WHITE PAPER / **AUTOMATION AND CONTROL FOR MINING**

RAISING THE BAR FOR CONNECTED MINING OPERATIONS

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A holistic and integrated approach to modernizing mining operations is the key to a connected, automated and controlled mining operation. Upfront planning and flexible project management help operations understand the countless supplier technology options and select the right course for maximum return.

The value of smart mining is on the rise. From underground and surface mining to modeling ore value and mineral processing, mining operations are being transformed by the deployment of new automation and control technologies.

While other industrial and manufacturing processes have implemented smart technologies over the past several decades, the challenges for mining are different. Operating in remote, harsh locations and uncontrolled environments, adopting and deploying the right automation solution is difficult. However, faced with a growing demand for energy, minerals and metals — and ongoing pressure on cost and safety — the time is right for operators to overcome obstacles and carefully examine the potential for mining automation and control.

EXCAVATING THE POSSIBILITIES

The mining industry is a matrix of complexities. From the variety of ore-bearing rocks to the diverse mining landscapes, every operation is unique. In recent years, the industry has experienced particular turbulence in fluctuating commodity prices, operating costs, production output, labor requirements and cash flow. Despite the many different operating environments and industry challenges, mining is a capital- and labor-intensive industry where automation and control offer tremendous promise.

Mining operations are broken into the distinct processes of exploration, mining, processing and closure. The right automation and control strategy targets productivity and efficiency gains, no matter where they might reside in the operational chain and offers the potential to bring together otherwise distinct and siloed processes.

Like the mining processes themselves, mining automation and control options vary and each one may not be optimal for every mine. Some mines benefit from deploying basic sensor technologies and the internet, while others leverage broad-scale artificial intelligence and cloud computing for sitewide results. Automation is about acquiring the right data at the right time to deliver insight that drives decisions to add value.

Automation is possible for a range of mining operation processes:

- Cleaning, preparing and processing
- Conveyors, crushing and grinding
- Equipment and machinery monitoring
- Exploration, drilling and sampling
- Geological modeling, surveying using geographic information and positioning systems (GIS and GPS)
- Haulage, trucking and loading
- Mine development and production
- Transportation, shipping and pipelines

The applications for mining automation and control are almost limitless and so is the confusion and uncertainty of where to begin. Working within a robust and growing market of smart mining equipment means an extensive array of suppliers and vendors offering sophisticated and often similar technologies and solutions.

No matter the mine size, location or place on the technology adoption curve, mining operators can determine the right technology solution by exploring the reasons for change, defining the goals of the operation and developing a strategy that integrates automation for optimal return.

STARTING WITH THE END

Smart mining initiatives ultimately revolve around the ability to identify, track and monitor the flow of the ore to maximize recovery and optimize processing and delivery of products safely. These functions, however, operate in challenging and hazardous environments where the terrain is often severe, access points restricted and wireless networks lacking.

With so many elements to consider and a multitude of technological options to evaluate, project clarity comes from defining an overall project objective. The outcomes of improving efficiency, lowering cost and increasing production are often complementary in terms of outcome, but defining which is the goal of an automation project to help focus efforts and streamline decisions.

Putting technology options and proprietary systems aside, mining operators can determine the fundamental reason or outcome desired for a project. Front-end planning that is collaborative across key stakeholders helps define the end-result that will serve as the touchstone for all project decisions.

Smart mine project goal clarity helps streamline technology evaluations that, in turn, can better facilitate project decision-making, planning, procurement and execution.

CONNECTING THE MINE

Key mining operation processes often work independently without the infrastructure, technology or communication capabilities to talk to each other. Integrated automation and control of the mining fleet helps systems work in unison to control costs, enhance productivity and increase awareness of activities for improved safety.

Many areas can be automated within mining. Using the project goal, operators can evaluate opportunities within the key operations to determine where automation will be beneficial.

FIXED EQUIPMENT

The life of a mine is dependent on extracting and processing ore using mechanical equipment. Automating this fixed machinery not only increases safety, but also offers tremendous efficiencies that can help to maximize the output of a mine.

Upgrading material handling using proven automated conveyor systems helps improve efficiency, reduce cost and increase safety. However, moving raw material with automated systems is just the start. Many operators are deploying automation and controls to get more value and insight into mining.

Online cross-belt analysis systems on conveyors provide real-time identification of the composition and quality of bulk raw materials as the material is conveyed. Avoiding time-consuming lab analysis, online analyzers not only determine the percentage of sellable product available but can also help distinguish the section of the mine where more valuable product resides. Real-time insight offers the

opportunity to analyze mine samples and pinpoint where higher-value ore exists. Likewise, there is an advantage and differentiation of mining companies that can deliver quality assurance on the delivered product to buyers.

MOBILE EQUIPMENT

With strict government regulation and an emphasis on safe operations, autonomous mining machinery is a practical and beneficial use of automation for the mining

DEALING WITH DISRUPTION

In a world grappling with the unexpected disruption from the COVID-19 pandemic, all industries are exploring how automation might help businesses continue to run while keeping personnel safe. For mining operators, automation offers compelling advantages that may aid with preparedness for future long-term success:

- **Advanced analytics** can track and predict how machinery is operating and target where any equipment maintenance and repair is required.

- **Augmented reality (AR) and virtual reality (VR)** capabilities guide the operation of machinery accurately and remotely.

