs make use of internet connectivity through satellite and W-Fi communications, which allows real-time data to be captured and stored in a cloud database. This provides our customers with direct access to process data at any stage of the loading process – to monitor productivity in real time."

On top of this, the Smart MMUs have a single operator design logic, eliminating the need for additional operating personnel and providing an optimised resourcing methodology.

BME has, according to Hariparsad, differentiated its MMU technology through an in-house specialised assembly and fabrication facility where more than 200 units have been built.

Moving to real-time data use

Another company with 'Smart MMUs' on its agenda is **Dyno Nobel**.

The company's ΔE jumbo trucks have gradually been adding layers of automation to their DIFFERENTIAL ENERGY emulsion loading processes over the years, moving from manual processes to semi-automated loading, all with an aim of fully automating the process.

Yet, the company would have no way of offering such automation without a sold data back bone, which comes from its Nobel Fire digital platform.

This proprietary platform has linked Dyno Nobel's unique design capabilities, bulk explosives products, and explosive delivery and initiation systems to enable "end-to-end automation of the 'Connected Bench'", the company says.

An example of this is how the company pulls data from drill holes to customise an emulsion recipe for each hole.

"This could be up to five segments of different densities in one hole," Mike Kotraba, General Manager of DynoConsult, Dyno Nobel's consulting division, told IM recently. "You are basically gassing the product as you are putting it in the hole...putting the right explosive in the right place in the bore hole to impact the geology present in that location."

The data these smart MMUs are armed with to deliver different density emulsions comes from blasting engineers – in house at the mining company or within Dyno Consult – with on-board GPS allowing the MMUs to know what recipe is for what hole.

The data goes in both directions, with the MMUs also analysing the properties within the

hole as they distribute the solution.

"Data is captured such as the depth of the hole, the amount of water in the hole, how accurate the coordinates are in the hole, etc," Kotraba said. "You then, post-blast, get a post-mortem on the best practice of this process to provide a continuous improvement loop."

These processes are all part of Dyno Nobel and Dyno Consult's 'drill-to-mill' initiatives that look beyond the blast to – up stream – the drilling process and – downstream – the impact on fragmentation.

On the latter, Kotraba pointed out the use of HxGN Split-Desktop, which delivers manual, off-line coarse rock fragmentation size analysis of muck piles, leach pads and more at some of the company's mine site operations.

"This is both for baselining and optimisation purposes," Kotraba said. "When used for baselining, we are typically trying to match the existing fragmentation the client is seeing on the bench and through their processing circuit; using that to calibrate our blast model."

He also highlighted the use of a HxGN Split-ConveyorCam to carry out online measurement of the PSD information for material travelling across conveyor belts, post primary crusher, as part of ongoing drill-to-mill developments.

Such initiatives are key to providing immediate feedback to the mine on blast performance; feed forward to the plant on what is coming from the mine; correlation of PSD to shovel maintenance; and enhanced process control decisions, according to Hexagon's Mining division, which supplies the solution.

"In all of our mine-to-mill studies for integrated operators, we are targeting that -0.5 inch (-13 mm) benchmark," Kotraba said. "What has been proven in many of our studies is that you don't necessarily need to increase your powder factor or use a higher power explosive to achieve this."

In one operation that the company trialled a solution and ultimately won the contract, Dyno Consult widened the drill pattern by up to 30% and still improved the fragmentation performance with the same powder factor, according to Kotraba.

"Contrary to popular belief, it's not always about squeezing the pattern in and putting more powder or a higher energy explosive in," he said. "For example, you can change the fines percentage by 2-3% by a change in timing."

Such timing changes are being facilitated through Dyno Nobel's increasing use of electronic detonators, available through its EZshot® series.

Offering users the benefits of accurate electronic timing without the complications that come with wired systems, EZshot is available for both underground and surface blasting.

Factory-programmed delay times on EZShot detonators can range from 1,000 to 20,000 milliseconds, with long-period delay timing ideal for the likes of 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.

Hypex Bio's trials have shows that, at a charge quantity about 20% lower than the comparable ammonium nitrate technology, HPE can achieve the same results in terms of fragmentation, pull and wall control but without any NOx gas, nitrates or ammonia

Also aiding these efforts is the company's use of its DIFFERENTIAL GPS, embedded in EZshot.

Whereas normal GPS provides a position of an object using signals generated by satellites revolving around earth – gaining a nominal accuracy of 10-15 m – DGPS can, according to Dyno Nobel, offer sub-1-m accuracy for blast hole tagging and logging.

"DGPS is a vast improvement from GPS," it says. "It reduces or eliminates signal degradation, resulting in improved accuracy."

