Mining Magazine

Clean bill of health

Equipment health monitoring can be used at mine sites to optimise production and maintenance schedules, allowing mines to move material in the most efficient manner with the least amount of downtime. Ailbhe Good body finds out more

Modular's MineCare provides the information and tools for mines to monitor the health of their entire fleet in real time

Asset Management > Maintenance

Ailbhe Goodbody

One of the largest impacts to the production of any mining operation is maintenance of the equipment, so it is critical to ensure that production and maintenance schedules align. This allows maintenance and operations teams to react to immediate issues that might otherwise be unknown, as well as detect and resolve emerging issues during planned maintenance activities.

Eric Winsborrow, executive vice-president of corporate strategy at Wenco, says: "The mines we work with at Wenco estimate about 30% to 50% of their ongoing operating costs are related to maintenance. For some mines, that figure is 60% or higher."

Using technology to continuously monitor equipment provides early detection of conditions that can lead to failure. To get a complete picture of an asset, mines need a solution that analyses both process and equipment data to calculate overall asset health.

However, mining equipment and processes are complex and interrelated and this won't lessen with the move towards automated mining and remote operations centres. "There are more moving parts and it is imperative that data be processed seamlessly and consistently," explains Jane Phillips, AMT product manager at RPMGlobal. "As equipment ages, it becomes more susceptible to failure. Information is a valuable tool that can be used to sharpen the maintenance programme and manage the maintenance approach to be more when needed versus when predicted."

As a result, the reports and information that are being fed from monitoring tools must be correct, complete and sufficient to be of any use. Phillips says: "Data capturing therefore needs to use a standardised format to ensure that the correct data is captured."

Many mine sites rely on default factory threshold settings and intermittent data downloads from their mobile equipment units to notify them of problematic conditions affecting critical components, which can delay notification alerts about preventable damage events. Simon van Wegen, product manager - maintenance systems at Modular Mining Systems, comments: "This can result in frequent and significant equipment downtime, which can severely affect a mine's equipment availability, production, and maintenance costs. These failures and associated activities also have the potential to cause harm to mine personnel, equipment, mine infrastructure and the environment."

Using condition monitoring data collected at the machine (such as oil analysis, inspections or onboard sensors) allows the maintenance team to identify any immediate and/or emerging problems that need attention. "They can then plan the corrective work so that it fits in with existing and future maintenance schedules," says Colin Donnelly, VP of product management at Dingo. "The impact on production is less maintenance downtime per machine, increasing both availability and productivity."

Looking at operator-induced events, such as overspeed or abusive shifts, allows the mine to retrain operators to operate the equipment correctly, which improves equipment health and reduces the future maintenance workload.

By using data from the machines, it can help the mine planning team to optimise haul profiles, to lessen maintenance impact on machines and reduce overall cycle times.

"Managing telemetry from mobile and fixed machinery provides raw data for analysis in a number of different ways," notes Carl Brackpool, product management & innovation at Hexagon. "It's important to differentiate between real-time monitoring and historical reports, although what you're seeing on a 2-D or 3-D operating centre monitor instantly becomes 'historical data,' and increases the statistical significance of the ever-growing dataset."

Trend analysis is the easiest way to use time/series data to establish a baseline, run scenarios, and then actually compare past events with current changes in tasks for optimisation. Brackpool says: "The key is speed at which you can process data into actionable information and then improve models until both activities and machine movement is at its optimal levels of production. And when you can react quickly to events you can also schedule maintenance as a prescriptive measure with contingencies."

A Cat dealer using a remote equipment monitoring centre

Timing maintenance

Downtime, when known in advance, can be managed. However, unexpected downtime, no matter its severity, is a burden that all mining operations in today's economic climate can do without as it is disruptive and costly.

Premature component wear costs mines time and money in lots of ways. Unnecessary replacement components are one cost, along with the labour to install them. But there's also the cost of machine downtime, lost production and, in some cases, cascading failures that result in even bigger repair bills. Unscheduled maintenance can cost three to 1 O times more than scheduled maintenance - using a maintenance management solution to optimise maintenance schedules can therefore significantly reduce maintenance costs.

