Condition monitoring in mines

2024 Report

Bentley SEEQUENT

Contents

Introduction

The global mining industry plays a vital role in the world economy by providing essential resources to businesses, including coal, metals, minerals, and precious stones. Generating several trillion dollars in revenue annually, the industry encompasses thousands of active mines spanning many countries around the world.

Yet the sector faces a series of pain points and needs, including the need to reduce risk and improve safety, meet ESG and sustainability goals, ensure regulatory compliance and good governance, better understand mine site performance, and achieve system and data integration. These factors heighten the imperative of optimizing condition monitoring practices and workflows.

To understand condition monitoring trends and practices across industries, Bentley Systems commissioned ThoughtLab to conduct a global survey of 400 industry experts from North America, Europe, and Australia. Experts included a mix of C-suite executives, technical managers, and technical staff working for companies ranging in size from under 100 employees to over 1,000.

The survey included 52 mine owners and their service providers–such as engineering firms and consultants–who focus on geotechnical, structural, and environmental monitoring. The responses from these experts are covered and analyzed in this report. The results clearly show the progress that mine owners and service providers are making in condition monitoring—including a shift to automated monitoring—to achieve their goals for sustainable operations, enhanced mine site safety, and greater efficiencies over the longer term.

Current landscape

Automated condition monitoring predominates for mines

Geotechnical, structural, and environmental data collection is now largely automated in the mining industry. However, mine owners are further along in automation than their service providers—particularly in the most advanced data collection method, automated remote monitoring for transmission via telemetry. Moreover, nearly a quarter of mine owners fully automate their data collection versus 17% of service providers.

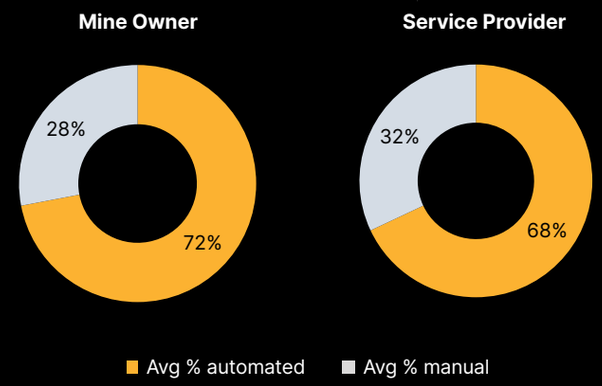
Why mine owners are moving faster

One reason that mine owners succeed is that they tend to be large, sophisticated firms with the resources to install automated monitoring systems. They understand the myriad benefits of automated monitoring to improve efficiency, reduce costs, mitigate risks, and ensure compliance. Given such benefits, service providers have the opportunity to move faster to automation to stay in step with the needs of their mining clients.

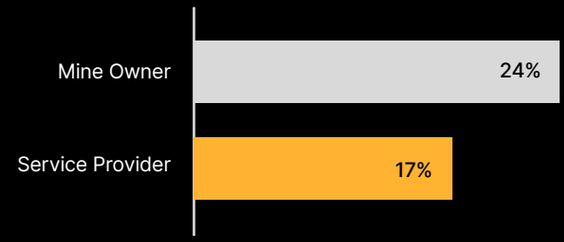
> We leverage real-time monitoring capabilities to enable faster decision-making and proactive maintenance.
>
> – Chief Digital Officer, Canadian mining firm

Q. How does your organization collect data for its monitoring programs?
Q. What percentage of your organization's monitoring utilizes manual data collection?

