Each year, inefficient coal recovery in challenging geologies at coal mining operations around the world results in significant financial impacts for operations. Maximising coal recovery and extracting marginal coal seams represent a significant opportunity for coal mines to increase the value of their resource and productivity of operations.

A blasting programme that optimises fragmentation and placement of the overlying waste material, whilst protecting the coal seam from damage and dilution, is critical to ensuring the success of the operation. An integrated blasting solution combines technical expertise and innovative technology with smart systems that enable mine operators to better understand the localised geology and coal seam location, ensuring the optimal blast result can be achieved.

**Understanding the coal seam with gamma logging**

Accurate identification of the coal seam location is the first step to preventing damage or dilution of the coal seam. Understanding the potential inaccuracies associated with site geological models and/or drillers touch coal information allows for accurate modelling and correct placement of explosive charges to protect the coal, without compromising the fragmentation or placement of the overlying material to allow for efficient excavation.

At a coal mine in Queensland (Australia), gamma logging was introduced in addition to an Orica total load and blast design service, to conduct localised mapping of the coal seam and provide an accurate model for blast designs. Gamma logging, combined with the accuracy of implementation associated with the Orica blast design and loading service, enabled the mine to implement a successful through-seam blasting operation. The coal mine recorded a significant improvement in coal recovery and recorded significant increases in excavator production rates from 18-36%.

**Blast design and modelling**

Control of both blast material movement and energy transfer into the surrounding rock mass during a blast operation is critical in preventing coal seam damage and value degradation. The ability to successfully model a blast design and predict likely outcomes removes the need for excessive trial and error in the field, and significantly reduces the time spent on continuous improvement associated with a coal loss reduction programme.

The use of blast design software, such as Orica's SHOTPlus™ – unique in its capability to handle complex blast designs –
combined with heave modelling software and mechanistic blasting model (MBM) modelling tools, allows technical services engineers to test, design and predict outcomes of proposed blast parameters including, but not limited to, blast movement, rock fragmentation and estimated coal damage.

Orica’s heave modelling software was utilised at a coal mine in New South Wales (Australia) to assess impacts of various blasting methodologies on coal loss. The successful selection and implementation of the optimum blasting method resulted in a reduction in coal loss from 11.5% originally, to 0.7% with the new blasting methodology.

In addition to blast modelling and the advanced design capability of the SHOTPlus software, Orica also provides an integrated technology solution to assist with blast optimisation using the BlastIQ™ system. The system, released in 2018, connects the mine planning office to the bench and empowers customers to manage the quality of blast execution. Blasts can be tailored to efficiently utilise energy and reduce wastage. Better quality blasts can be delivered, using targeted specifications that result in increased downstream productivity and reduced unit mining costs.

The BlastIQ system also allows customers to view blast designs relative to neighbouring blasts and the total mine landscape. The system overlays related mine information and previous blasting outcomes, such as coal loss, to provide rapid and improved insights on previous blasts and assists in determining required changes for improvement in future blasts.

**Controlled energy delivered at the right time**

Energy control, along with movement of the waste material during a blast, is critical in preventing coal losses associated with blasting. Localised geological data analysis using geophysical logging ensures that explosive energy can be tailored to suit the surrounding rock mass properties. Blast results can be optimised with Orica’s broad range of bulk explosives, minimising the risk of damage to the coal seam and ensuring suitable fragmentation of the waste material for maximum excavation productivity.

In addition to the broad range of energy offered through Orica’s bulk explosives range, the use of Orica’s premium i-kon™ electronic detonators allows for greater and more precise control over the blast initiation sequence and associated blast movement. This results in even greater coal recovery and optimised productivity for mining operations.

At one of the longest established coal mines in Queensland, concerns were raised over the effectiveness of through-seam blasting using older generation non-electric detonators, which were prone to inaccuracies and misfires, resulting in substantial coal loss and coal recovery significantly below target.

Blast modelling was conducted by Orica to assess the potential benefits associated with the introduction of electronic detonators, due to the ability to manipulate both firing sequence and direction. Adjustments were made based on assessments of previous blast results, and analysis of individual blast conditions allowed the initiation sequence to be designed in SHOTPlus.

Introducing the premium i-kon electronic detonators allowed for adjustment of timing delays between decks and the adjustment of angles of initiation, minimising potential for movement of the coal seam, which occurred with the typical timing techniques used with non-electric initiating systems.