DGPS aims to eliminate potential human errors to provide accurate tagging of blast holes; offer a semi-autonomous tagging method of blast holes; provide an easy, reliable and fast deployment to speed up the blasting process; and offer a hole logging position option when blast hole GPS coordinates are not available.

It also aids the automation efforts the sector is advancing, offering the ability to integrate into future fully autonomous (robotic) deployment and tagging processes.

Such solutions – overlaid with Nobel Fire – are allowing clients to think "beyond the bench", Kotraba says.

He explained: "Anywhere we go, the first thing I ask a client is: 'what outcome do you want from your explosive?' When you are potentially investing millions of dollars on detonators, boosters, product, you need to know what outcome you want.

"The benefits of improved upstream blasting have to trickle through the whole mining process – it could be about making digging easier, reducing ground engaging tool wear, reducing rope shovel wear, improving bucket fill factors for better cycle times on shovels, to what happens when it hits the primary crusher or the mill.

"For us, it is all about the outcome."

This is where Kotraba is convinced the sector will move towards more readily utilising real-time data in its decision-making practices on the bench, instead of focusing on key performance indicators measured and reviewed after the fact.

"In order to optimise the value chain, you need to be able to able to make changes when you see things going awry," he said. "We are heading in that direction and have all the technology and expertise to facilitate such a shift."

HPE-based explosives

Sweden-based **Hypex Bio** says it has been able to solve a long-standing problem in the explosives space: develop an emulsion explosive without NOx, nitrate leaching and crystallisation issues that matches the performance of standard nitrate-based explosives.

Hypex Bio was formed to commercialise and take ownership of the hydrogen peroxide explosives technology developed under the umbrella of Swedish explosives company AB Etken Teknologi. AB Etken Teknologi had been working for some years with international and Swedish agents and partners to explore the commercial and industrial potential of hydrogen peroxide explosives. Initially, testing was conducted using hydrogen peroxide water gel formulations (HPG) to explore the benefits, costs and risks associated with the technology.

This resulted in a HPG patent application and an in-depth study of production aspects, risks and performance metrics (from an underground operation). Concerns over reactivity issues led to a further development of a significantly more

stable hydrogen peroxide emulsion technology – HPE.

Suitable for underground or surface blasting, the HPE solution, is a highly viscous emulsion with a white to light yellow colour, the company explains. The product can be custom made to exhibit a wide range of viscosities and comes with or without a sticky texture, facilitating use in up (production) holes. The emulsion is waterproof and can be used in wet applications and underwater, according to the company.

Developing a solution without the environmental impact the nitrate-based solution has is not all Hypex Bio has achieved, according to CEO Thomas Gustavsson.

"We have invested significant efforts into ensuring we have a solution which is as non-disruptive as possible in the operational use phase," he told ***IM***. "The current Hypex Bio product is a bulk emulsion which is chemically sensitised (gassed) into the drill hole and initiated using standard detonators and primers.

"Our extensive trialling shows that, at a charge quantity about 20% lower than the comparable ammonium nitrate (AN) technology, we achieve the same results in terms of fragmentation, pull and wall control but without any NOx gas, nitrates or ammonia."

This trialling includes stints at Boliden's Kankberg mine and a recent test at a Skanska-owned tunnelling project in Norway.

The company also has new trial sites lined up in the Nordic region – including at Boliden-owned Garpenberg – followed by sites in central Europe and North America.

Gustavsson said one of the biggest inhibitors to wider use of the product could come in gaining approval from regulators for its use.

"So far, the technology is very similar in terms of use to the status-quo; some operational considerations are currently present but nothing that would have significant impact on implementation. As the product is completely new, one challenge is regulation, as the current legal framework (in Sweden) is not adapted to nitrate-free solutions. However, these hurdles have been overcome due to close dialogue with Swedish authorities."

Hypex Bio has developed its own production plant to scale-up supply of the environmentally friendly emulsion, with one plant in operating in Norway and three more underway.

"We strive to offer everything that is required to use our products; from the production plants to the charging units and the required raw materials," Gustavsson said.

HPE has already shown it can achieve the same results from a productivity standpoint as the traditional AN solution, and Gustavsson is hoping to also prove out its economic competitiveness.

"We have carried out quantification of cost in some instances, however, it is challenging to conduct a proper analysis since operations are still contaminated with AN residues," he said. "Objective cost savings can be evaluated based on compartmentalised data, particularly in terms of savings in capital expenditure investments for nitrate cleaning plants and ventilation requirements.

"Carbon intensity is relatively straightforward as environmental data from AN and HPE production is readily available, indicating up to a 90% reduction in CO_2 emissions in regard to the oxidiser phase. This is a substantial saving, which aligns with the emission reduction roadmaps of the majority of mining houses.