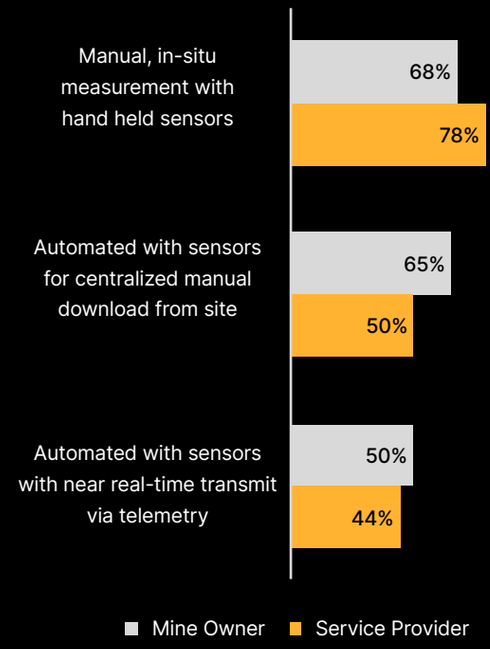
Average % automated vs. manual collection of data



% of companies that fully automate their data collection



Monitoring data collection methods



Mine owners integrate more data sources

Both mine owners and service providers use a range of software to analyze the condition monitoring data that they collect. On average, mine owners employ 3.8 software applications, compared with 3.3 for service providers (out of nine that we surveyed). Most favor general-purpose programs such as Excel, Tableau, and Power BI, rather than specialized software designed to analyze sensor data.

However, as both mine owners and service providers advance in automating their condition monitoring, they are likely to adopt specialized software that provides benefits, such as real-time monitoring of data, advanced visualizations of the subsurface, and customized reporting.

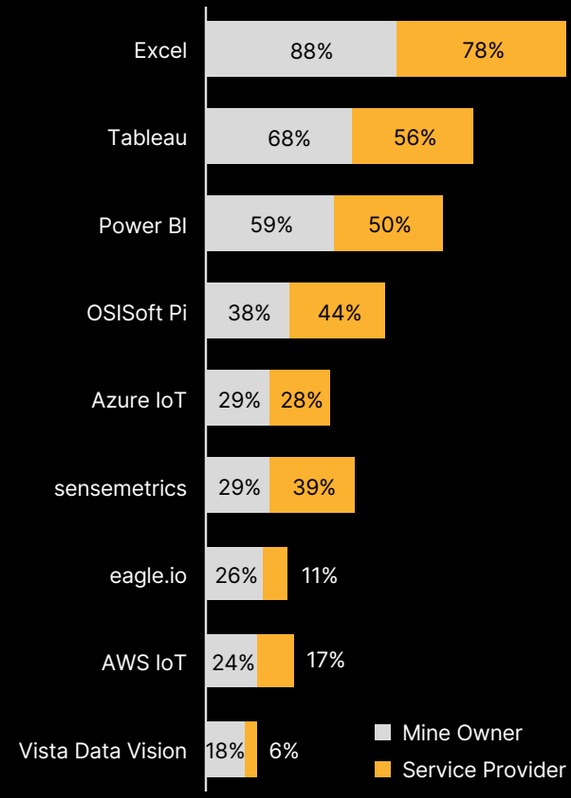
Integration with other data sources is key

Organizations can enhance the value of condition monitoring data if they integrate it with data from other information sources. Mine owners, who tend to be more automated than service providers, are more apt to do this integration, particularly with data from asset management systems. These systems give owners a holistic view of mine performance and maintenance history.

Mine owners and service providers integrate their sensor data with geoscience data, GIS layers, digital twins, and predictive models. These capabilities give them the ability to forecast maintenance requirements, anticipate mine-related risks, and make timelier and more data-based decisions.

Q. What software do you leverage for sensor monitoring activities?
Q. Is your organization currently integrating sensor data with additional information sources to increase insights? If so, which of the following apply?

