AI enabled predictive maintenance in mining

REPORT

The tomorrow of mining.

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Using AI to improve equipment reliability and availability in mining.

The overall success of a mining operation is directly impacted by the reliability and availability of mining equipment. Traditionally, the big three metrics governing mining performance are throughput, workplace safety and cost per tonne. A focus on equipment performance can unlock billions of dollars in productivity returns for miners. But it's not easy and the larger the operation, the more complex the challenge becomes to deliver the best outcomes.

Improving asset availability helps reduce costs, increase throughputs and improve safety. Conversely, unplanned downtime and extended fault investigations reduce operating time and inflate maintenance costs. If your key performance indicators (KPIs) are tied to operational performance, then overall equipment effectiveness (OEE) is an essential metric to track where you're making progress and to see how you can improve.

Common symptoms of poor overall equipment effectiveness

- High maintenance costs
- Low reliability
- Reduced availability
- Rising or unstable costs per tonne
- Decreased productivity
- Missed production targets

Rising demand for remote operations presents safety, reliability and availability challenges

Reaction to the global pandemic created unexpected challenges. State mandates for border closures led to longer FIFO swings to reduce exposure to infection. The side effects for workers included safety concerns like fatigue, loneliness, and mental health issues. *A Reliable Plant is a Safe Plant is a Cost-Effective Plant*[1] proves there's a direct link between safety and equipment reliability. Lastly, global supply chain issues and logistics problems contributed to availability issues when parts were hard to source.

Evolution of maintenance in mining equipment

Despite the direct link between OEE and mine performance, the approach to equipment maintenance is still evolving. For critical pieces of equipment, this has a direct impact on achieving the company's operational targets and the bottom line. For example, one hour of downtime of a bucketwheel reclaimer on an iron ore mine costs more than $1,000,000 in lost production alone.

Companies serious about both cost control and productivity need to have a greater focus on the efficiency of their equipment. Maintenance practices can influence typical availability rates; more attention to maintenance usually results in better availability. An increase of only a couple of percentage points in availability rates can make a huge difference in production yields.

Most miners want an increase in uptime and greater asset availability but there's no consensus, at least in practice, on the best way to get there.

Reactive maintenance – assets run to failure

Despite massive investment in engineering solutions to maintenance problems, reactive maintenance remains the most common approach to problem-solving. When equipment operates outside design specifications, or to the point of failure, the universal edict is to get it working as quickly as possible. This firefighting approach can lead to a vicious cycle where no one has time to do a root cause analysis (RCA) or follow a structured problem-solving process. (Or worse, process dictates an RCA must be performed on every problem and your KPIs drown in bureaucratic problem-solving.)

Even when a detailed reliability-centred maintenance (RCM) strategy exists, it often does not influence behaviours or improvements at the mine site. It's commonly understood that chronic failures cost the most over time, but they typically don't attract RCA activity. Both these situations lead to long cycles of costly reactive maintenance.

Breaking out of a reactive maintenance cycle is difficult for several reasons

- Operator training is often conducted outside of any RCM strategy, so the same problems continue to attract the same fixes.
- Symptoms of a problem are treated, but not the root cause.
- Operators are bombarded with an overwhelming number of equipment alarms but lack visibility into overall equipment health.
- No one reviews fixes or repairs over the long term to determine whether solutions are sustainable.

Preventive maintenance – schedule-based maintenance

The point of preventive maintenance (PM) is not to fix problems faster, but to prevent problems from happening in the first place. Think about it this way: if you're rewarding firefighting, you'll keep getting firefighters in your organisation. You want to shift to a model which takes into consideration how assets are operated and how you care for them.

Preventive maintenance is based on a theoretical rate of failure rather than actual equipment performance. A thoughtful strategy provides greater control over unplanned downtime and ensures OEE for your entire plant. It also means you must communicate change to your workforce to drive the results you expect.

Drawbacks to implementing a preventive maintenance approach

- Schedule-based maintenance can lead to equipment being over or under maintained, or over inspected.
- Parts are replaced before they fail, which causes unnecessary downtime and leads to an increase in total cost of ownership.
- Unexpected faults drag an operation back into reactive problem-solving.
- Organisational changes can impact or derail reliability initiatives like PM strategies when a change in management might alter the overall focus or philosophy about maintenance.

