Healthy and wise

Real-time monitoring can give miners an extra edge in fleet productivity

The evolution of real-time production machine health monitoring systems has gathered pace, giving mines the ability to address problems as they happen, reports Paul Moore

IN THE past it was not uncommon for mining equipment to be run until it broke down, requiring costly repairs and the wholesale replacement of significant components and significant downtime before return to service. AJ Bartkoske, product manager for the maintenance systems at Modular Mining and the author of several papers on truck monitoring, refers to this as "breakdown maintenance".

This was replaced by 'preventative maintenance' (PM) whereby maintenance teams perform inspections and rebuilds. PMs were based on equipment service hours, combined with an OEM's estimated component life and recommended service hours, at regular intervals to avoid failures. However, these estimates could often be – and still are – very conservative, again leading to unnecessary downtime.

This is the crux of truck health monitoring, or 'real-time maintenance' – allowing problems to be identified at the earliest possible stage, i.e. as they occur, even before the operator has noticed. This means that a machine can be serviced in the mine or brought in for maintenance at the appropriate time and kept running at its optimal performance for as long as possible.

Mr Bartkoske refers to the 'P-F interval'. When deterioration begins (a factor that may be random in terms of service life), equipment undergoes a reduction in the ability to perform at optimal levels, or worse it cannot fulfill its intended function. At some point (P), approaching failure is detectable through inspection or other condition-monitoring techniques. Unless addressed and dealt with, performance levels can deteriorate to a point where the asset no longer performs at its demand level – this is called 'functional failure' (F). The biggest challenge in mobile mine equipment is to reliably detect the potential failure (P) in a timely manner, considering the variability of the operating context. This is the true value of real-time monitoring.

OEMs install various equipment-component health-monitoring sensor systems that collect vital component data and operational parameters. Products like Modular's MineCore interface with these systems that gather this data – sometimes referred to as electronic control modules (ECMs) – and then organise and process it before sending it wirelessly back to the control centre. The data-collection systems include Caterpillar's Vital Information Management System (VIMS) and Komatsu's Vehicle Health Monitoring System (VHMS), as well as those supplied by the other equipment manufacturers and component OEM companies, such as engine and electric-drive manufacturers, whether Cummins, MTU, Siemens or General Electric.

These systems collect vast amounts of data, but are mainly used in practice to keep track of key operating parameters such as temperature and pressure, as well as being set up to alert the operator through a warning message/alarm of an impending or abnormal condition on the machine. Depending on the severity of the event, it will recommend an appropriate course of action. ECMs also alert engineers of problems through a diagnostics downloaded to a PC during a regular maintenance interval. For example, in Komatsu VHMS, a fault is triggered when component measurements reach critical threshold values or during unusual activity. Each fault has a timestamp, duration and SMR reading, and will be prioritised as red (critical), orange (cautionary) or yellow (advisory).

The problem with using individual ECM data-collection systems has been the requirement for a physical connection, such as a laptop or PDA, to download the data and then the use of proprietary software to manipulate it. This results in non real-time data and sometimes inconsistent data handling. This results in reactive maintenance activities after component lifecycles are reduced or have failed.

The leap forward is in the real-time, 24/7 picture provided by truck-health systems and the three main players – Caterpillar, Komatsu/Modular and Matrikon – all believe they have significantly improved the life of equipment in some situations. As stated, the core idea of the systems is to provide accurate, real-time feedback to equipment operators, as well as to provide this information to a central point where the whole fleet of machines can be monitored. Users no longer have to shut down equipment to board it to download data. Removing this download step also increases productivity. Additionally, this augments safety by eliminating the need to physically visit various equipment fleets and on-board systems.

CATERPILLAR

The three components in the Caterpillar set-up are VIMS, MineStar and MineStar Health. VIMS is a Caterpillar-only system and cannot be installed on other manufacturers' equipment. It provides operators, maintenance and engineering with vital machine health and production information. Introduced in 1994, VIMS is now standard on 785, 789, 793, and 797 haul trucks, the 854 wheel dozer, and the 991, 992, 993 and 994 wheel loaders.