Software used for analysis



Integrating sensor data with other sources

	Mine Owner	Service Provider
Asset management systems	71%	50%
GIS layers	50%	39%
Digital twins	41%	33%
Public data	41%	28%
Predictive models	32%	22%
Remote sensing data	21%	22%
Drone-based photogrammetry	29%	6%

Automation lowers mine monitoring hurdles

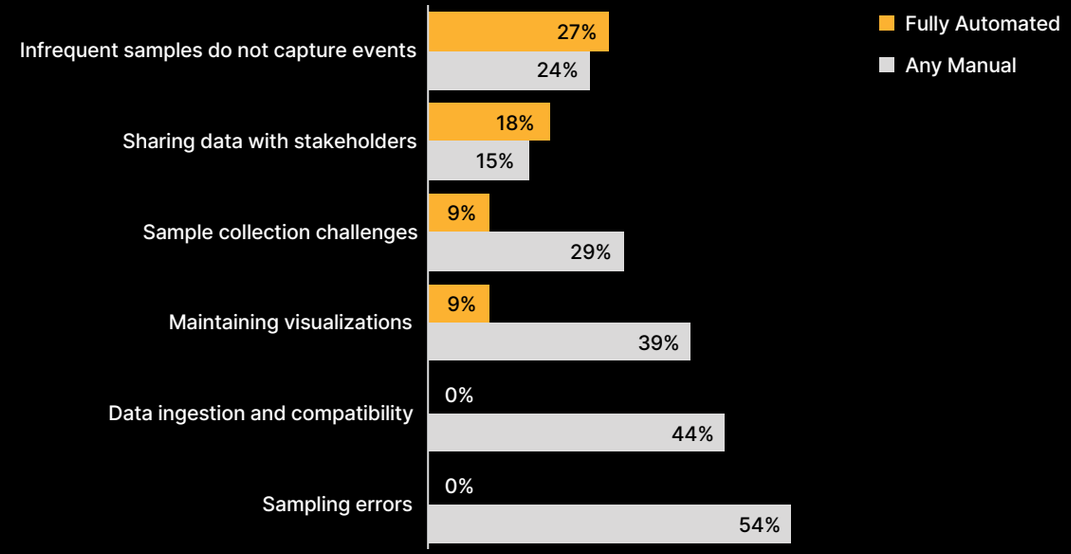
As part of our research, we compared the performance of organizations that utilize fully automated monitoring with those that use any degree of manual monitoring. We labeled the first group as “fully automated” and the second group as “any manual.”

On average, fully automated organizations face fewer challenges in condition monitoring than manual ones–on average 1.5 challenges versus 2.9, respectively. In fact, no fully automated enterprise surveyed reported experiencing difficulties with data ingestion and compatibility or with sampling errors.

It is a different story for organizations that do any manual monitoring. More than half reported problems with sampling errors, and 44% reported problems with data ingestion and compatibility. In addition, manual organizations are more than four times as likely to have difficulty maintaining visualizations and charts. They also reported more trouble with sample collection and frequency, as well as with sharing data with stakeholders.

> We get higher quality of output from our automated system.
>
> – Project engineer, mine service provider, Australia

Condition monitoring challenges



Q. What are the largest challenges that your organization experiences with its current monitoring programs?

Trends: the shift to automation

Mine site monitoring continues to advance

Over the last two years, both mine owners and service providers have switched to more automated monitoring while reducing their use of manual methods. One-third of service providers and 29% of mine owners accelerated their use of automated real-time data collection during that period.

