Bently Nevada
a Baker Hughes business

Mining: Why digital innovation is vital

How to capture the skyrocketing demand for minerals with increased operational efficiency via predictive maintenance technology

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Executive summary

Mining dates back thousands of years. Since its inception, mining has helped civilizations and created many of today's modern conveniences. Consumer electronics, building materials, and chemical manufacturing all rely on mineral components. Coal remains the primary power source for electricity in many developed countries.

Mining is an integral part of the economy for nations worldwide and our reliance on minerals is profound and widespread. And, demand is forecasted to skyrocket in the coming years. As the world embraces new carbon neutral and green initiatives, the need for minerals is escalating. Mining companies, however, must embrace digital technology and better optimize operations to extract these minerals profitably and meet growing demand.

Since mining is a cyclical industry with capital-intensive operations, successful mining operators must achieve the lowest possible production costs. The key lever to reducing costs is maintenance, a function full of untapped potential. Areas such as decreasing the steep cost of fleet maintenance and reducing the frequency of unplanned downtime are ripe for mining innovation today in order to meet demand tomorrow. Novel predictive maintenance approaches answer this need.

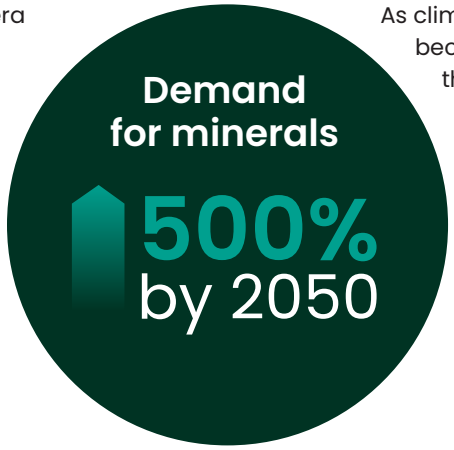
In this paper, we've outlined an innovative way forward for mining companies, built on proven and extensive industry experience. Our goal is to inform, enable, and support mining companies, help them meet their goals and collectively build a stronger, greener future for all.

Skyrocketing demand for minerals

Mining's rich history has ushered in tremendous possibilities for humankind. From salt and toothpaste to electric vehicles and smartphones, minerals are an important part of our everyday lives. The valuable resources found underneath earth's surface have enabled profound innovations, bolstered newfound capabilities, and spurred economic growth.

Today, mining is poised to catalyze a new era of innovation in green energy and low-carbon capabilities. As a result, demand for minerals is expected to skyrocket. Per a World Bank Group report, graphite, lithium, and cobalt production could increase almost 500% by 2050 to meet the demands for clean energy.

A significant lever to mineral demand is the requirement to achieve a "below 2 degrees Celsius" future. Estimates project that 3 billion tons of minerals and metals are required to deploy energy storage and wind, solar, and geothermal power in order to achieve this goal. Nearly 200 countries are committed to limit global warming to no more than 2 degrees Celsius by the year 2100, the worldwide metric that mitigates significant and negative changes to the planet.



As climate targets and clean energy requirements become more ambitious and accelerate, the demand for minerals escalates in-kind. Because of their pivotal role in our economy and future, mining companies have been and will continue to be crucial. Their track record is proof. Mining companies' resilience during volatile times has earned them the moniker, "the bedrock of economic recovery".

Urgent need: Improve maintenance and production efficiencies

In preparation to meet the increasing demand for minerals in the future, mining companies must innovate today. Specifically, proactive, versus reactive, management of mining's highly cyclical and capital-intensive operations is necessary to maintain the lowest possible production costs. Compounding this challenge for miners are rising costs in energy, building materials, and equipment. And, no miner is exempt. According to The Globe and Mail, "Cost issues do not discriminate by the metal produced or the size of the miner."

Why the urgent need for innovation? Because as demand grows, concurrently, process interruptions carry significantly steeper costs. Additionally, today's mining operations are not at appropriate efficiency levels—mostly due to maintenance issues—to fully capitalize on the increasing demand. Let's look at some data points:

70%

Currently, mining operations run at 70% operating efficiency due to breakdowns, stalled production, and other operating issues

30–50%

Maintaining plant, fleet, and equipment comprises 30–50% of mining operating costs

3–5X cost

Breakdowns and unplanned maintenance are 3–5X greater than planned maintenance

5% RAV

The average mining facility spends 5% of RAV (replacement asset value) on maintenance each year. By contrast, top performers spend 60% less, or 2%of RAV, on maintenance

Enter: Digital technologies and data strategies

To overcome these current operating challenges, the adoption of automation and digital technologies is required. Technological capabilities will foster the creation of "Digital Mines" and help to:

1. Prevent failures/breakdowns/unplanned downtime
2. Enhance worker's safety
3. Improve efficiency
4. Reduce energy consumption
5. Meet environmental requirements

Maintenance is the first step, and a powerful lever to achieve lower production costs in mining.