The most common cause of unplanned downtime in a mining operation is equipment failure. Real-time insight into the health and performance of a company's mining assets can help them move toward zero unplanned downtime. Van Wegen adds: "Additionally, the improved awareness about

component condition facilitates better management of equipment availability to optimise production."

Sean Gladieux, product manager, MineStar Health & Cat equipment care advisor at Caterpillar, says: "Maintenance and service tracking also lets you know that preventative and scheduled maintenance services are performed right on time. When a specific problem is addressed, you can also get follow-up data to ensure that the repair was effective and that the machine is now working as it should."

Another common practice is for maintenance teams to replace components based on time, rather than condition. Van Wegen recommends: "While this time-based schedule might help mines better manage their planned maintenance activities, evaluating time-in use as a sole replacement condition often results in replacing components with considerable remaining useful life, which impacts a mine's maintenance costs and equipment availability."

Mine operators want to know the precise moment equipment needs maintenance - not when the OEM tells them to do preventative maintenance, which could be months before it's actually needed; and certainly not after a component's failure, which can be very costly in lost productivity and repairs.

By leveraging a health monitoring solution, maintenance personnel can monitor equipment components based on their condition, identifying potentially-problematic components earlier. This allows the maintenance department to schedule component repair or replacement, helping to minimise downtime and impact on operations.

Winsborrow says: "Ongoing condition monitoring and predictive maintenance can help anticipate when a component or part actually needs to be serviced. This can help the maintenance team plan with much more accuracy, which also helps optimise productivity by keeping assets in operation longer - taking equipment out of production only when needed and putting it back into service more quickly and cost effectively."

Additionally, maintenance teams can set their own monitoring parameters to identify conditions outside of what the OEM will automatically monitor. Van Wegen notes: "By acquiring real-time telemetry data related to an asset's engine, chassis, drive system, tyres, oil analysis and more, maintenance departments are armed with plenty of raw and aggregated data with which to evaluate component health. From there, they can project the component's estimated remaining useful life, and schedule maintenance around that projection, or even take immediate action (repair or replace) to mitigate a catastrophic failure if necessary."

When the maintenance department have the correct information and can make decisions knowing the impact they will have on the mine's production and operations, then it ensures that decisions are being made that achieve the best outcomes attainable. Phillips says: "Having all the equipment health information available and in easily digestible formats ensures that production targets can be managed or adjusted for both expected and/ or unexpected unavailability."

This insight allows maintenance teams to take equipment offline on their terms and keeps workers out of harm's way by eliminating non condition-based maintenance. Doug Morris, director, power &

mining at Emerson Automation Solutions, suggests: "The key is to avoid situations where a critical asset fails in an unplanned manner in the pit. The mine plan is much less impacted when downtime is planned."

Equipment monitoring systems

There are several companies that offer health monitoring systems for mining equipment, some of which also offer performance-related monitoring capabilities; some of the main players are detailed below.

Caterpillar

Cat Health and other Cat MineStar capabilities allow equipment managers to easily gather and analyse all kinds of data from equipment. With data-based comprehensive health management, the machines can tell users when and why they need attention, so they can fix minor problems before they lead to expensive failures.

For example, Cat Health provides real time alerts when a problem is detected. Gladieux says: "It lets operators know what action to take - such as slowing down or shutting down - to minimise component damage, plus it lets service people know what to expect so they can optimise the repair time."

The system monitors critical components on a machine and reports out-of-tolerance temperatures and speeds. Cat Health can monitor all equipment assets, regardless of manufacturer.

"With satellite location data tied to each alert, Cat Health can help managers identify specific areas of the mine that are causing excess wear and tear, so they can take corrective action," explains Gladieux. "For example, haul road dips, soft spots and sudden grade changes can all take a toll on truck suspensions and frames as well as transmissions. Road repairs can reduce wear and boost reduce cycle times."