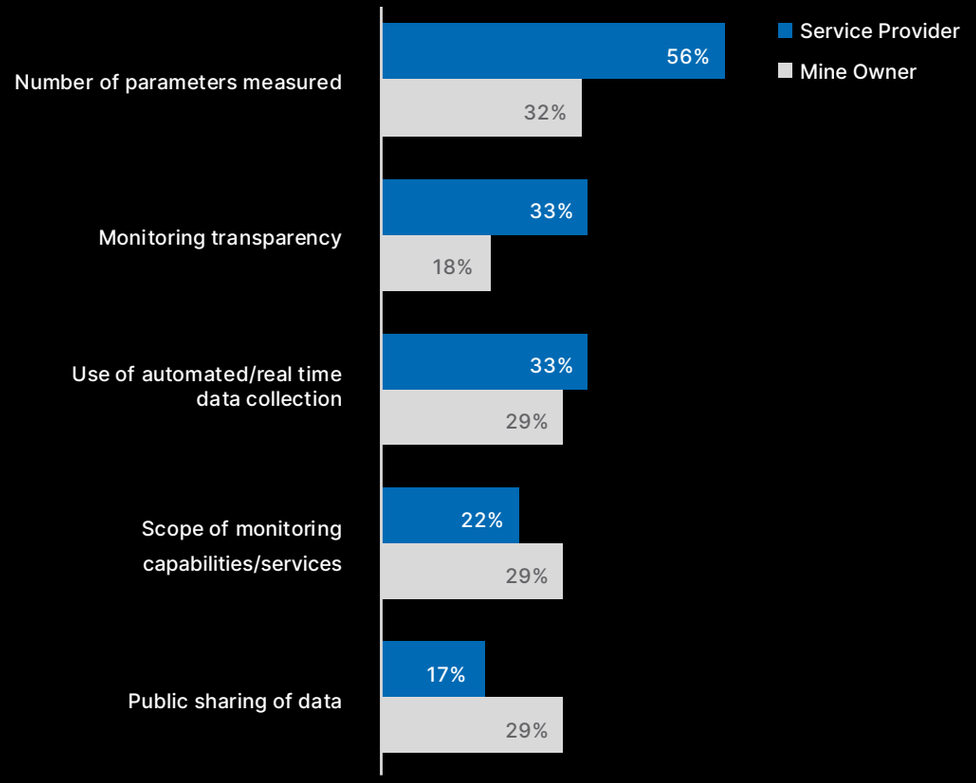
This shift has contributed to other important trends. More than half of service providers and nearly a third of mine owners have increased the number of parameters that they measure, from particulates and air quality to wind and temperature. Similarly, 22% of service providers and 29% of mine owners plan to widen the scope of their monitoring capabilities.

Public disclosure builds trust with the community

To demonstrate environmental responsibility and build trust with customers and regulators, 29% of owners have bolstered public data sharing over the past two years. Service providers have increased it a bit less, but they tend to follow their clients on public disclosure policies. However, providers have done more on monitoring transparency—for example, by clarifying data sources and improving reporting to internal and external stakeholders.

> After shifting to automation, we realized that it provides a competitive edge to our organization by enhancing technology capabilities.
>
> – CAD designer, Canadian mining firm

Organizations reporting increases in monitoring practices



Q. How have the following monitoring practices at your organization changed over the last two years?

Stakeholders drive automation trend

The biggest driver for automating condition monitoring in the mining sector is social license—the need to communicate strong condition performance to stakeholders. Approximately 65% of mine owners and 67% of the service providers that support them see global and growing environmental and safety demands as very influential.

Service providers also say they are strongly influenced by evolving technology. Maintaining a competitive edge and appropriately servicing their clients requires them to keep abreast of the latest developments with sensors, gateways, cloud platforms, and other technologies. Operational demands—the need to measure and respond to issues in real time—are also more important for service providers than for mine owners as a motivator for automating their monitoring. Indeed, automation facilitates the acquisition of this operational data in real time.

Growing impact of technology and regulations

While specific regulations may not explicitly mandate automation, the overarching emphasis on workplace safety, environmental protection, and operational efficiency is driving mine owners to adopt automated monitoring systems. Regulations set by the U.S. Mine Safety and Health Administration (MSHA), for example, include requirements for monitoring parameters including ground stability, air quality, and equipment integrity.