Consider this mining example, where predictive maintenance technologies enabled the reduction of unplanned downtime. Condition monitoring insights provide the data to alert operators of potential failures prior to functional failure. Thus, it allows proactive scheduling of work to occur during planned maintenance, partial outage periods, or normal equipment rotations. This optimizes production, increases asset availability, and minimizes maintenance costs while enabling reliable operations. The result? A 14% reduction in maintenance spend which produces an $8 million reduction in operating expense.

Current state—maintenance spend of $56.7M

Planned	45%	$20.0M
Unplanned	55%	$36.7M

Improved ratio—maintenance spend of $51.1M

Planned	70%	$31.1M
Unplanned	30%	$20.0M

Improved ratio—maintenance spend of $48.8M

Planned	80%	$35.5M
Unplanned	20%	$13.3M

14% reduction in maintenance spend equivalent to ~$8M in OPEX

Source: PWC report "Balancing Uptime and Working Capital: Maintenance and Inventory Strategies in Mining"

Innovation and transformation, however, go beyond just reducing maintenance costs and implementing predictive maintenance technology. For mining companies, it's about working differently and working smarter, to achieve more reliable mining operations. Foundational to this goal is the need to develop a digital data strategy—across functional siloes and technologies.

The potential of data to transform operational effectiveness is irrefutable. However, there is a big jump between collecting data > using and analyzing data > extracting actionable and meaningful insights from that data. A 1% utilization of data, for example, is the equivalent of squandering 99% of the data-collection investment. Without industry-tailored algorithms and actionable insights to drive measurable business outcomes, the full potential of data-driven innovation cannot be realized.

Similarly, balance is key. Data helps drive smarter decisions by balancing the reduction of maintenance costs while simultaneously ensuring improvements in operational efficiency via equipment reliability and availability. Enabling operation-wide optimization mandates change. This change begins when the shift from reactive, tactical maintenance to predictive, strategic asset management is underway.

In mining operations, employee safety is of paramount importance. Technology is recognized as a key determinant of enhanced safety. Due to less machine interaction and a decrease in urgent, reactive work, the outcomes of proactive, planned maintenance can also foster significant improvements in safety. In one example, an OEE (Overall Equipment Effectiveness) improvement of 52% delivered a safety improvement of 69% during a 10-year period.

Source: https://www.lce.com/A-Reliable-Plant-is-a-Safe-Plant-1266.html

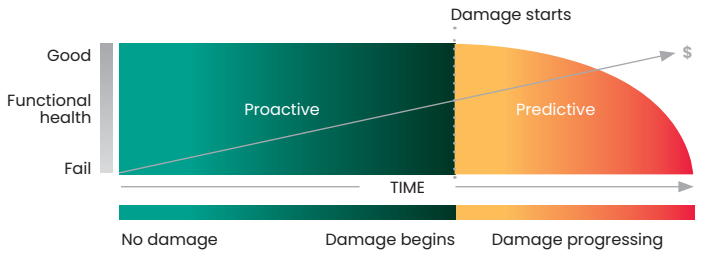
The power of condition monitoring systems

In mining operations, predictive condition monitoring systems are the gateway to unleashing the latent potential in maintenance and strategically leveraging it. While condition monitoring systems are proven to deliver outcomes, adoption in mining operations is often in siloed applications and not fully integrated as a sustainable business process. Data-driven, predictive condition monitoring systems, however, are now a must-have competency across mining operations.

The underlying tenet of predictive solutions is this: failure is a process, not an event. This means there is an opportunity to mitigate full failures at the lowest possible cost and with the least operational impact. It also means that time-based systems, although still in use today, are poor predictors of potential failure. Time-based systems can create avoidable and costly unplanned downtime, while also incurring preventable costs and downtime with unnecessary routine maintenance tasks.

Failure is a process

Condition monitoring's unique value is built on failure as a process. The P-F curve depicts this concept by delineating the span of time between potential failure and functional failure. Indicators of asset health are used to identify potential failure prior to any damage or degradation. As a result, higher order situations can be averted, sound decisions made, and repairs scheduled at the most advantageous times and lowest possible costs.



How condition monitoring detects potential failures

The way that condition monitoring systems predict impending failures before they occur is by monitoring and assessing an asset's mechanical characteristics such as:

- Vibration
- Temperature
- Efficiency
- Oil chemistry/particulates

By monitoring these variables, customized for each asset, pattern changes or anomalies can be identified. Together with tailored algorithms and customized configurations and set points, operators are then alerted to developing issues that need to be addressed.

