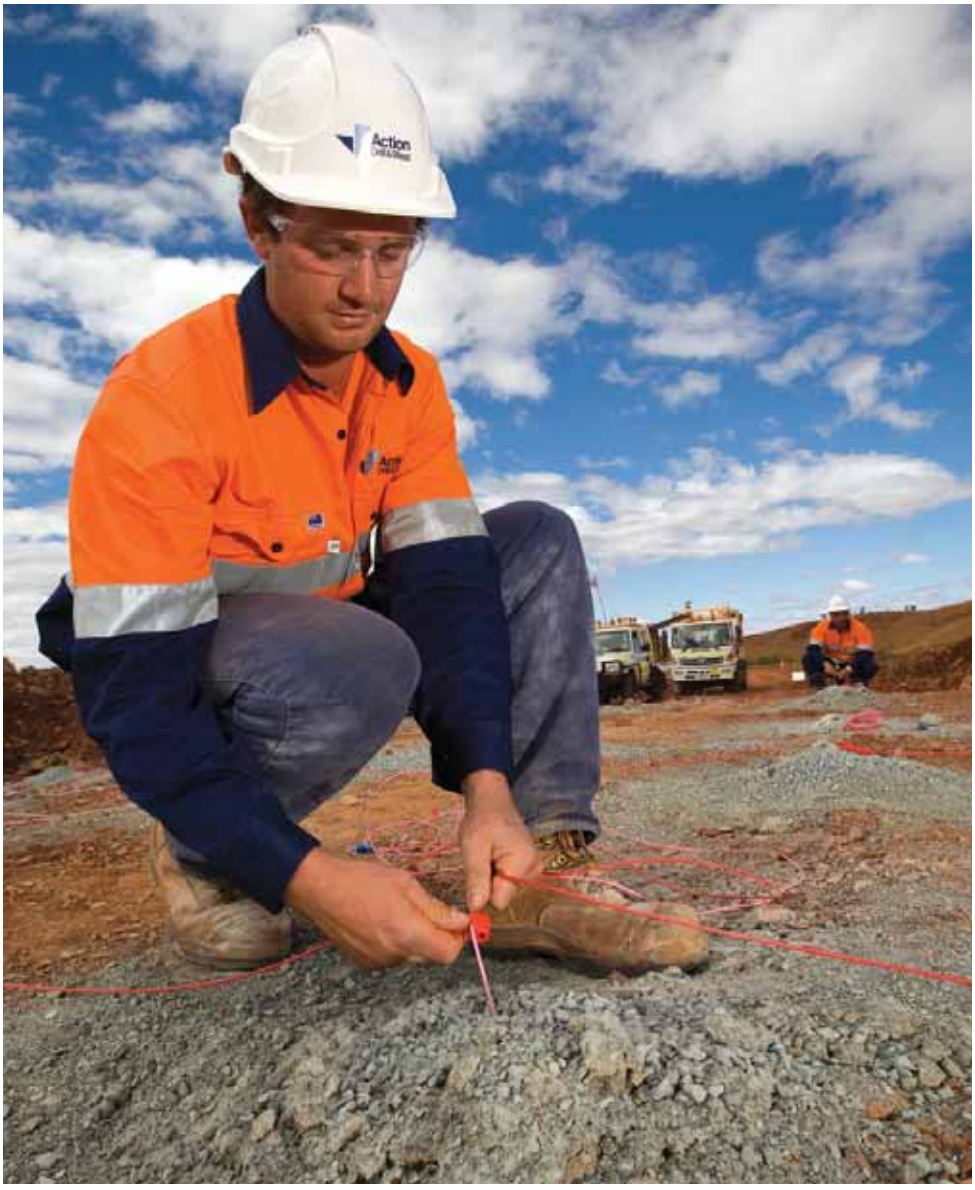
Detonators: Best-for-Project Practices in Drill and Blast

By Michael Wiseman and Stephen Timbrell

As the mining industry becomes more and more lean, a "one-size-fits-all" approach is becoming increasingly obsolete. A commitment to continuous improvement—finding ways to do things better, faster and more cost effectively—is how asset owners and contractors are ensuring their ongoing success.

In drill and blast, developments in detonation systems have provided forward thinkers with an opportunity to dramatically enhance their blast capability. Highly tailored blasting solutions, with the potential for significant cost and productivity benefits, are now being implemented by teams and contractors who have been willing to invest in increasing their knowledge base, trialing new electronic initiation technologies and upskilling.