- **Connected operations** using "internet of things" (IoT) technology provides real-time and remote analysis of operations for remote management of production.

- **GPS and remote sensing** enable operators to monitor environmental changes, rehabilitation and restoration progress and manage environmental risks.

- **Mobile technologies** can be used to easily and quickly monitor, track and troubleshoot ongoing operations.

- **Remote technologies** can help critical operations continue while keeping personnel out of crowded or high-risk areas.

AUTOMATION ADVANTAGES

As with almost every other industry, there are many advantages of effectively adopting automation and control for mining:

- **Enhanced health and safety:** Incorporating automation removes workers from high-risk areas and hazardous conditions — such as dust, heat and vibration — and provides an enhanced work experience.

- **Greater cost efficiency:** Gains are achieved in safety, productivity and performance that relay directly to operating results.

- **Improved performance:** Enhanced access to operating data improves asset management and machinery life span through predictive maintenance. Automation also provides production that does not fatigue, delivering consistent and repeatable performance.

- **Increased productivity:** Automated machinery can offer better control and accuracy for extended periods and in more remote areas. Utilizing precise data also allows the targeting of mining for increased quality of product in a quicker way.

industry. While the automation of mobile equipment has been used for some time in mining, implementation requires consideration given the infrastructure needed.

In addition to mining equipment, automation of mobile machinery involves a suite of technologies including robotic hardware, software to convert equipment, computing power, radio and wireless communication and GPS tracking, and more.

Mobile equipment automation is available in several different formats:

- **Driver-assisted technology** enables a vehicle to sense where it is in relation to other objects to be able to precisely maneuver. Many machines are only partly automated, but this technology can serve as a transition to implementing a more sophisticated command-and-control platform using GPS for remote operation of a vehicle.

- **Full automation** utilizes autonomous control on more than one vehicle or piece of mining equipment. Full automation incorporates all aspects of the functioning of machinery, including such actions as steering, braking, and blade or excavator bucket control. Full automation requires an extensive investment but offers the potential for considerable productivity gains.

- **Remote control equipment** gives operators line-of-sight of operation as well as the ability to maneuver vehicles and equipment from a portable, radio-linked control box. This automated solution helps with tight spaces, including extended or deep cuts and underground longhole stoping, but still requires personnel to be within the vicinity of potentially hazardous environments.

- **Teleoperated equipment** is remotely controlled by an operator using sensors, software and cameras often utilizing a handheld control or joystick. Teleoperation, also known as teleremote, gives operators a better view of surroundings to maneuver and removes personnel from hazardous areas.

PROACTIVE EQUIPMENT MAINTENANCE

Mining utilizes a broad array of heavy equipment — vehicles, drilling machines, conveyors and processing systems — all of which have hundreds of components and moving parts working in harsh conditions. With an emphasis on safety and lowering operating cost, mining operations cannot efficiently rely on personnel walking through sites to visually inspect when machinery may need attention.

Using embedded sensors and remote connectivity, machinery performance indicators such as pressure and vibration are monitored to alert operators of issues or attention required. Predictive maintenance monitoring and analytics are automated functions that provide real-time machine health data, so that problems can be intercepted before dangerous or expensive failures occur.

Temperature sensors, for example, can be installed to track motors, drives and bearings of machinery that allow for early detection of potential failures. Control systems can also be configured to interpret data from the electrical distribution system to track amperage against tonnage passing on the conveyor. Similarly, monitoring the load of the conveyor motor can control the variable speed drive to extend the life of the equipment. Ventilation systems with temperature monitoring and control provide critical real-time data to maintain requirements for minimum air flow and maximum temperatures, while providing automated oversight of energy consumption to minimize costs.

EXPLORING A NEW WAY FORWARD

With so many operating components, technology and supplier options, the complexities for mining automation projects can seem impossible. However, reducing the exposure of people to hazardous environments, lowering costs while raising productivity, increasing sustainability and reducing maintenance variability are benefits that make exploring automation a worthwhile effort.

For successful integration of automation and control in mining, the traditional approach to project management is not enough. Mining automation projects require an agile project methodology that develops clear goals and utilizes the necessary controls but is also capable of incorporating project iterations through a rolling wave of planning to address unique operating criteria.

Successful automation projects need a holistic view, during both the upfront planning and execution phases, that identifies the proper infrastructure and systems needed. A complete view of the end result helps identify the proper infrastructure and systems required to deliver a connected, automated and controlled mining operation. Processes need to be improved and balanced across the mine to realize the benefits of automation; otherwise, the improvements risk being only incremental and the results largely underwhelming.

BIOGRAPHIES

NATHAN BLAND is a material handling specialist at Burns & McDonnell, responsible for system design, specification, compliance submittal review, contract administration and all other aspects of material handling systems for mining projects. He has worked on projects for conveyed coal, limestone, gypsum, fly ash, bottom ash, granite and other bulk material solids.

THOMAS DOBIECKI is a senior designer with Burns & McDonnell with extensive experience in industrial control, networking and life safety systems. Focused on the mining industry, his field experience includes design, construction, construction management, troubleshooting and commissioning of systems for power distribution, fiber optic and copper networks, DCS and PLC-based control systems, field instruments, conveyors, crushing, grinding, flotation, carbon in leach, SX-EW, tailings and water treatment.

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16172-MAC-1020