Different minerals, different assets, different strategies

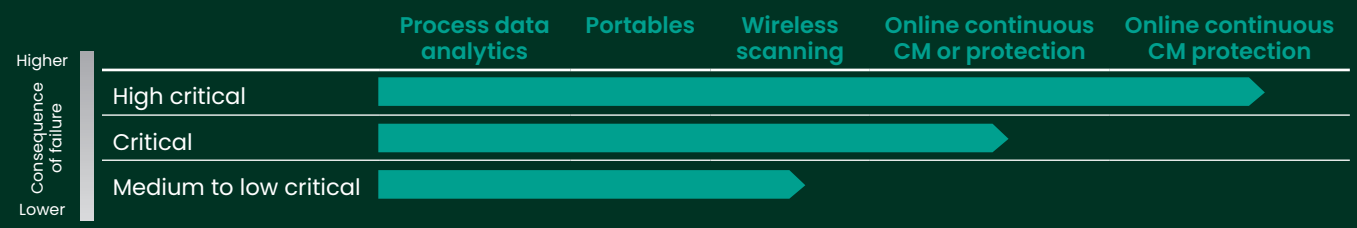
Across mineral types, the three primary mining processes, surface mining, underground mining, and mineral processing, are diverse. Further variations, such as open pit, quarrying, slope mining, and shaft mining, exist within the three major mining categories. Within each mining operation, there are many different assets used (spoiler alert: mining schematic in next section).

While condition monitoring is beneficial across all mining types and processes, different machines require different strategies. As shown below, factors such as consequence of failure, availability of replacement parts, and criticality/process all impact condition monitoring specifics.

Additional customization is done for each asset upon implementation to collect the proper data. And, industry-tailored algorithms diagnose that data into actionable insights and a roadmap. A clear roadmap helps mining operators to prioritize maintenance activities, establish focus, and incorporate knowledge-based experience "automatically", thereby reducing dependence on the inherent variability in workforce experience while boosting employee safety.

Different assets, different approaches

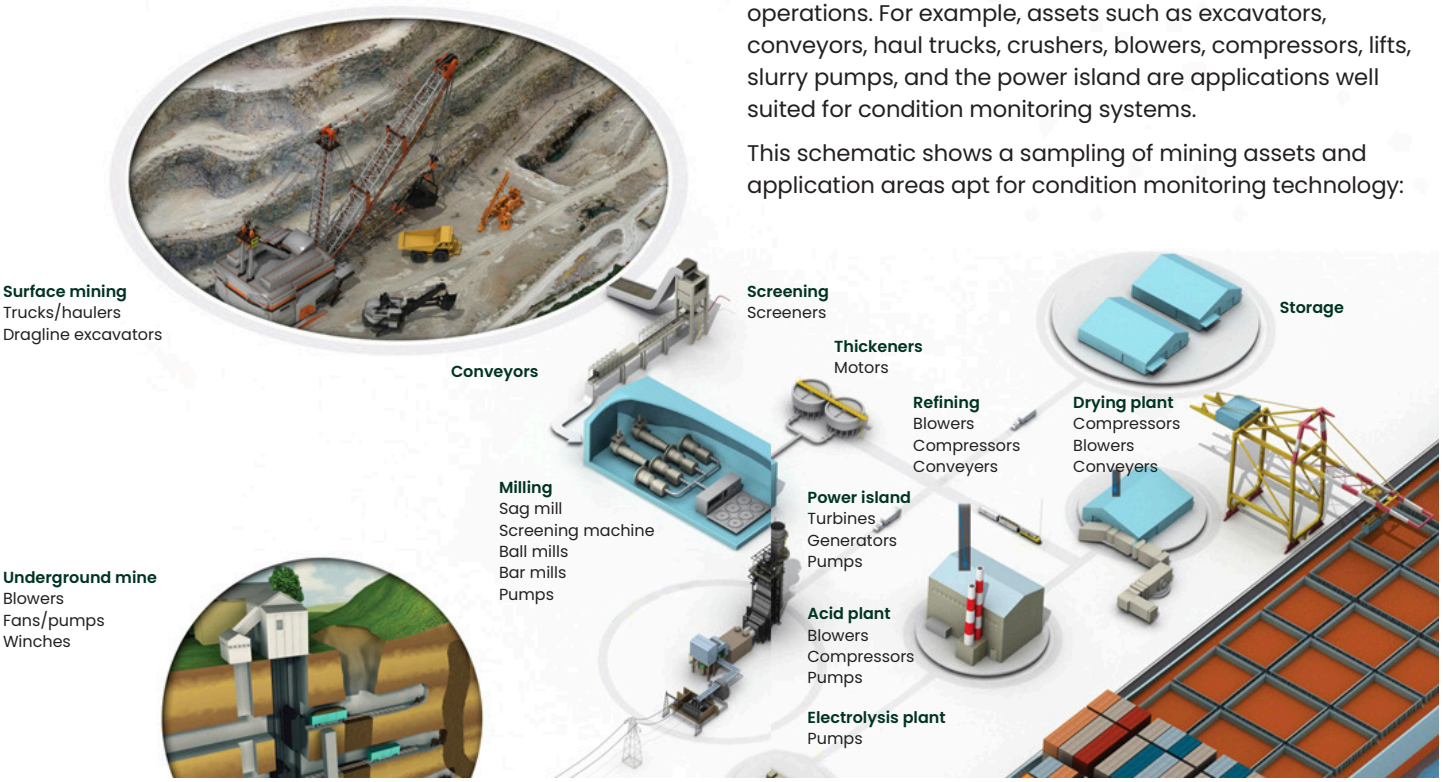
Based on the criticality rank of assets, the assets are divided into high critical, critical, medium to low critical ranking.