The Cat MineStar Health display in a control room

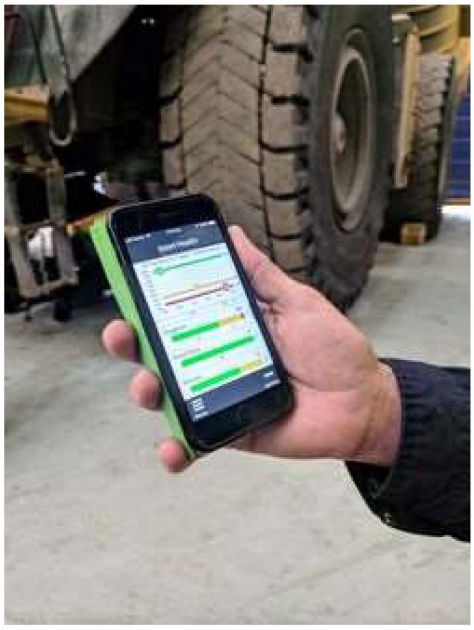
Dingo

Dingo's predictive maintenance platform seamlessly connects to all an operation's condition monitoring data sources, including onboard sensors, fluid analysis, visual inspections, vibration and thermography. Donnelly says: "By housing all the data in one system, Dingo can run powerful predictive analytics and prescribe the precise maintenance actions that will minimise downtime and keep equipment running in peak condition."

The parameters are quite varied: they can be wear metals, contaminants and oil properties from oil analysis; temperatures, pressures and shift times from onboard sensors; and images and text from visual inspections.

"Some of the condition monitoring data is batch type data, only collected during an equipment preventative maintenance task every 250-500 hours," comments Donnelly. "Other information from onboard sensors is transmitted at a higher frequency, from a daily average down to being collected and transmitted every few minutes. Dingo's system was designed to ingest and analyse both batch and real-time data."

In the realm of sensor data, Dingo doesn't believe that there's significant value in replicating the alerts and alarms that are already available in the operator's cab. Donnelly says: "The real value stems from using the onboard data in predictive analytics and machine learning models to identify emerging problems as early as possible, so they can be addressed during a planned maintenance task."



Dingo's Trakka Asset Health Management app

A large Canadian copper mine partnered with Dingo to implement a comprehensive and holistic predictive maintenance programme and hit best-in class availability and life targets. The mine had been condition monitoring with oil analysis, vibration and thermography for years, but its fleet health and life were not achieving desired targets. The plan was to purchase two new trucks to supply the production capacity needed. To address these challenges, the mine partnered with Dingo.

Dingo provided critical support in the following areas:

- Serving as a continuous source of expertise; and
- Providing recommended corrective actions to local team and tracks issues through resolution;
- Organising information so the focus is on component health management and not just monitoring condition;
- Using predictive analytics to identify emerging issues and plan condition-based work for existing maintenance windows;
- Providing structure and focus through dashboard key performance indicators (KPIs), process control and benchmarking.

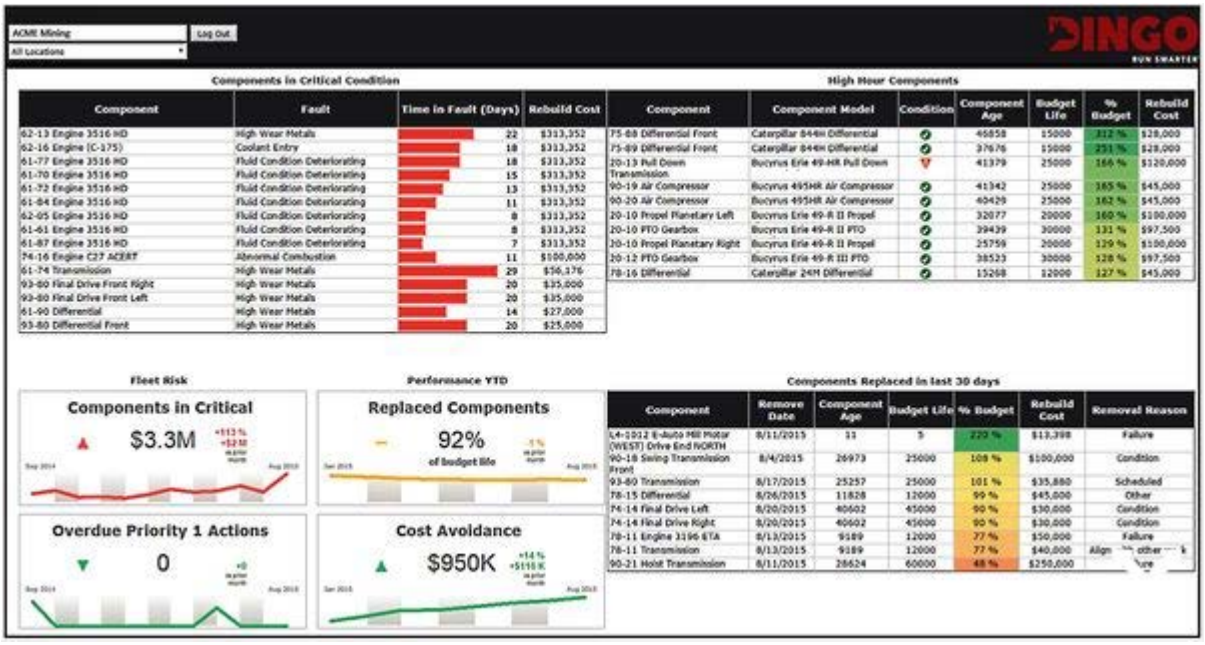
As a result, the mine didn't need to buy the two new trucks - saving C$9 million (US$6.8 million).