The importance of selecting the correct blasting system and technology, based on what is best for a given project, cannot be overstated. It's essential to embrace innovation where it can be seen to deliver value.

In Australia, for example, prior to the 1990s pyrotechnic detonators, also known as electric and non-electric detonators, were the most commonly used in that country's mining industry. In the late 90s, electronic initiation systems were introduced through a variety of explosive suppliers. Initial uptake was slow, but as the technology evolved and advanced to address the recognized practical limitations and to meet the specific needs of the end user, uptake progressively increased.

In these early years, the largest consumers of electronic detonators were underground and open-pit coal mines—projects that could realize an immediate benefit to their operation because pyrotechnic detonators did not offer a solution to the problems associated with these types of projects, such as excessive ground vibration.

Today, through increased industry understanding, testing and delivery of tangible results demonstrating the benefits of using electronic detonators (covered in detail later in this article), they are now widely used across different commodities in both open pit and underground operations.

However, despite electronic systems' proven benefits and advantages over conventional products in many blasting situations, a step-change is still required within some blast teams to overcome concerns, fully understand the technology and utilize it to its full potential in order to offer best-for-project solutions.

Addressing the Barriers to Uptake

Despite their advantages, the higher cost associated with electronic systems compared to conventional systems, along with the additional training required, still acts as a deterrent for many companies as there is not an immediately recognizable direct cost saving to the operational budget for drill and blast.

Further, it is well known that the majority of cost benefits of using electronic systems are generally realized downstream via mining productivity and crushing throughput, which are optimized through a continuous improvement program or series of site-specific trials, which also come at an additional cost to the project.

For many companies, the cost of changing to electronic technology outweighs the reward—not overly surprising in light of the current market conditions and the pressure to deliver immediate cost reductions.

Determining Best-for-project

An electronic initiation system is not just about the detonator. While it's an integral part, it is all three elements of the system—the detonator, the blast planning software and the detonator programming hardware—that provide the technology with its unique advantages.

Typically, electronic systems are best suited to:

- Projects in close proximity to vibration sensitive infrastructure, such as houses, bridges, tunnels, rail lines and optic fiber telecommunication where greater and more precise control over the blast is needed;
- Large-tonnage blasting where electronics can deliver cost efficiencies by reducing delay scatter, which will improve fragmentation and ultimately reduce the amount of bulk explosives required;
- Projects where creating the muckpile profile to suit the digging fleet is the primary objective, for example, cast blasting using draglines and dozer push; and
- Complex blasts that have a requirement for multiple decks, for example, coal mining through seam blasting.

Productivity Benefits of Electronic Systems

Most of the concerns around electronics can be overcome by investing in short-term training for long-term gain, smart technology selection and a change in mindset. It's essential to embrace innovation where it can be seen to deliver value.

The benefits of electronics are numerous; they include:

Reduced bulk product use – This is electronics' key advantage. The overarching goal for drill and blast is to use the raw energy from the bulk product to do the most useful work on the rock.

In most mines, the bulk product cost is more than all other drill and blast costs combined. Electronic initiating systems when used to their potential will achieve more with the rock using the same energy. Depending on the mine's situation, this can deliver increased productivity or assist in reducing costs by blasting the rock better so it digs faster and the mine produces more for the same cost. Alternatively, if the mine is operating at full capacity, capacity can be maintained but at reduced cost by doing the same work with less bulk product because the energy is being used more efficiently.

One of the most useful applications for electronic systems is in large-tonnage blasting where electronics can deliver cost efficiencies by reducing delay scatter, which will improve fragmentation and ultimately reduce the amount of bulk explosives required.

Cheaper at longer lengths – In a pyrotechnic detonator, the head of the detonator is relatively cheap and the tailwire is relatively expensive. In electronics, the head is very expensive due to its computer chips, but the tailwire is cheap, as it is just wire. This means short-length pyrotechnics are cheaper per detonator but at long lengths, usually greater than 50 m, electronics are cheaper.

Improved fragmentation – Most of the gains achieved with electronics are not made through the detonator itself but through the use of its advanced software. A blast team has the ability to plan in just a matter of hours timing sequences that would otherwise take days using conventional equipment and be impossible to practically implement.

Even when using the exact same timing sequence across both systems, electronics deliver an advantage as the detonator is accurate to the timing it communicates (+/- 1 millisecond). This is in constraint to the unavoidable natural variability (+/- 5 to 25 milliseconds, called "scatter") in pyrotechnic initiation systems. This often means smaller or bigger time gaps between detonations than expected, or holes may even detonate in the wrong order.