- "Analysis paralysis" can occur while trying to determine an ideal strategy.
- It's easy to be lulled into a false sense of security by compiling reports and graphs from your data management (DM) system without making sustainable improvements or forming good maintenance habits.

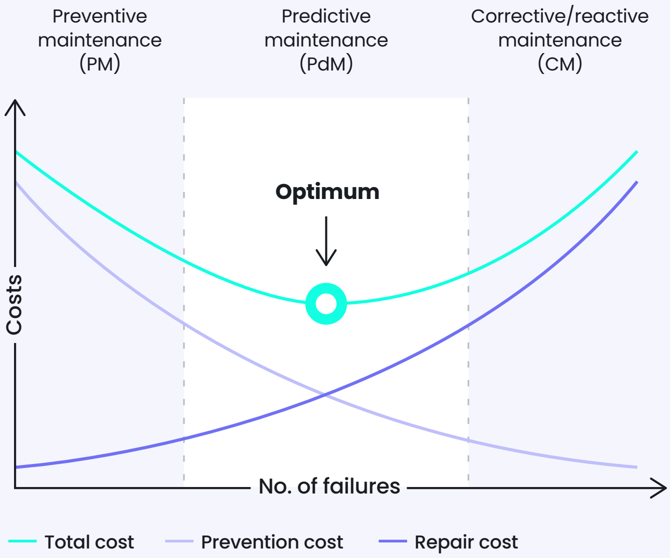
Predictive maintenance – maximising asset reliability

Predictive maintenance (PdM) strikes a balance between reactive and preventive maintenance. Rather than running an asset to failure or replacing a part when it still has operational value, PdM allows organisations to conduct maintenance only when completely necessary. Modern day PdM relies on the Industrial Internet of Things (IIoT) to continuously monitor equipment operating conditions, predict possible equipment failures, and create a maintenance schedule using artificial intelligence (AI) and machine learning (ML).

PdM increases availability, reduces operating costs, and extends part life. Over time, actionable insights from historical data are collected through deep learning models which contribute to more operational efficiencies. It's the ideal way to manage OEE.

The value of predictive maintenance

AI-based predictive maintenance minimises expenditures



How PdM works

Equipment manufactured in the "Industry 4.0" era comes with sensors already installed. Legacy equipment can be fitted with smart sensors. These sensors produce the data required for PdM insights. Data is collected in real time for operational metrics such as temperature, vibration, load factors, belt tension, engine idle speed and oil analysis. The data must be verified, cleaned, labelled and aggregated into a common machine learning database. Only once this happens can the benefits of automation, AI and ML be realised.

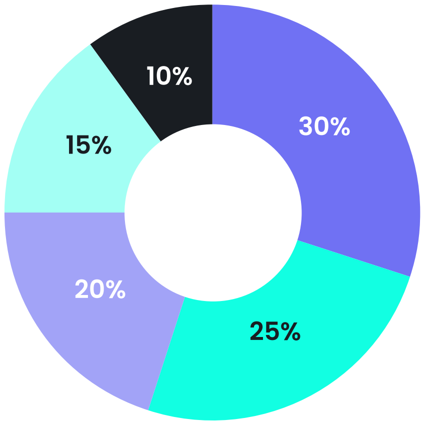
Potential challenges implementing a predictive maintenance approach

- The mining industry is awash in data it doesn't know how to harness or apply to problem-solving.
- A typical mining operation has a vast number of sensor types, including mechanical sensors, programmable logic controller (PLC) calculated variables, acoustic data, and visual sensors.
- Data overload has caused many managers to question whether data can help them make better decisions. Many miners say they don't trust their data.
- Extensive data cleaning and labelling are required, which is labour-intensive and reduces ROI.
- Set-up and implementation of PdM require the specialised skills of a data scientist.[2] These employees are in high demand and can be hard to attract to the mining industry.[3]
- Executive buy-in is essential. A champion in the leadership team is needed to support the up-front investment of time and resources for a successful PdM implementation.[4]

Activity breakdown for mining data scientists[5]

How data scientists spend their time (excluding meetings)

- Data cleaning, aggregation, visualisation, verification, interrogation and storage
- Maintenance/coding of machine learning database
- Monitoring for faults and exceptions
- Developing operational and strategic insights
- Coding algorithms