The mill is operating with less than 1% unscheduled downtime in recent months, and the increased availability and extended equipment life are saving the mine over C$5.5 million (US$4.2 million) per year.

At another mine, the company had a A$150,000 (US$109,000) dozer engine that was on the path to catastrophic failure after only 4,000 hours of operation; however, the lab ratings pointed to a steady state of operation and weren't catching the underlying issues.

Dingo's Trakka predictive analytics engine identified and correlated several contaminants that were at critically high levels and deduced combustion issues in the engine. As a result, Dingo's condition intelligence experts immediately issued a work order with the steps to pinpoint the root cause of the combustion issue - these checks identified that four exhaust valves and an injector were not within OEM specifications. The issue was rectified, combustion returned to normal, and the dozer was cleared for operation.

Trakka identified an otherwise undetectable combustion issue before damage occurred, while its workflow management system enabled the maintenance team to quickly find and fix the root cause. As a result, the engine rebuild cost was avoided by the mine.



Dingo's Asset Health performance dashboard

Emerson Automation Solutions

Emerson Automation Solutions has a wide range of products and services for machine health monitoring. Starting with the consulting group, Emerson provides deep asset reliability consulting to help customers who face growing needs to improve safety, increase plant uptime and reduce maintenance costs.

"In the mining industry, there is a need for monitoring technology that works under high loads and low speeds," explains Morris. "Emerson offers continuous online vibration sensing technology that utilises a patented technology called PeakVue, perfect for detecting anomalies on rolling element bearings well before it would be detected using traditional vibration analytics. A perfect application for this is on drive and pulley systems on conveyors or hoist, crowd, and swing systems on a rope shovel.

Plantweb Health Advisor is a suite of preconfigured software applications that use machine learning algorithms to continuously analyse both process data (such as load, flow, speed, pressure, current, voltage} and condition-based data (vibration, temperature, sound, corrosion, etc.} to provide an overall asset health rating 0-100%.

"These applications embed a powerful analytic package that includes pre-tuned algorithms for the developed applications, so the alerts generated are easy to understand and do not require interpretation by experts," says Morris. "Emerson's expertise goes from the sensor selection and positioning for a specific asset to the information delivered to the right person or system at the right time."

For the mining industry, asset templates include shovels, drills, and conveyor belt systems. Emerson delivers solutions ready to install with algorithms pre-configured for detecting a list of failure modes. Depending on the speed that these failure modes develop, the sampling rate for data actualisation is tuned.

Morris comments: "Emerson provides comprehensive solutions that include both software tools and hardware with the broadest portfolio of sensors allowing subject matter experts to look at machinery health condition data. Machinery health sensors include vibrations, proximity, acoustics, and temperature sensors among many others. Most of them are available wirelessly, reducing the installation costs."

Emerson has many installations in Latin America, North America, Africa and Asia Pacific that are all benefiting from its online condition monitoring technologies and analytics.