Q. How influential are the following external market forces in driving adoption of automated monitoring?

Forces driving adoption of automated monitoring

		Mine Owner	Service Provider
Social license - Need to communicate strong condition performance to stakeholders	Very influential	65%	67%
	Moderately influential	26%	17%
Technology - The advent of more accurate, lower cost sensors, gateways, telemetry, and cloud processing	Very influential	26%	50%
	Moderately influential	71%	50%
Operational demands - Requirement to measure and respond to conditions that might impact my business in real time	Very influential	24%	33%
	Moderately influential	74%	61%
Regulatory - Increasing governmental requirements to implement real-time monitoring to detect or avoid harm	Very influential	24%	17%
	Moderately influential	50%	72%
Economic - e.g., the cost of labor and manual monitoring is increasing over time, automated data collection is becoming more economically feasible	Very influential	24%	17%
	Moderately influential	59%	78%

Benefits of automation to mine owners

Since mine owners have automated their operations more than service providers, it follows that mine owners tend to realize somewhat more benefits for their businesses—when asked about five specific benefits, mine owners reported realizing 2.5 of them on average versus 2.1 for service providers.

More than eight out of 10 mine owners say that they can execute projects more cost effectively due to automation, and 76% report a greater ability to move into new markets.

Automated monitoring boosts revenue and productivity

However, more service providers (33%) than owners (9%) say that automation allows them to operate with leaner teams and staff, contributing to greater productivity.

Somewhat more providers (44%) than owners (36%) also say they can unlock recurring revenue. They can do so by expanding their client base and providing more services to existing clients.

Similar percentages of service providers and mine owners say that they can execute more projects in a year.

> Automated monitoring offers a higher return on investment compared to manual monitoring.
>
> – CEO, Australian mining firm

> Automated monitoring plays a crucial role in enhancing efficiency within critical and complex tasks.
>
> – COO, Spanish mining firm

Q. How has the shift to automated monitoring affected your business?

Benefits of shifting to automated monitoring

	Mine Owner	Service Provider
We can execute projects more cost effectively.	82%	44%
We have more capability to move into new markets.	76%	44%
We can execute more projects in a year.	45%	44%
We are able to unlock recurring revenue.	36%	44%
We can operate with leaner teams/staff.	9%	33%

A look to the future

The move to automation will accelerate

Mine owners will continue to shift their monitoring practices toward automation over the next two years, increasing their average percentage of automated data collection from 72% to 80%. Service providers will follow suit, augmenting their average percentage of automated collection from 68% to 77%. While this is a sizable increase, in two years, service providers for mining will continue to lag the average of 81% for the providers in all industries in our study (which includes transportation, dams, utilities, and water distribution/wastewater infrastructure).

Resistance to full automation

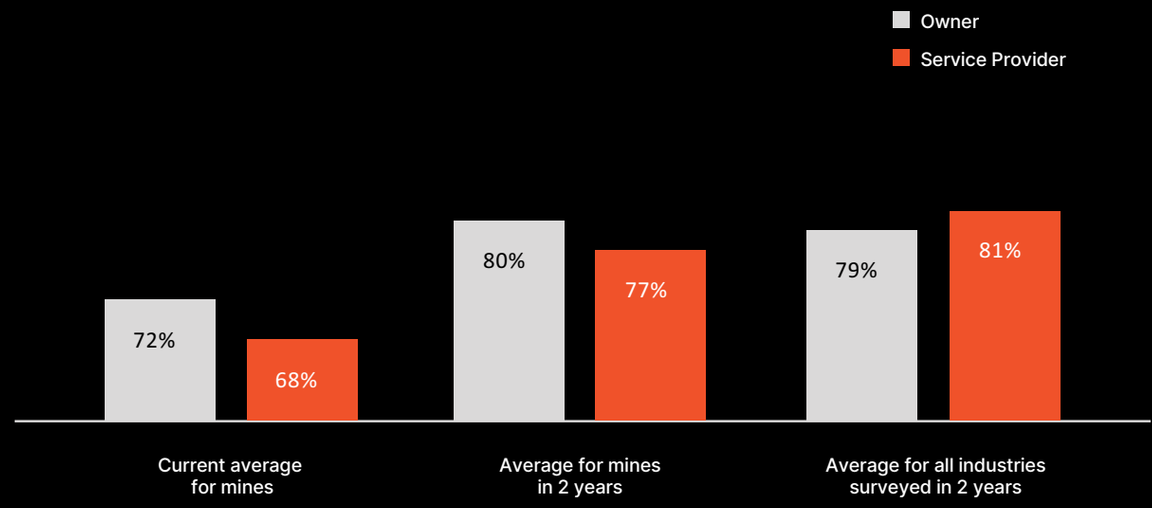
While, overall, the move to automation is clear, some firms remain reluctant to fully automate data collection because they believe manual monitoring has advantages. Some think that manual processes are cheaper. However, 82% of mine owners and 44% of service providers said they could execute projects more cost effectively through automation.

