Accelerating Digital Transformation to Deliver the Mine of the Future

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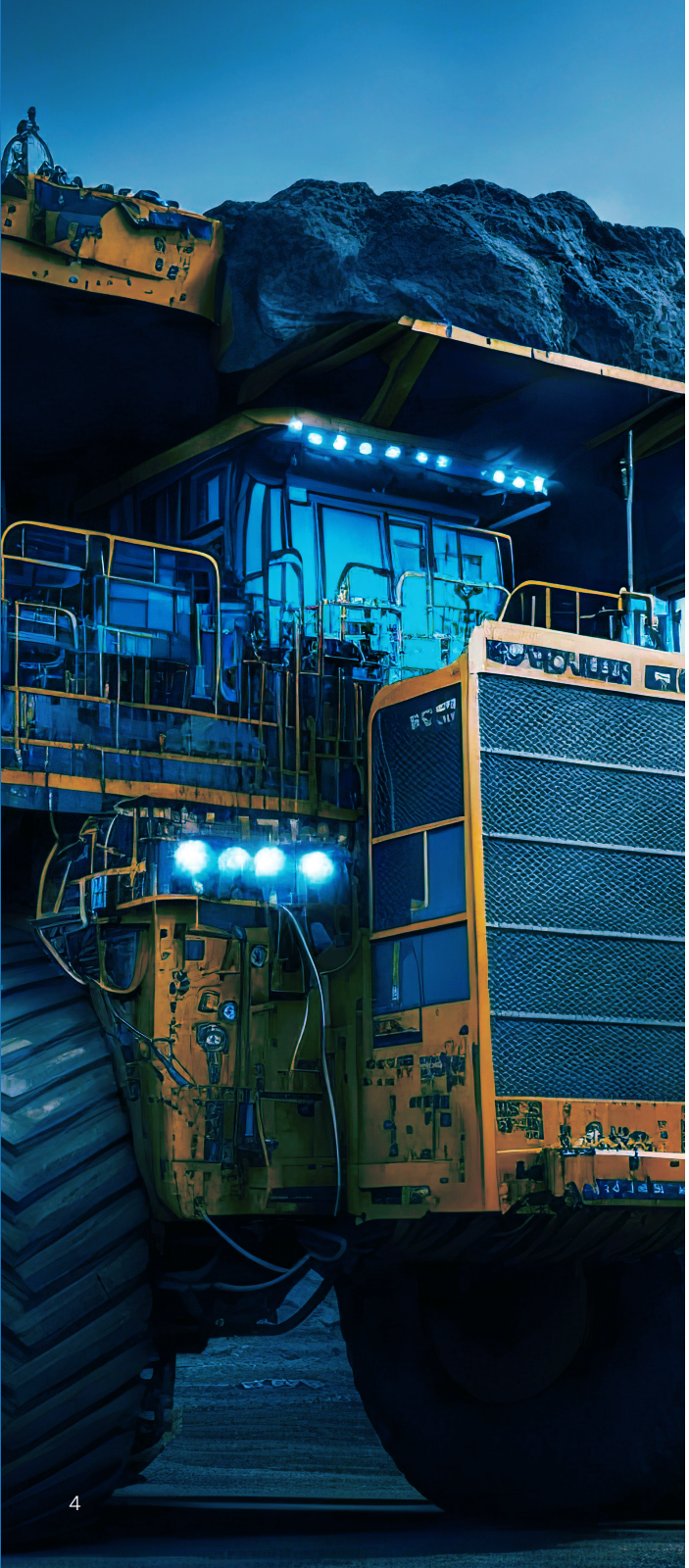
Executive Summary

For thousands of years, mining has been one of the cornerstones of human civilization, beginning with early man's discovery that certain rocks were well suited for making weapons or stone tools.

Today, the metals and mining industry is critical to the modern digital age, providing key components for everything from the batteries that power EVs to the circuits in smartphones to copper wiring, fiber optic cables, wind turbines, lasers and even light bulbs.