"In regard to cost of the product, as the supply volume for HPE increases, costs are likely to decrease and be comparable to AN emulsion, but this could take some time. Currently, due to smaller volumes, the cost is slightly higher, but it is expected that these costs will be significantly offset by savings in mitigation for nitrate, NOx and ammonia handling."

Getman Corporation says it has made significant expansions to its underground explosive charging equipment line in recent years, with one notable addition being ProCharge MAXX, which was launched in 2021. This innovative equipment maximises the emulsion capacity available within a given footprint. Furthermore, Getman introduced a range of ANFO and emulsion transport machines last year, consolidating their offerings.

"These machines now span from portable emulsion cassettes to container transport machines capable of safely moving full 20 ft (6.3 m) containers of emulsion or other materials underground," the company said.

In the present year, Getman is focusing on the opposite end of the spectrum with the introduction of its new line of ProPack ANFO and emulsion chargers. These chargers are small, portable systems that are self-contained and excel in accessing tight spaces where dedicated mobile equipment may struggle, according to the company. When combined with Getman's line of Telehandlers, which were launched last year, these platforms complement each other perfectly. They provide a capable and cost-effective charging solution, particularly when space or budget constraints limit the use of larger charging equipment, Getman claims.

The ProPack ANFO system is specifically designed for mounting on flat deck trucks or for transportation by forklift vehicles in surface tunnels or anywhere within a mine. Equipped with an incorporated step ladder, these units can be filled using 55 lb (25 kg) ANFO bags. Each unit includes remote pneumatic pilot controls for ANFO charging start/stop, hole or hose clearing, a Lo-stat hose, and air controls for adjusting pressures and flow. They can be connected to mine air or an external compressor, while the ProPack Portable ANFO Delivery System offers the option of fitting single or dual 1,000 lb ANFO pots.

Similarly, the ProPack Emulsion system is designed for mounting on flat deck trucks or for transportation by forklift vehicles. These units feature a high-pressure diaphragm pump with a screened inlet port and can be filled using an approved transfer pump and a 3 in (76.2 mm) hose. The emulsion unit includes a remote pneumatic pilot control for starting/stopping the emulsion charging process. Additionally, it is equipped with a 65 litre water tank and pump that supplies water for hose lubrication, which activates automatically when the emulsion starts. This unit is designed for pre-sensitised emulsion, making it user-friendly by simply connecting it to mine air or an external compressor, according to the company. The ProPack Portable Emulsion Delivery System has a capacity of 1,000 litres of emulsion.

Getman says it remains dedicated to ensuring the safety of miners, with the ProPack portable delivery systems catering to a specific segment of the mining industry that requires safe and efficient charging solutions underground.

Going lead-free

Speaking of removing contaminants from the blasting process, **Austin Powder** says it has developed lead-free primary explosive detonators for its clients that come ahead of regulators mandating the use of such an alternative.

The company started looking for a lead-free alternative to lead azide all the way back in 2007 at its detonator facility, Austin Star Detonator. The initial work was started by Morris Bannerman and Göran Jidestig.

"Developing, testing and producing a new primary explosive is the biggest nightmare for any explosive/detonator maker," Jan Jidestig, Director of R&D and QC, said. "It is a project that has taken us nearly 15 years. The new substance was designed by experienced chemists who worked collaboratively with the engineers to design the production process.

"We couldn't rush the process, and we had some dead ends and had to significantly change the product design, and even parts of the entire manufacturing process. But we did it."

By 2016, a pilot-scale reactor was designed,

Austin Powder says it has developed lead-free primary explosive detonators for its clients that come ahead of regulators mandating the use of such an alternative

which could produce small-scale batches. This was then used to develop the method and to produce enough powder to perform a qualification test.

The first field test was carried out in 2018 with 8,500 detonators for Philipsburg in Pennsylvania, USA. During this time, a full-scale reactor was developed with the help of Daniel Rontey and the engineering team at Austin Powder.

The first full-scale reaction was completed on April 5, 2019, with production of the new component starting in late 2020, with over 93,000 detonators shipped to the field for trials.

In 2022, a total of 2.6 million detonators were shipped and used throughout Mexico and USA.

Otta Greben, Global Director of Detonator Products for Austin Powder, said: "There is a rule for any explosive makers – don't change it if it works. But the world is changing, and our approach to safety and health within our production is changing. Here we have internal and external contributors to drive the change. We also have requirements from regulators (you must) and our own decision to improve production hygiene and safety (you should). However, we proactively made the decision to develop lead-free detonators way in advance."