An Emerson CSI 6500 machinery health monitor

Hexagon Mining

Hexagon recently released HxGN MineOperate Asset Health Advantage, which improves the performance of the company's existing line of onboard data collection hardware devices by creating a brand-new platform of microservices.

"These services, like Xalt edge client, perform precomputing at the closest point to end-point sensors on a complex machine," says Brackpool. "The packets of information are converted and published as MQTT messages in broker that other HxGN and third-party microservice modules can subscribe to. In simple terms, what that achieved was realtime data telemetry logging, alarm processing from interfaces and a wide variety of parameters like brake system anomalies."

Supervisors, dispatchers and maintenance engineers all have different visual and reporting cues they respond to, depending on their own KPIs. However, the obvious ones are gear selection, speed/ overspeed, brake wear; engine parameters like exhaust temperatures, fluids; even seat belt and idling and prestart minimum/maximum time.

Brackpool notes: "Independently these data points are useful, but with amazing breakthroughs in data visualisation we can provide greater actionable information than ever before. Gone are days-old reports, spreadsheets and one-dimensional views of a mine map, and showing some recent position and state of mobile fleet assets when they last reported in to a dispatch centre or a radio call, [which] resulted in handwritten status on a large control room board."

Modular Mining Systems

"Modular Mining Systems introduced the mining industry to real-time asset health management in 2002 with the MineCare maintenance management solution," says van Wegen. "Since then, the MineCare solution has helped mines reduce their unplanned maintenance by responding to, tracking, documenting, researching, and predicting mobile equipment health issues before they become catastrophic failures."

In addition to monitoring all parameters made available by the OEM, the MineCare solution leverages data from third-party interfaces related to strain gauges, oil analysis, tyres, and more. "The data delivery speed depends on network latency, but the solution typically provides visualisation of data within two seconds of its generation on the machine," explains van Wegen. "To help maintenance teams further maximise uptime and prolong equipment life, Modular offers RemoteCare maintenance management service."

The RemoteCare maintenance management service leverages teams of highly-trained specialists to remotely monitor and manage the real-time telemetry data generated by a mine's entire fleet. RemoteCare helps drive information and action from the data collected by the MineCare solution; specialists rely on the data from the solution's wealth of OEM interfaces and real-time computing capability to identify possible problem areas in advance.

Van Wegen says: "They can then provide direct feedback and recommendations to maintenance and operations personnel at the mine site to address potential component breakdowns or failures before they occur."

A recent example of a mine site benefiting from Modular's Remote- Care service comes from an open-pit copper mine in Peru, which used the MineCare solution to identify recurring instances of service brake misuse on some of their haul trucks. Van Wegen notes: "The RemoteCare team targeted service brake use at speeds greater than 8mph [12.9km/h] and for more than three seconds at a time with MineCare's user-definable analytics and data visualisation tools. They then issued an alert to notify offending operators in real time when the misuse occurred."

After a period of approximately four months, the mine reduced service brake misuse by more than 62%, which:

- Reduced maintenance labour; and

- Lowered the rate of seal failures caused by overheating;
- Significantly reduced wear to the front brakes and other components;
- Reduced contamination of the hydraulic oil system;
- Reduced the need for, and cost of, replacement parts;
- Increased equipment availability.

In addition, a large coal mine in Australia implemented the Mine- Care solution to significantly reduce its unscheduled downtime.

By focusing on the conditions surrounding unexpected component defects, the maintenance team was able to better understand where issues were arising, and target those specifically. As a result, the mine reduced its unplanned maintenance activities by 25%.

RPMGlobal

RPMGlobal provides software solutions that receive and monitor automated results from on-board sensors, instruments and meters as well as manual observations.

"RPMGlobal does not provide the sensors themselves as this area still largely the domain of OEMs such as Caterpillar, Komatsu, Hitachi, Volvo, ABB, etc. due to the nature of the electrical connection to the physical equipment," says Jeremy Hanrahan, operations management solutions executive at RPMGlobal.

He adds: "RPMGlobal's solution strength lies in the validation of data, and then using that data, captured from the many disparate systems that are typically found on today's machinery."