The digital mine: Application areas

Automation and digital technology, starting with condition monitoring systems, can be used throughout mining operations. For example, assets such as excavators, conveyors, haul trucks, crushers, blowers, compressors, lifts, slurry pumps, and the power island are applications well suited for condition monitoring systems.

This schematic shows a sampling of mining assets and application areas apt for condition monitoring technology:



Haul truck example

In mining operations, reliance on haul truck health is escalating. Haul trucks move raw materials, so extraction speed must correlate with transportation speed. Miners have been investing in larger, automated trucks to ensure better timing alignment. As such, monitoring the health of these assets to bolster availability and reliability is an increasing challenge. Unique haul truck requirements, such as offline monitoring effectiveness, data collection at precise and critical times, and a data link to a monitoring center, must be overcome.

For one mining company, Bently Nevada engineered a customized solution for the haul truck's control system to monitor its' health in two critical states:

1. Running and loaded. Vibration data is collected while the truck is running, loaded and in reverse mode (braking the truck using the electric motor of the electric wheels).
2. Unloading. Vibration monitoring when the haul truck bucket is rising.

The result? An estimated savings of $5 million USD per year. This is based on an iron mine fleet of 30 trucks operating at 80% capacity. Specific savings categories include: $40K USD savings per truck/year, the mitigation of catastrophic failures (using wheel cost of $400K USD) and the increase of uptime and availability of haul trucks which in turn reduces maintenance time and intervention activities.

Getting started

Outcomes like the haul truck example above are transformational for mining companies—and this is just one of many applications possible for mining operations. All condition monitoring systems, however, are not created equal. In fact, as digital technologies and automation are used more frequently in mining operations, proven, comprehensive experience becomes increasingly important. Since technology investments must be scalable and connectable, it's essential to start with the proper foundation.

To ensure optimal performance, miners need industry-tailored solutions via a like-minded partner with deep, proven expertise in full-suite condition monitoring technology and mining operations.

Essential attributes of top tier condition monitoring systems

When paired with an experienced solution partner, here are some of the most essential attributes of a top tier condition monitoring system:

Cyber secure architecture
Data extractions based upon specific domain expertise and reliability engineering competencies
Interface to corporate data systems
Enterprise-wide focus (including fleet analysis) with multiple predictive maintenance techniques and analysis methodologies within a single, standard software platform
Templating for deployment and maintainability efficiencies
Human-machine interface (HMI) visualization of all asset health data across enterprise hierarchies (from fleet level to individual production assets).
Exception-based monitoring design, which assigns subject matter expertise to configure and optimize the system only when a pre-configured alarm threshold or automated fault detection triggers the need for analysis. This can drive more effective deployment of maintenance and reliability resources and may reduce analysis workload by 90+%.

Summary

The gateway to a greener future rests largely on the strong, time-tested shoulders of mining companies to supply the minerals for energy storage solutions and make "below 2 degrees Celsius" initiatives possible. To help mining operations to meet this increasing mineral demand, technology innovations are needed to better optimize production. Monitoring critical asset health to reduce maintenance costs and mitigating unplanned downtime is the first step. Expanding further to connect siloed data and optimize entire operations will bring additional benefits. The key is to start today so that lower operating costs help miners harness the benefits of increased uptime, optimized productivity, enhanced employee safety, and improved profitability. When this happens, mining companies can reap significant benefits.

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