Jimmy McCarty, product support consultant at Caterpillar Global Mining, told *Mining Magazine*: "VIMS data provides the technician [with] a tool to better troubleshoot a machine, the maintenance planner a tool to manage his equipment, and the production manager a tool to manage productivity and operator training needs."

Caterpillar uses MineStar to transmit data wirelessly if required. MineStar is a comprehensive system that links machine data gathered in the field, and existing ➔

ore control and material identification information, to the office business enterprise systems.

Included in MineStar are a number of features that help improve safety for operators and others on site. For example, the system can be set up to require an operator to punch in a code that will allow him to operate a particular piece of equipment only if he is certified to do so. Once he has been approved a machine, the operator follows an electronic checklist that must be completed before he can begin work.

An on-board display contains a number of safety features. It can be programmed to transmit regular safety messages, notify operators of machine problems, and inform them of existing or new hazards on site. A moving map on the GPS screen shows the operator the haul road, dump and loading tool directions.

A positive outcome from the implementation of MineStar at Newmont in the US has been the ability to track the many types of gold ore on site. Using the high-precision Computer Aided Earthmoving System (CAES) on loading tools, Newmont operators can identify the types of ore, and create mine models and maps. MineStar uses this information to schedule trucks and loaders to meet the daily goals.

The MineStar system that offers real-time analysis is MineStar Health, which collects raw data off the machine, transmits it to a server and allows it to be analysed using VIMS software. Key benefits of MineStar Health, according to Caterpillar, include saved component failures, extended component life, reduced phantom breakdowns, full-fleet health monitoring, efficient data analysis and improved maintenance practices.

Another option with VIMS is adding a radio network to transmit data wirelessly. Few large mines use this, but it is useful for smaller sites without the full MineStar infrastructure. In addition, Caterpillar trucks and other equipment can be monitored via satellite radio using Product Link, a web-based application, along with the data-management software Equipment Manager. The hardware is available globally, but factory installed for machines sold in North America.

MATRIKON

Matrikon is unique in that it is not a major OEM, but has a truck health monitoring offering – Mobile Equipment Monitor (MEM). But, the company does have long experience in the monitoring of fixed plant equipment in mines, refineries and power plants. David Fisk, director, mining solutions, tells *Mining Magazine*: "Matrikon excels in data collection and analysis, having 20 years of experience with fixed process plants. We were also a pioneer in mobile equipment-monitoring systems, having worked with Syncrude to design and deploy a custom, real-time monitoring sytems for their trucks and shovels in 2001. The system is still successfully operating there today. We are able to work with equipment from any of the OEMs, linking into the various on-board systems for the engines and other vital components that generate performance data that normally is available only by boarding the machine. Third-party systems, such as tire monitoring or lube systems, can also be integrated. Distinct from dispatch systems from Modular, Wenco and others, vehicle health systems provide comprehensive analysis of the equipment performance in real time. So, this information is about predictive and preventative maintenance rather than waiting for an alarm to go off".

Like the other major truck health systems, MEM works by interfacing to VIMS on Caterpillar equipment and the various other Electronic Control Modules (ECMs) on other manufacturers' equipment, which are effectively the data-collection nodes. MEM then acquires the data from the ECM and transmits it to a central database. Mr Fisk comments: "It is the analysis, trending, predictive and alarming capabilities of the MEM software that provides the value, rather than the raw data itself. MEM provides very sophisticated analytical capabilities to easily determine long-term trends with the equipment, including benchmarking of equipment, operators and sites for multi-site operations. It also provides predictive analysis capabilities to identify developing faults on the equipment before it actually causes downtime or collateral damage."

MEM supports maintenance best practices such as Reliability Centred Maintenance initiatives and condition-based maintenance practices by providing the necessary data on which to base the programmes. The results have been clients seeing reductions in mobile maintenance budgets of over 5% and unplanned downtime reductions of 10%.