However, the big benefit of the accuracy and flexibility of electronics' timing capability is to be able to devise a plan that best suits the shot in question. Very fast, very slow and/or very complex sequences can be used to get the most useful work out of the explosives to achieve optimal fragmentation. Trying these sequences without electronics would be unsafe, impractical or impossible.

Reduced ground vibration – The best electronic initiating systems come with a vibration prediction tool so that the vibration can be predicted at various points, particularly sensitive ones. This is called "time of arrival analysis." The blast timing can then be modified to protect those points and the vibrations can be aimed in a direction where nothing of value needs protecting.

Further, because of the accuracy of the timing, the explosive energy is released at the exact time it was set to; there are no unplanned spikes in energy (and therefore vibrations).

Improved control of blast movement – As mentioned above, with electronic systems' advanced timing, it's possible to speed up and slow down certain parts of the shot to change the muckpile profile. A basic rule is that a hole that detonates a long time after the hole next to it will tend to move into the gap where the last hole was. It's possible to change the height of the pile and where the pile sits by changing the timing between the holes.

Integrated safety and security – Pyrotechnic detonators have a very advanced and shielded fuse, but they can still be set off by anyone with the appropriate tools. Similarly, an electric system can be set off by stray electrical currents, such as radios, lightening, mobile phones, etc.

While each electronic system differs between suppliers, generally speaking, the firing box communicates with each detonator in the circuit via the internal microchip to check for continuity by using enough power to test the circuit, but at no stage enough power to initiate the detonator. Any faults in the circuit are reported to the firing box. Once the firing

box is armed and ready to fire, full power is delivered to the detonators to enable initiation. Additionally, because electronic detonators have a built-in microchip, they have a unique serial number that can be tracked if required.

Reduced detonator stock requirements – Pyrotechnic detonators are a fuse, so the timing delay that is on the box is based on a very small fuse in the detonator. This means for each timing, a different detonator is needed. If different lengths of detonator are needed for each timing, a dozen or more different detonator piles might be needed, but only a couple of types will be used for each blast. With electronics, the timing is programmed in, so only different lengths are required. With less than half the combinations needed, double the quantity of each length can be used in the same magazine.

The Technology on the Market Today

There are a number of different suppliers marketing products today and everyone in the industry has their preference.

There are "single chip" systems where the same chip/capacitor that is used for testing is used for firing. This makes the product cheaper but more pedantic when programming the detonators, and more fragile—only so much energy can be sent during testing and programming.

Other products are more expensive but have arguably more robust, dual chip/capacitor systems, where one chip is used for programming the blast and the other one for firing it. A smarter and more powerful programming chip enables more to be done automatically and robustly. There's no concern over sending too much energy to the chip and setting it off, as the firing chip only is unlocked at firing time.

There is only one system with vibration modeling and muck pile shaping in its software. It's possible to instruct it to shift and lift in certain directions, and protect areas. It can send the timing to the detonators and provide information on what impact that has vibration-wise on the sensitive points.

The timing programs for the other products are more manual, and if they have vibration modeling it's generally only available at extra cost or access is only available by hiring their technical team.

Best-for-project is Key

Selecting technology based on what is best for project must be front-of-mind for any drill and blast team.

If the project is basic, using advanced electronic systems won't realize any productivity or cost benefits when conventional products will perform what's required.

On the flip side, an unwillingness to adopt electronic technology because of the perceived extra costs or training required—when the likelihood that the cost efficiencies gained in other areas of the project would outweigh the upfront capex—would be an unfavorable approach in any economy, and even more so in the current climate.

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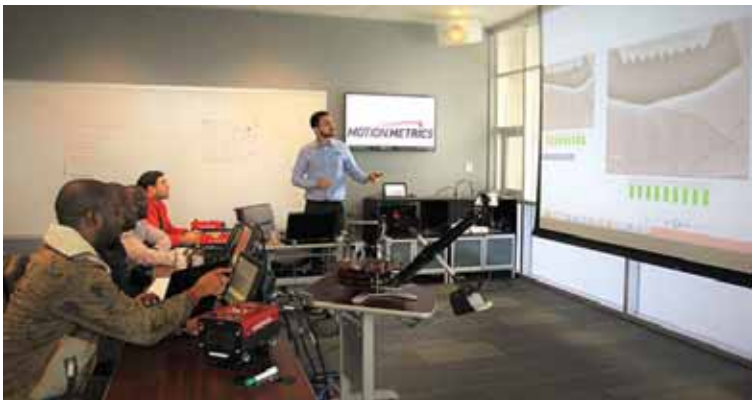
With today's mining industry facing tough challenges, Motion Metrics offers innovative solutions putting safety and cost-effectiveness at the forefront. Using the latest in machine learning and artificial intelligence technology, Motion Metrics solutions are designed to ensure that mines operate in the safest and most efficient way possible.

