Mining productivity is heavily influenced by the outcome of the first stage of rock breakage – drill and blast. The highest operational costs in the mining process lie downstream of blasting, yet the pathway to delivering sustained productivity and unit cost benefits lies in blasting to specification, irrespective of variation in rock mass. The downstream processes are impacted by many variables and the capability to systematically understand fundamental blast performance, such as fragmentation, is of increasing importance and value. This is especially true in the digital age, where technology enables miners to realise the holistic vision of pit to port optimisation.

Fragmentation measurement has long been recognised as one of the required validation points of blast performance. To this day, in most mines, blast fragmentation measurement is enabled by manual image capture, followed by varying degrees of manual and automated image analysis. However, this method of measurement has its limitations.

Manual image capture is costly and impractical from both an operational and safety perspective, and it typically does not provide enough data for miners to understand the fragmentation distribution across a blast. Put simply, sampling a day’s worth of digging with only a small quantity of photos of a given area will not provide...
enough information about how the fragmentation may vary through changes in rock domain or loading practices.

**Measurement techniques and challenges**

The most common continuous fragmentation sampling location is over a conveyor belt in a crushing and grinding circuit. This provides a measure of fragmentation feed size that is particularly useful for processing plant operators. For improving blasting outcomes, however, limitations remain. It is difficult to associate data related to the fragmentation to a blast, rock properties and explosives energy applied to the rock. This poses a barrier to continuous improvement for many operations, predominantly where blending and stockpiling occurs between the blast and the plant.

Shovel-mounted fragmentation systems are also available, bringing automated fragmentation sampling to the mining face. This provides a measure of fragmentation feed size that is particularly useful for processing plant operators. For improving blasting outcomes, however, limitations remain. It is difficult to associate data related to the fragmentation to a blast, rock properties and explosives energy applied to the rock. This poses a barrier to continuous improvement for many operations, predominantly where blending and stockpiling occurs between the blast and the plant.

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Shovel-mounted systems experience significant physical forces during operation and are more consequently more prone to reliability issues than conveyor systems. Many mines experience data loss when communications fail and raw unprocessed image data is not retained.

Furthermore, lighting conditions are not as controllable as on a conveyor. Commercial shovel-mounted systems rely on optical imaging and edge detection to define particle size. Often, shadowing effects create challenges where sunlight is casting shadows of rocks onto other rocks, leading to edge detection algorithms misinterpreting shadows as a separation between rocks, causing erroneous interpretation. As a result, the demand for more advanced, robust and automated fragmentation sampling and analysis has increased, and technologies have been developed to meet the needs of the industry.

**Digitally-enabled blasting to specification**

Automated blast fragmentation sampling and analysis is of growing interest as the industry tries to measure systematically and provide a basis for continual improvement. Miners increasingly want automated systems that are dependable in both operation and measurement accuracy, enabling them to move away from manual and non-value adding repetitive activity. Companies want insights available to them in real time, integrated seamlessly with other related data sources, and insights that drive improvements in blast designs, ultimately delivering better blast outcomes and downstream value for the mine.

**A solution for automated capture and reporting of fragmentation data**

Orica’s FRAGTrack™ is a fragmentation measurement tool that uses machine vision technologies to enable autonomous triggering, processing and supply of high frequency particle size distribution (PSD) sample data. The system can be configured for operating the face shovel, enabling continual assessment of PSD at the dig face of a muck pile, and allowing the determination of both volume and mass of material above the operational conveyor.

Improved accuracy and efficiency of fragmentation measurement is achieved with the stereoscopic image analysis using combined 2D and 3D techniques. This unique system provides a step change in the grade of image analysis as it eliminates commonly encountered conditions that result in poor sampling outcomes, such as the effect of shadows when using a 2D-only technique. FRAGTrack also ensures data security and control through the preservation of both sample and processed data on the device at times of communication failure, eliminating issues of lost and incomplete datasets.

Driven by the needs of its customers to accurately assess blast outcomes including fragmentation, Orica is investing in developing intelligent and autonomous measurement systems that are easily integrated into existing mine ecosystems. FRAGTrack is designed to improve productivity and optimise drill and blast through the integration of fragmentation data into the drill and blast planning and design processes. This creates an opportunity for customers to significantly improve downstream outcomes.

**Case study – optimising fragmentation for downstream process efficiency**

An operation in South America has demonstrated how automated, high quality fragmentation analysis enables the delivery of value downstream. In Coquimbo (Chile),
an opencast copper mine located less than 1 km from the town of Andacollo was experiencing reduced and fluctuating daily production due to the increasing rock hardness and challenging geological conditions.

To understand how the fines content (smaller than 1 in.) affects the semi-autogenous grinding (SAG) mill throughput, six months of operational data was statistically analysed by Orica. It was determined that an increase of 20% in the fines content would be necessary to achieve the desired throughput. Based on these results, Orica proposed a series of trials focused on blast fragmentation improvement, with the objective of increasing the SAG mill throughput.

Modelling showed that the fragmentation around a standard blasthole was not as fine in the stemming zone. To resolve this problem, Orica increased the subdrill without modifying the bench height. By doing so, the additional explosive in the ‘extra subdrill’ would improve fragmentation in the stemming zone of the next bench down. Holes were offset from one bench to the next to improve blasthole collaring and place the ‘extra subdrill’ in the zone between blasthole toes. This proved to be the most effective way of producing the desired fragmentation result for the mine.

To achieve the result that provided the right fragmentation profile to improve mill productivity, Orica made extensive use of fragmentation measurement both in the pit and at the plant. Automated fragmentation measurement over the conveyor belt captured the fragmentation measurement before the rocks entered the SAG mill. This data was critical to baselining fragmentation and blasting performance for rock domains sources from geotechnical data, and then analysing this versus mill productivity. It was also used for modelling improved blast designs and measuring fragmentation to validate outcomes.

The results of implementing the modelled designs showed a 16% decrease in the 80% passing size for run of mine (ROM) fragmentation from the preconditioned benches, as well as an increase in fines content from 35.4% to 39.0%. Fines content in the SAG feed also increased by 8%.

Furthermore, improved and consistent fragmentation has led to a better particle size distribution in the SAG mill feed, and the throughput consequently increased by 2.3%. This led to a decrease of 1.8% in SAG energy consumption and significant financial savings for the mine.

**Boosting productivity and blasting quality**

Orica’s next generation BlastIQ™ digital platform is designed to optimise blasting outcomes by integrating data and insights from digitally connected technologies across the drill and blast process. Solutions enabled by BlastIQ aim to deliver predictable and sustainable improvements that reduce the overall cost of drill and blast operations, boost mining productivity and safety, and facilitate regulatory compliance.

The BlastIQ platform enhances blast performance and outcomes by connecting data under a single platform.

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**Figure 3. View of crushing plants and the mine.**

**Figure 4. Chart showing an increase in ROM fines and SAG feed fines from standard blasting and preconditioned blasts.**

**Figure 5. The BlastIQ suite of integrated technologies.**