Demand for renewable energy is expected to continue rising in the coming decades. By 2050, global demand for energy is expected to increase by 50 percent according to International Energy Agency (IEA)[1] estimates. Spending on the electrical grid is expected to more than double, to $740 billion by 2030[2], to accommodate this growth. As electrification increases, so too will the need for key metals like lithium, demand for which is expected to grow by as much as 600 percent by 2035[3].

Yet, despite its central role in enabling a high-tech world, the work of digging into the Earth in search of metals and minerals remains surprisingly low-tech.



Industry Challenged with Keeping Pace to Implement New Technologies

While most modern mines use some amount of digital technology—to control ore processing or monitor equipment using sensors—the reality is that the pace of implementing these new technologies has not kept pace with their rapid growth. As a result, many mines are continuing to rely on older, outdated solutions.

Another big concern is that many existing technologies currently in use are designed to solve a specific challenge. Single-point solutions, though effective, ultimately create additional concerns. The lack of integration makes it difficult—if not impossible—to share data between applications with the speed needed to drive informed decision-making.

Given the scope and complexity of mining operations, the ability to communicate data from one part of the enterprise to another is critical. The expansion of an existing ore deposit, for example, needs to be factored into mine planning and scheduling systems, which then affects how equipment like drill rigs, excavators and trucks move around the site—and how mine development benches are designed, planned and blasted. As ore is removed, information about its pre- and post-blast location and grade will affect where it is stockpiled, which in turn, impacts how it is blended and then processed.

Using disparate applications from different vendors (or even the same vendor) can make it more challenging to share information natively. Some operators have resorted to low-tech methods, like using physical media, passed from one employee to another, to move data from point A to point B. That process, however, is far too slow and can lead to potential errors, data integrity issues and version control problems. Different parts of the mine may be operating in the dark, unable to communicate or coordinate with other areas, resulting in decreased efficiency and lost profits.

While more mines are embracing digital technology, the industry's relatively small margins have led many operators to be highly risk averse, and wary of spending tens, hundreds, even thousands of dollars on new technology. Even small improvements can

translate into millions of dollars spent across a massive enterprise. The same goes for negative impacts however—if new technology investments lead to performance drops or unanticipated interruptions, it can be the difference between an operation being profitable or not.

Further complicating operators' decisions about which digitalization solutions to pursue is the lack of technology expertise in many organizations. While large mining companies may have the budget to create and staff IT departments responsible for evaluating and implementing different solutions, many mid-tier owner-operators or smaller mining operations lack the funds. Often, those decisions are left to employees who are responsible for using a particular application. For instance, an employee who manages mineral processing might be tasked with selecting process software or a reliability engineer might have to choose between Asset Performance Management applications. When added to already-full workloads, employees may not have the time or knowledge to fully vet solutions, and may be more likely to choose options that are less effective, fail to meet the promised return on investment or don't integrate well with other parts of the value chain.

There can be a steep learning curve period—weeks or longer—before users get up to speed on new software and begin to fully implement solutions. With increasing numbers of older workers retiring, mining organizations, like many in process industries, are having a difficult time filling the skills gap. To attract and retain younger workers, companies will need to provide specialized training , especially with fewer mentors in the workplace.

Digital Technologies to Transform Mining Operations

While those technological challenges are significant, mining companies are recognizing the potential for digital technology to transform their operations and advance sustainability efforts while maintaining profitability. The following section highlights several critical areas where digitalization is being utilized, both now and for the future.

Remote Sensing

One of the primary ways digital transformation can impact mining is using remote sensing to simplify exploration and surveying work.

In recent years, advances in drones and unmanned aerial vehicles (UAVs) have transformed the surveying process. Using a drone, operators can fly over a prospective greenfield site and drop virtual GPS tags to mark points of interest for any purpose. Once identified, drilling rigs can drive to the marked locations, drill exploration holes and return with samples for assay analysis.