Blasts were designed in individual layers, with each layer initiated to move material along the strike of the coal and maximise confinement of the seam. The outcome delivered minimal potential for movement of the coal seam, whilst still providing suitable fragmentation of the surrounding material to allow for more efficient coal recovery.

The through-seam blasts with the i-kon electronic detonators at the mine demonstrated more consistent blast movement and fewer signs of visible coal disruption, resulting in a significant increase in coal recovery.

**Blasting through multiple seams with the through-seam technique**

Mine operators are under constant pressure to maximise coal recovery from their operations and, therefore, become more skillful at mining thin, deep and undulating coal seams productively without sacrificing quality of the end product. Successful through-seam blasting demands accurate location mapping of the coal seams and adjacent strata, which is critical to maximising the efficiency of mine operations.

Orica worked on a multi-seam thermal coal deposit in Indonesia, which consisted of many seams of variable thickness and dip. Seams as thin as 200 mm
were separated by interburden between 2 - 12 m thick. The highly variable geology made it difficult for geologists and planning engineers to accurately predict the location of coal seams prior to drilling.

In order to help the mine maximise the value of its operations, Orica delivered an integrated blasting solution through a total load service offer, including integrated gamma density geophysical logging techniques using SHOTPlus and its range of bulk explosives systems.

The blasts were initiated with the premium i-kon electronic detonators, allowing the mine to manipulate the blast timing between decks, sufficiently breaking the rock and ensuring coal seams were kept intact. Overall productivity and performance in both coal and interburden mining increased with faster coal exposure, and more than a 50% increase in the vertical advance of the mining blocks in the overall operation were recorded. Additionally, Orica’s gamma logging of drill holes also enabled the mine to update their pit model with more accuracy, improving their mine planning sequences and scheduling.

The use of electronic detonators and the through-seam blasting technique increased mining productivity through improved bench preparation, increased drill productivity and reduced operational delays. Blast events were reduced by 80% with an enhanced dig rate of 61%, bringing total drilling requirements down by 55%. The improved coal model accuracy of the blast implementation also reduced dilution issues, enhanced reserve estimates and assisted with the build-up of broken inventory.

The coal mine converted most of its blasting operations to the through-seam method with the continuous support from Orica to deliver consistent coal recovery and reduced blasting costs. Today, Orica continues to improve its offer with the introduction of the Bulkmaster™ 7 explosives delivery system designed for use in the opencast mining sector. The Bulkmaster 7 is the latest evolution of Orica’s market leading delivery system technology, delivering a leap in productivity and safety on bench, and another significant step towards automating drill and blast operations in the future.

Reducing the number of blasts
In central Queensland, a coal mine was experiencing substantial coal loss and damage due to the fragile nature of the coal and challenging geological conditions. Orica introduced the Stratablast™ technique onsite to help improve coal recovery and productivity, which saw coal recovery levels increase dramatically along with providing improved productivity without increasing the number of drill and blast cycles.

Stratablast can combine separate blast events into a single blast through the innovative use of the i-kon electronic blasting system. Multiple overburden and coal strata can be drilled, loaded with explosives and initiators, and blasted in a single cycle. Each layer is blasted with a unique design, enabled by Orica’s SHOTPlus blast design software and achieves its targeted blast result different from that of the other layers.

Designs in each layer generally differ in explosive type and powder factor, inter-hole and inter-row delays, direction of initiation, and initiation time and position. High throw is achieved in the overburden while coal losses and pulverisation are reduced, leading to increased coal seam recoveries. Specialised blast models and advanced blast design software are used in the design process to ensure the desired outcomes are achieved.

Stratablast was implemented successfully at the site over many years, with Orica and the customer working together to reduce coal losses and maintain productivity throughout all aspects of mining value chain.

Mine operators are under constant pressure to maximise recovery of coal resources, maintain waste movement productivity and reduce overall costs. An integrated blasting solution – developed in close collaboration with customers, combining blast modelling and management, technical expertise and services, the broadest range of bulk energy, innovative electronic blasting technologies and novel blasting techniques – helps coal operations maximise economic value, improve coal quality, and reduce coal loss and dilution resulting from blast damage.

Figure 3. The i-kon III electronic blasting system is designed to help customers improve productivity, operational efficiency and mine safety.

Figure 4. Stratablast method for combined throw blasting and coal blasting – single coal seam example.

Figure 5. The Bulkmaster 7 is the latest evolution of Orica’s market-leading delivery system technology delivering a leap in productivity and safety on bench.