The company was founded in 1999 by Dr. Shahram Tafazoli who had developed a state of the art payload monitoring system for hydraulic shovels as a PhD student at the University of British Columbia. During the early years, Motion Metrics was focused on improving mine productivity with bucket-by bucket payload monitoring, but working alongside the mining industry brought the problem of broken shovel teeth to the company's attention. Broken teeth are a major problem for a mine as they can get hauled away with the rest of the material and end up jamming the crusher, requiring a dangerous and costly removal process and long hours of downtime. Motion Metrics saw this as a lucrative opportunity and developed the unique camera-based missing tooth detection system that put the company on the map.

Today, missing tooth detection and payload monitoring, along with in-bucket fragmentation analysis, tooth wear monitoring, and blind spot surveillance form the basis of ShovelMetrics™, Motion Metrics' complete monitoring solution for shovels and excavators - a system that has been installed on over 240 shovels worldwide. Motion Metrics has also developed a complete monitoring system for loaders. LoaderMetrics™ uses a modified version of the missing tooth detection system using a thermal camera with a lens cleaning system and deep learning algorithms, which automatically detect when a tooth goes missing. ShovelMetrics™ and LoaderMetrics™ are designed to maximize the amount of useful data collected by mining machinery while minimizing safety hazards, equipment damage, and machine down time.

In addition to machine monitoring solutions, Motion Metrics is also a leader in rock fragmentation analysis. When the



ShovelMetrics™ missing tooth detection system was first deployed, Motion Metrics saw that the overhead bucket camera could also be used to capture valuable rock fragmentation data, which mines could then use to optimize their drilling and blasting parameters. Motion Metrics went to work developing an advanced algorithm to automatically calculate particle size distribution. This in-bucket fragmentation analysis solution is now being used by ShovelMetrics™ clients around the world. In 2014, Motion Metrics unveiled PortaMetrics™, a game-changing solution solely for fragmentation analysis. PortaMetrics™ is a patented "point and shoot" tablet for on the spot fragmentation analysis. Using 3D imaging technology, this hand-held device measures particle size distribution and slope without the need for reference scaling objects.

PortaMetrics™ allows users to safely capture, process, and manually alter images in any environment. It works by integrating three high-resolution cameras into one hand-held device, capturing and interpreting 3D images of any bench face, stockpile, or quarry. An essential tool for every mine and quarry, PortaMetrics™ has been proven effective on all types of material from large blasted rocks to one inch crush. In a recent test at a full-size production quarry in Texas, Orica engineers used the device to evaluate crush piles of known sizes and found that PortaMetrics™ was 20% more accurate than the competing product as well as much easier to use.

To encourage more users to adopt this versatile 3D imaging fragmentation tablet, Motion Metrics has introduced subscription pricing. Under the new pricing model, PortaMetrics™ users can purchase a yearly subscription starting at US$12,000. The subscription includes the patented PortaMetrics™ 3D imaging tablet, ongoing support from our in-house team of fragmentation experts, and complementary access to MetricsManager™ Pro, our online data management platform.

MetricsManager™ Pro integrates ShovelMetrics™, LoaderMetrics™, and PortaMetrics™ data onto a single cloud-based web application that serves as a centralized platform to access all Motion Metrics system data. Customizable dashboards allow mine personnel and support specialists to easily monitor the health of each Motion Metrics device. With laptop, tablet, and smartphone compatibility, detailed equipment productivity reports can be easily generated. MetricsManager™ Pro provides real-time equipment status updates, shovel productivity reports, tooth wear prediction rates, and fragmentation analysis reports. With our centralized management system, clients can use big data to minimize site incidents and maximize mine productivity.

At Motion Metrics we back all our solutions by providing comprehensive customer support. We take pride in the ongoing relationships we maintain with our clients. Our engineers travel around the world to perform everything from on-site installation and commissioning, to training, to scheduled maintenance, and performance reports.

For more information, please visit www.MotionMetrics.com.