Maintenance approach pros and cons cheat sheet

MAINTENANCE APPROACH	BENEFITS	CHALLENGES
Reactive (RM) Assets run to failure	• Easy maintenance strategy, not much planning and governance required	• Unplanned downtime • Potential damage to other assets • Increased maintenance costs • Increased safety issues • Risk of not having the necessary spare parts when needed
Preventive (PM) Schedule- or condition-based maintenance	• Lower maintenance costs • Less unplanned downtime • Less equipment malfunction or failure	• Cultural change in how maintenance is managed • Extensive spare part inventory • Increase in planned downtime • Assets receive maintenance whether they need it or not
Predictive (PM) Maximising asset reliability	• Higher throughput • Reduced maintenance costs • Improved safety outcomes • Extended asset life	• Executive support required • Up-front infrastructure expense and management • Complex systems management requirements • New job roles and functions • Data derived from multiple sensor types and formats must be normalised into a single database

Data for predictive maintenance is available – but not leveraged properly

Data is currently being collected throughout the mining data supply chain but is usually used in a piecemeal fashion to track individual actions or events. There tends to be a focus on specific concerns such as ventilation monitoring, accident analysis, fleet and personnel management, or tailing dam monitoring. For example, if the temperature or pressure of a drill rig exceeds the recommended range, a warning alarm goes off and the information is relayed back to the database. The operator can take immediate action to prevent a costly equipment breakdown, but only if they understand the purpose of the alarm. Information may or may not be logged for use in future maintenance planning. The user experiences an overload of dashboards that report past KPIs but don't give an outlook or assist in future maintenance planning.

Real-world mining data usually includes imperfect documentation of faults. Typical mining data management problems include:

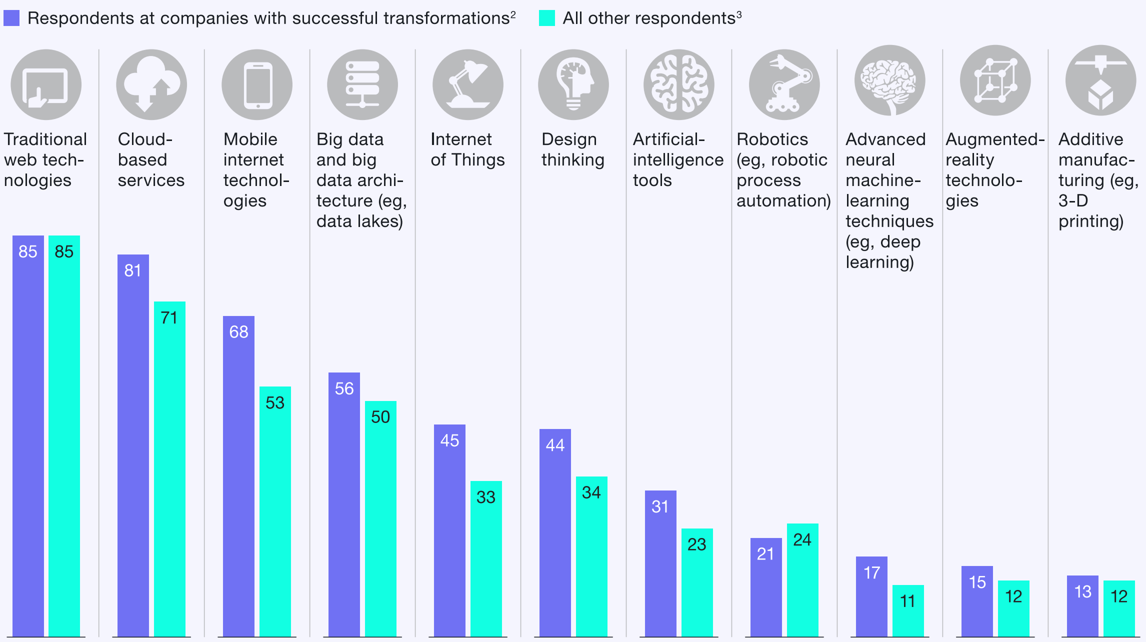
- Misclassifications due to human interpretation
- Undocumented malfunctions
- Asynchrony between delays in accounting, ERP and root causes
- Machine set-point changes that alter fault definitions
- Undocumented maintenance procedures
- No accountability or individual KPIs for coherent and accurate data capture

It's safe to say an overall IIoT architecture suitable for general conditions in the mining industry is missing.[6] The problem is machines don't operate in isolation. The failure of one piece can impact the operability of the entire workflow, either through decreased output or additional equipment failure. This is where a whole-of-plant approach to PdM becomes beneficial. AI, ML and deep learning algorithms can use the available data to ensure that the workflow is not interrupted due to the malfunction or failure of any one component.