The use of drones, however, isn't limited to exploration. For mining operations, surveys are used to identify areas for possible expansion and plan how material is removed on a day-to-day basis. Rather than conduct surveys every few days or once a week, drones enable operators to survey a site—in some cases every few hours—giving them a detailed snapshot of the mine as it exists on that day, helping to plan for expansion over time.

Simplification and Comparative Algorithms

Using drones to collect vast amounts of data, however, comes with its own challenges, particularly for finding the necessary information to

make decisions. Integrated simplification algorithms—either on board the drones themselves or embedded in mine planning packages—enable surveyors and mining engineers to quickly parse data, identify the most useful information and make decisions in a timely fashion, resulting in more informed, more fluid operations.

Operations is only one area of the mine that can benefit from algorithm use. Applying simplification algorithms to topographical datasets, for example, enables geotechnical engineers to compare multiple images of open pit, underground workings or even tailings dams across time, potentially revealing changes that might indicate signs of an impending failure. Combined with physical sensors, these tools can provide meaningful and actionable early warning of potentially significant risks to safety, operations and ongoing license to operate.

Design and Planning

As mines move from exploration to operation, design and planning are critical. Using planning packages, mining engineers and geoscientists can bring together survey and geological data collected during the exploration stage to create ore body models and design open pit and underground mines. To optimize those designs, software can help identify the most efficient way to remove the least amount of overburden to reach the ore, helping the mine reach profitability faster. The same technology can also be applied to developing mines that are focused on increasing mine life through brown field exploration, slope steepening projects or development of nearby deposits that leverage existing infrastructure.

Leveraging the block model created during the modeling process, digital scheduling technology divides the mine into three-dimensional blocks, with data such as ore grade, tonnage and density, and it then sequences

the extraction of this data. By creating a constant supply of mill feed stock, scheduling tools ensure provision of supply to comminution circuits and processing plants—critical for consistent operation—and helps keep mines running efficiently over long periods of time.

Similarly, advanced design and drafting tools enable mining engineers, process engineers and consultants to estimate the capital cost of proposed designs before any work begins. As mines are built and developed over time, those tools can also evaluate the cost of changes to the fixed plant and other equipment. With knowledge of the cost of buying, transporting, installing and commissioning each piece of plant and machinery—and the ability to model how those costs change as underlying conditions change in different parts of the world—modeling solutions can save both time and implementation costs. They can also enable mining operators to make informed decisions about which alternatives are optimal for planned changes and which geographies offer the most advantages in terms of production and profitability.

Fleet Management

With dozens of trucks, excavators, drilling rigs and other pieces of equipment moving around a mine site at any one time, it is increasingly important for operators to employ fleet management solutions that enable dispatchers and fleet controllers to track not only where every piece of equipment is, but also where it's headed, how fast it's moving, how it negotiates changes or obstacles on haul roads and more.

Understanding that equipment data is critical because mine schedules are predicated on a number of factors, such as the number of trucks, drill rigs and other mobile equipment that is available on a day-to-day basis. Using automation, that information can be tracked and updated in real-time as conditions change and managers can make sure ore is delivered to the correct stockpile for processing for instance, helping the mine run more efficiently and predictably.

In addition, integrating fleet management and scheduling solutions can provide a real-time view of the impact of day-to-day operations on short-, medium- and long-term plans—and of how realistic those schedules are.

Similarly, data received from mobile plant and equipment can be fed into analytics platforms that communicate and report on performance, resulting in more informed decision-making and increased predictability of schedule-to-operations compliance.

Asset Performance Management

Mines often rely on preventative maintenance programs to keep equipment and vehicles running, given the number and variety of pieces of equipment used in modern mining facilities. More often than not, this approach leads to unexpected breakdowns. The resulting unplanned downtime can be incredibly costly. In some cases, the breakdown of just a single piece of equipment can cost millions per day. AI-driven Asset Performance Management (APM) solutions, however, can help predict failures before they happen, avoiding costly downtime. APM tools deliver predictive and prescriptive maintenance strategies, enabling mines to make maximum use of equipment before taking it offline for repairs. Those strategies help operators increase reliability by optimizing how assets are used, increasing operational predictability and the likelihood of operators meeting production targets.