Similarly, despite the worries of some executives, automating data collection does not eliminate human judgment or oversight. Instead, it frees up people from the mundane task of collecting data, allowing them to use their time more effectively and apply their insights where needed.

> We get better results from automation compared to manual processes.
>
> – Drafter, Australian service provider for mines

Q. What percentage of your organization's monitoring utilizes manual data collection?
Q. What percentage of your organization's monitoring data do you expect to still be manually collected in two years?

Average percentage of automated data collection



Automation is needed to future proof business

The message is clear for both mine owners and service providers: in the long term, automated data collection is crucial for meeting the needs of stakeholders.

Automation will drive the future readiness of mine owners...

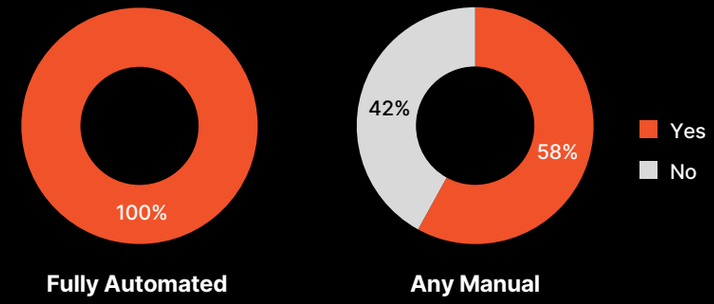
Automated condition monitoring enables mine owners to generate accurate, real-time data and unlock greater data insights at lower costs. That is why 100% of fully automated mine owners believe that their condition monitoring practices will allow them to continue to meet stakeholder demands in 10 years. In contrast, 42% of those doing any manual monitoring say that their practices will not suffice.

...and the economic viability of service providers

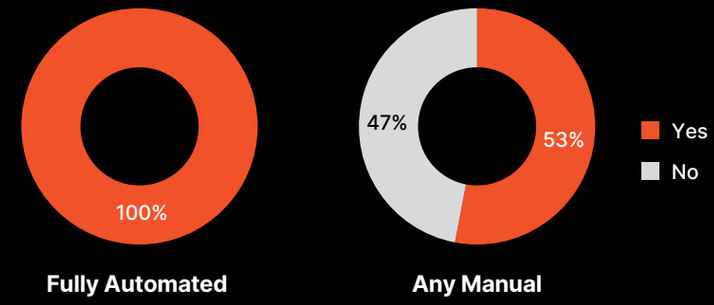
Service providers also recognize the importance of automation for their future business success. Every fully automated service provider surveyed believes that their condition monitoring practices will remain economically viable in 10 years, while nearly half of manual providers realize that their approach will not hold up in the future.

Q. Mine owner: Do you think your organization can continue to meet the demands of various stakeholders in 10 years if it continues with its current data collection approach?
Q. Service provider: Do you think your organization's condition monitoring practices will be economically viable in 10 years if you continue with your current data collection approach?