Once information has been gathered from each sensor it must be aggregated with the rest of the information from other parts of the equipment plus the production, operational and environmental data.

"RPMGlobal's MinVu solution connects to all of the various data sources including machine health systems, FMS systems and many others," comments Hanrahan. "All of this data is then combined and made available for both automated and on-demand reporting with options to supply the results in either real time or at prescribed intervals from as little as a few minutes to shift, end-of-day, end-of-month, and even end-of-year reporting. These reports are then available with all necessary corporate formatting required to produce actionable documents."

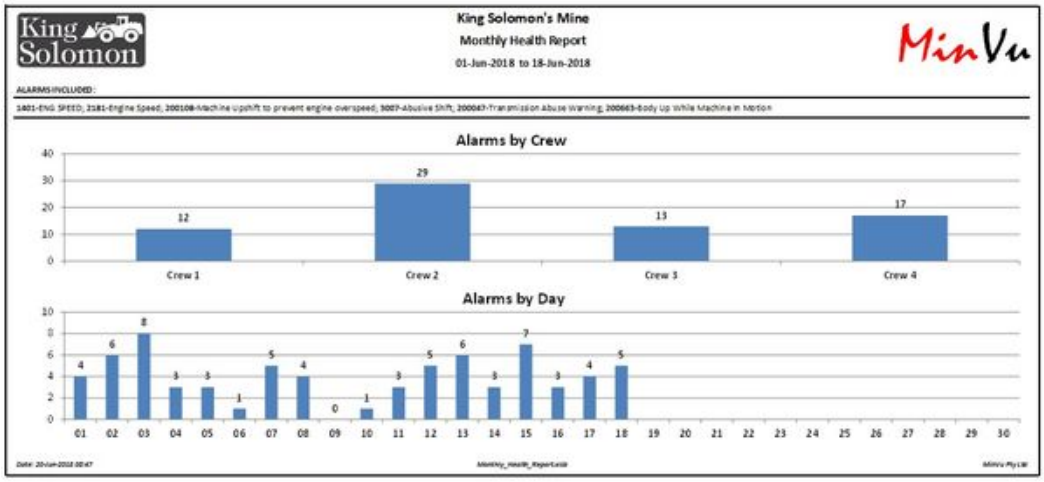
The real-time reporting requirement depends on the needs of the operational team, by transforming the amounts of 'big data' that may produce no practical insight into targeted actionable information.

"There are plenty of examples of mine sites that have greatly benefited from both MinVu and AMT [asset maintenance software] solutions," says Phillips. "One that comes to mind immediately is a number of coal mining operations throughout the Hunter Valley in Australia."

Min Vu has been used for many years on a handful of operations which then roll into the corporate solution. MinVu provides each individual operation with a solution to validate then combine all the

data from many different systems.

"Each operation is slightly different in the systems they use with different machines and models, different OEM health capture systems, different fleet management systems, high precision GPS systems, dragline systems, tyre systems and many more," explains Phillips. "MinVu pulls all these together for each individual site then provides corporate with a platform to benchmark and report across all the operations, regardless of the onsite systems being used."



An RPM Global Min Vu report showing a mine's monthly health report with details of the alarms raised

Wenco

Wenco's asset health monitoring system is called ReadyLine. ReadyLine monitors health related sensors - such as oil pressure, engine RPMs, plus hundreds more - gathering information in real time. Winsborrow says: "It presents this information across dashboards and real-time reports for the highest priority issues, plus generates historical reports for all other data."

ReadyLine also integrates with Wenco's business intelligence system, allowing mines to combine maintenance data with fleet management and third-party contextual data such as mine planning, enterprise resource planning (ERP) systems, oil analytics etc.

Winsborrow comments: "Together, these data associations enable ongoing conditions monitoring dashboards for maintenance departments, operations teams, and mine executives alike."

Readyline is installed at major mines worldwide, helping customers extract unrealised value by extending the life of equipment and reducing maintenance and operations costs. Winsborrow says: "While this information is confidential for each customer, Wenco can introduce interested mines to customers in their region who can help discuss system use and the benefits they have realised."

Wenco's ReadyLine monitors health-related sensors in real time

Aspermont

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