There is a case, however, for going big. According to McKinsey, the organisations who have experienced the most success in transforming their operations are likely to use multiple sophisticated technologies such as AI, the Internet of Things (IoT), and advanced neural machine-learning techniques.[7]

Organisations with successful transformations deploy more technologies

Digital technologies, tools, and methods currently used by organizations, % of respondents[1]



[1]Respondents who answered "other" or "don't know" are not shown.

[2]Respondents who say their organisations' transformations were very or completely successful at both improving performance and equipping the organisations' to sustain improvements over time, n = 263.

[3]n = 1,258

McKinsey&Company

How AI enables predictive maintenance strategies

Mining companies are beginning to experience the benefits of digital transformation, but often there's too much focus on the technology and not enough on how an organisation will use the resulting data.[8] When AI is used to enhance data management, the onus is removed from individuals to collect data, analyse it and decide what to do next. Miners are taking note; according to EY, 49% of miners are making decision intelligence — AI and machine learning — a priority in 2022.[9]

This is what using AI for predictive maintenance could look like in practice. Sensors and PLC tags on your mining equipment send real-time metrics about your operation to predictive algorithms. Imminent failures are flagged for attention, allowing you to manage those faults by exception, instead of in a reactive mode or from a prescribed PM schedule. Automatic workflows trigger work orders for your asset care team. Where necessary, purchase orders can be generated if specific parts are required to make the repair.

AI tools can be used to predict optimal maintenance schedules for critical equipment to help mining companies:

- Optimise maintenance processes
- Prevent unplanned downtime
- Lower equipment lifetime cost of ownership
- Expedite equipment maintenance and repairs
- Support decision-making
- Improve safety

Mining operations are already generating large volumes of data every minute – a single machine can host thousands of sensors constantly generating data. Imagine what can be achieved if all this data is combined, validated, and distilled to give a clear picture of asset health. What if you had weeks in advance warnings as to when your equipment would fail and why? What if you could immediately pinpoint the exact root cause of equipment trips and failures? What if you could differentiate mechanical failures from faulty sensors? How much time and money would this save your operation?

Well guess what? Now you can.

DataMind AI – unique product solves a specific problem for mining

Razor Labs' DataMind AI is a breakthrough product for predictive maintenance and improved equipment utilisation in the mining industry. Using an advanced application of AI and deep neural networks, DataMind AI provides accurate forecast warnings of up to 30 days before equipment malfunctions occur. You also benefit from real-time health monitoring and assessment of your plant equipment.

How DataMind AI works

The DataMind AI neural networks understand the unique patterns collected from real-time sensor activity that can predict a downtime event. They fuse all available data points – potentially up to tens of thousands of PLC tags – to provide a stable health score and time-to-failure forecast. For the first time, miners have access to all critical machine information on a single dashboard. This allows them to easily identify machine components which are about to fail, and take preventative action.

Razor Labs' unique methodology is built on the concept of Critical Control Indicators (CCI). A CCI is a mechanical parameter monitored by the PLC in real time. It can be a sensor or a continuously calculated variable. When a predefined threshold is met, the machine trips and the CCI causes downtime. CCI forecasting allows operators to prevent these delays from happening, improving machine reliability and increasing equipment availability throughout the mine site.

DataMind AI in your organisation

Every mine site is different, with different goals and challenges. DataMind AI is configured for each site, to extract the most business value for each customer. We have experience with a myriad of sensor types, including (but not limited to):

- Mechanical sensors: torque, temperature, speed, current, power, weightometer
- PLC calculated variables: numerical, categorical, binary
- Acoustic data: optical fibres, microphones, vibrometers, ultrasonic sensors
- Visual sensors: CCTV, thermal, IR, hyper-spectral

Why DataMind AI? Why now?

- **Gain value from existing oceans of data.** Start using industrial control systems data, with no need for additional sensors that require CapEx and maintenance.
- **No need to clean your data.** Handle real-world data discrepancies automatically, including undocumented and mislabelled failures.
- **Prevent rare but significant failures.** Deploy DataMind AI for critical failure types with only a handful of recorded events.
- **Evolving AI.** Continuously improve accuracy with new data, using evolving Neural Networks.

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