Meeting stakeholder demands through data collection practices



Economic viability of condition monitoring practices



Key takeaways

How automation is improving condition monitoring for mines

For the resource-rich mining industry, condition monitoring is now predominantly automated. Among mine owners, 72% of data is now collected via automated means, and among service providers, the figure is 68%. Over the next two years, owners and providers alike will further increase their automated monitoring of all data collected to 80% and 77%, respectively. Our analysis reveals that shifting to automation offers five key benefits for mining companies and their service providers:

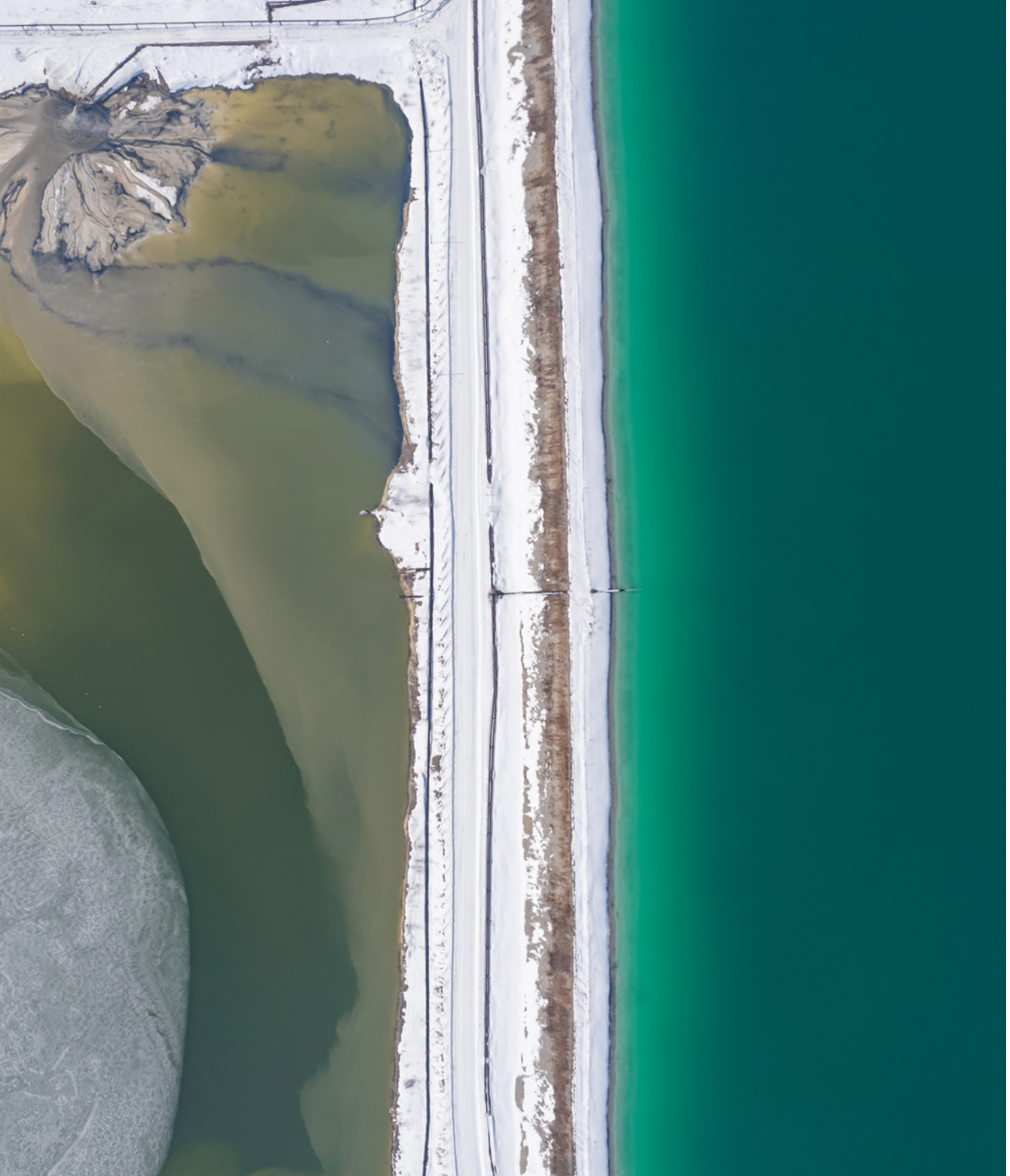
1. **Greater value from sensor data.** Automating condition monitoring—particularly when analyzing data with specialized software—makes it easier for organizations to get more from their data by integrating it with data from other information sources. These sources include asset management systems, geoscience data, GIS layers, digital twins, and public data.