Implementing AI-driven performance management systems also helps mining companies ensure that capital spending on spare parts is focused on those parts most needed for regular, ongoing maintenance, and not on warehousing parts in the event they are needed at some point in the future.

Advanced Process Control

Many of today's mines design their mineral recovery process based on a relatively simple formula—the time needed for processing and the amount of energy and reagents used are optimized for a particular grade of blended ore, varying according to stockpile availability. To deliver the ideal ore quality, different grades of ore are blended to create a consistent stream of raw materials for which the processing plant is optimized.

Mill feed blending and mineral processing, however, is far from precise. If higher-quality ore is fed into the process at the start, operators may lose valuable material that is not extracted. Starting with lower-quality ore means energy and chemicals are wasted trying to capture material that isn't there. Many processing engineers spend a significant amount of time and effort manually adjusting the disparate

parameters for their processing plants, often resulting in lost efficiency, suboptimal recovery and higher waste.

Advanced Process Control (APC) solutions continually measure, monitor and adjust each stage of mineral processing plants to ensure the optimal amount of reagent is used, a minimal amount of energy is consumed, the least amount of waste is generated and the maximum amount of metal is recovered. Using APC technology, mines can more precisely blend ores to meet their targets and adjust process parameters on the fly with far greater accuracy, supporting maximum recovery with less waste.

Integration Technology

As mines become increasingly digital, they will face a new challenge—how to manage the vast amounts of data they collect. Using historian and other integration technologies, data captured across the entire enterprise—from drone images to equipment sensors to process control data—can be collected and stored in a single, central location.

Integration technologies enable staff at all levels and parts of the organization to access recent data to drive improved decision-making and historical data to identify both positive and negative trends that can influence efficiency or profitability.

These technologies can help mitigate the challenge of having a series of different point solutions operating in isolation. Currently available integration technology can move data from single or multiple vendors, contextualize that data and serve it to any point solution that requires it.

Guiding the Journey to the Digital Mine

Taken together, these technologies can help accelerate the journey to the digital mine where the entire operations—from exploration and surveying to drilling, blasting and excavating, to processing and ultimately transporting material to customers—is integrated and all the "pieces" work together to maximize both profitability and efficiency.

In this new tomorrow, mines are dynamic, digital environments where a change in one part of the operation is instantly relayed to other parts—where if a mechanical failure forces an operator to take a truck offline, that disruption and its potential impact is automatically factored into mine schedules and other parts of the operation. Similarly, a fluctuation in the grade of ore sent for processing will prompt automatic changes in processing parameters, ensuring the recovery process works as efficiently as possible.

For now, this vision of the future for mining remains just that—a vision. No mine operator has implemented the full range of integrated digitalization solutions currently available. In the coming decades, demand for natural resources is expected to skyrocket. At the same time, mining companies will face increasing pressure to reduce their environmental footprints. The digital technologies discussed here offer a path to navigate that dual challenge.

Citations:

[1] International Energy Outlook 2021, EIA, October 2021

[2] World Energy Outlook Report 2022 – IEA Rev November 2022

[3] Lithium supply from mineral will lead the growth, Wood Mackenzie, March 2022

About AspenTech

Aspen Technology, Inc. (NASDAQ:AZPN) is a global software leader helping industries at the forefront of the world's dual challenge meet the increasing demand for resources from a rapidly growing population in a profitable and sustainable manner. AspenTech solutions address complex environments where it is critical to optimize the asset design, operation and maintenance lifecycle. Through our unique combination of deep domain expertise and innovation, customers in capital-intensive industries can run their assets safer, greener, longer and faster to improve their profitability and operational excellence.

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