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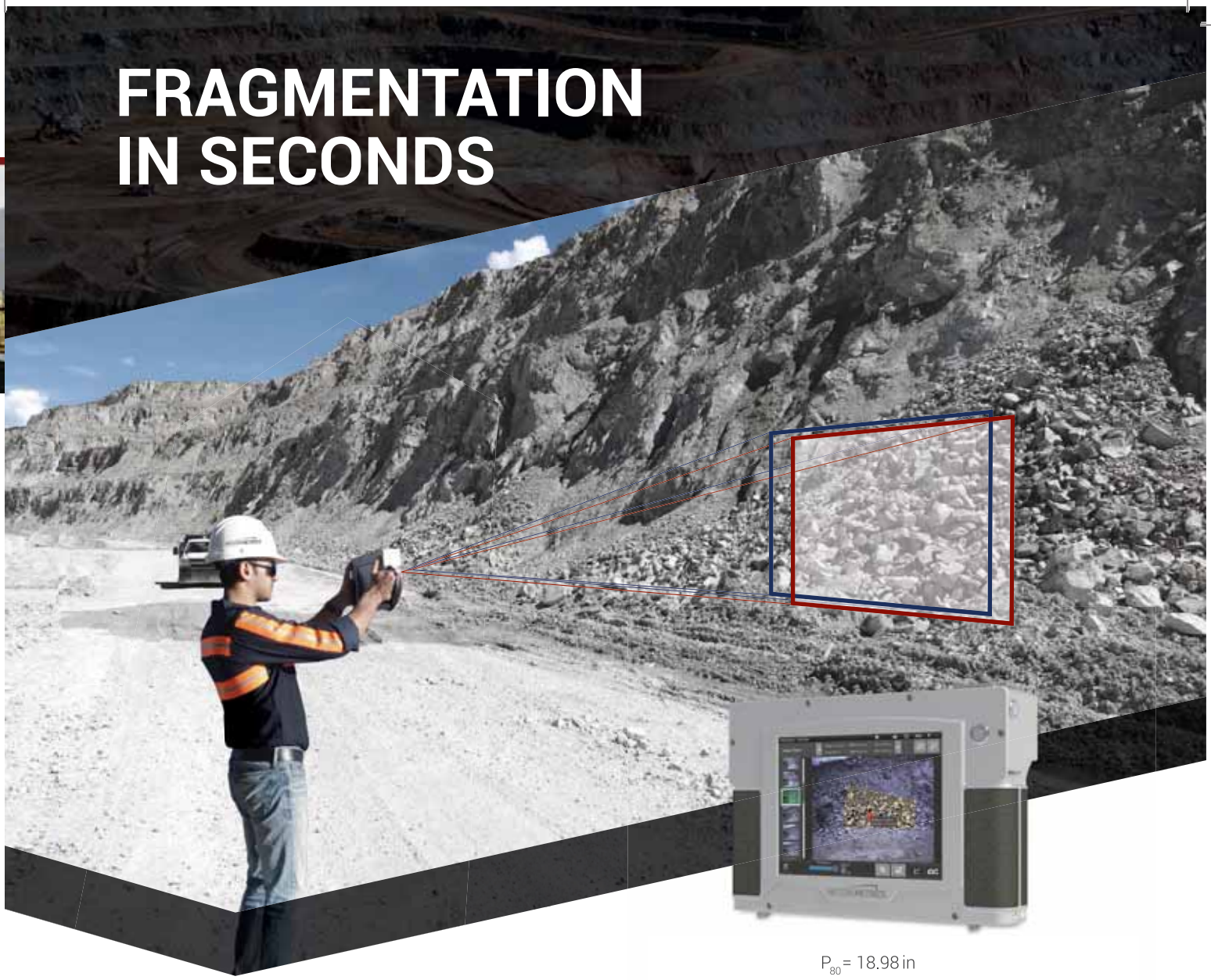
FRAGMENTATION IN SECONDS



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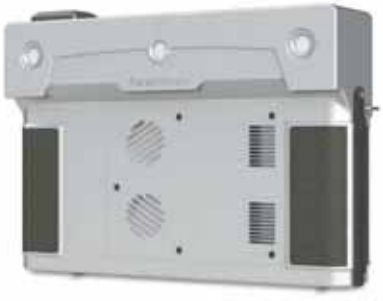

PortaMetrics™

PortaMetrics™ is a patent-pending portable tablet that provides fragmentation analysis of your desired scene without the need for any reference scaling objects.

- Fragmentation Analysis
- Slope Sensing
- GeoTagging
- Cloud Connectivity

For more info visit **www.MotionMetrics.com/portable/**

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