2. **Reduced challenges in condition monitoring.** Fully automated organizations experience fewer roadblocks in condition monitoring than manual ones. Data ingestion and compatibility, as well as visualization and chart maintenance, are some of the main challenges that mine owners and service providers overcome by automating condition monitoring.

3. **Ability to monitor more variables.** As they have automated data collection over the past two years, 56% of service providers and 32% of mine owners have increased the number of parameters they measure, such as particulates and load. More than two in 10 in both groups have also widened the scope of their monitoring to include more areas, such as air quality, noise, vibration, and structural soundness.

4. **Cut in costs and greater productivity.** Mine owners and service providers are seeing sizable cost benefits from their shift to automation. Eighty-two percent of mine owners say they can execute projects more cost effectively; 44% of service providers say the same. Meanwhile, 45% of owners and 44% of providers say that they can execute more projects in a year.

5. **Boost to the top line.** Automated condition monitoring stimulates revenue growth for both mine owners and service providers. More than three-quarters of mine owners say they can move into new markets, and 44% of providers say the same. A significant share of owners (36%) and providers (44%) say they can unlock recurring revenue.



Lessons learned on the road to automation

We asked mine owners and their service providers to tell us what they learned on their journey to automated condition monitoring. Here are five lessons they offered:

1. **Standardize and integrate processes.** Organizations that develop a comprehensive strategy for integrating automation with existing systems and processes achieve better results when automating condition monitoring. “Standardization ensures smooth integration and allows for easier troubleshooting,” said a design engineer at a U.S. mining firm.

2. **Ensure the right resources and infrastructure.** To successfully automate condition monitoring, mining firms must have the necessary digital and organizational foundation in place. “Setting up automation involves dedicating essential financial, human, and technological resources,” said an instrumentation specialist at a U.S. mining company.

3. **Maintain high quality standards.** Organizations should regularly review and optimize automated processes to ensure they remain effective and trustworthy. “It’s important to make sure that quality standards stay up-to-date and efficient,” said an instrumentation specialist at an Australian mining firm.

4. **Make data security and privacy a priority.** To ensure data security, companies will want to employ the right software and processes when automating. “Implement robust data privacy and protection measures to safeguard sensitive information and maintain compliance with regulatory requirements,” said the CEO of a U.K. mining company.

5. **Educate and engage employees.** Companies should ensure their technical staff know they are not being replaced by automation. Automated condition monitoring will simply reduce or eliminate the mundane, time-consuming work of manual data collection so they can focus on more important tasks. “Foster a culture where automated condition monitoring complements human expertise, rather than replacing human roles,” advises a technician with a Canadian mining firm.

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Bentley

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iTwin IoT

iTwin IoT is a cloud-based software designed to integrate real-time data from sensors and other connected devices with digital twins—virtual models of physical assets. This platform enables the collection, visualization, and analysis of data, providing comprehensive insights into the performance and health of infrastructure assets such as dams, bridges, and buildings. By leveraging iTwin IoT, users can monitor conditions, predict maintenance needs, and enhance decision-making processes, ultimately improving the efficiency, safety, and resilience of their infrastructure.

Chat with an expert about Bentley solutions for condition monitoring. >

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Seequent, The Bentley Subsurface Company, is evolving the way organizations work through a better understanding of the subsurface. Supporting mining, energy, environment, and civil sectors, Seequent connects the natural environment with the built environment so organizations can manage the impact of their projects at every stage. With Seequent's industry-leading earth modelling, analysis, data management and collaboration software, infrastructure professionals can model and simulate the subsurface to deliver projects safer, faster, and with more confidence, and improve infrastructure resilience and sustainability.

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