Matrikon sees MEM as having unique capabilities in that it constantly collects all of the available data from the equipment all of the time to build comprehensive equipment histories to look at longer-term trends it provides in-depth diagnostic and analytical capabilites, and access to the system is available from anywhere with Internet access. MEM works with any equipment mobile or fixed, not being linked to any one OEM, whether as a parent company or to one OEM's products.

MEM provides standard interfaces to each of the OEM's control systems for data acquisition, and the specific data that is gathered and how it is used can be defined by the user. Standard screens and dashboard are provided with the base system, but the screen reports, dashboards and KPIs can all be configured to the specific needs of the user. In cases where there is not a central ECM system, such as with older equipment, MEM has interfaced directly with the PLCs on board the equipment. Although this requires considerably more work, it is an option for mines with ageing fleets.

The MEM system is quite new – the full version of it has only been commercially on the market for about eight months. The Syncrude example was custom-built, beginning in 2001, and was effectively the pre-cursor for the current MEM system. Matrikon is implementing MEM in Freeport McMoRan's North American mine sites and is working with P&H, which is piloting MEM at a number of mine sites for use in monitoring their equipment in the field in combination with their own Centurion system. MEM is also in the process of actively being marketed and distributed in Australia, South Africa and South America.

KOMATSU

Like Caterpillar, Komatsu has the on-board, component sensor-based data-collection system, Vehicle Health Monitoring System (VHMS). VHMS on its own can function in a similar way to VIMS and MineStar in that it communicates key component data to a user interface via Orbcomm's satellite communication channels automatically. This in turn enables the remote evaluation of the machine's condition and operations. This data can also be downloaded manually or wirelessly. However, it is still not real-time data; instead it shows trends that display changes in component measurements over time. VHMS, along with Orbcomm, comes standard on Komatsu mining machines, including electric drive and rigid dump trucks, hydraulic excavators, wheel loaders and dozers.

Rizwan Mirza, project coordinator – VHMS, told *Mining Magazine*: "Machine owners can identify service meter readings, fuel consumption, cautions, operational data, payloads and key component measurements provided in forms of trends on an online, secured web application. Komatsu has developed a user interface called MyKomatsu, where machine owners can simply log in, just as they log in to their online banking or investments, and view their assets' performance and utilisation. Trends, displayed in change in component measurements over time, can help take a proactive approach towards machine maintenance and safety."

MineStar-equipped Caterpillar 793D and (inset) control room at Newmont

MEM Hauler Overview screen

MODULAR MINING SYSTEMS

Modular Mining Systems Inc (MMSI), while owned by Komatsu, has been offering MineCare as an independent product since 2003, which may be used not only on Komatsu equipment but also on any OEM's equipment fleets through an array of developed interfaces. Mr Bartkoske said the lag in real-time data collection for mobile equipment has been narrowing in recent years, with the mining industry as a whole working to reduce costs and increase productivity.

Modular pioneered mobile-equipment, real-time data-monitoring systems, and introduced the ability to provide alerts to maintenance and operations for abnormal conditions, such as the triggering of alarms or alerts when monitored parameters exceed OEM manufacturer or user defined (UDF) thresholds, or when equipment is operated in an unsatisfactory manner. In conjunction with this, the system offers predictive analysis capabilities to proactively identify potential maintenance issues early on before a catastrophic failure, which, in turn, can lead to increased downtime or collateral damage to other components.

Global groups such as Rio Tinto and BHPB, among others, have proactively moved forward in the installation of MineCare for their global operations over the last three to four years. Mr Bartkoske says: "This has come about as they deem the value and the competitive advantages of real-time equipment monitoring 24/7. Within the last year or so, we have been receiving increased enquiries and sales for our MineCare system among various mining companies from around the world's major mining regions."

The area of MineCare that has proven most useful for mines is real-time monitoring and the capability to set user-defined parameters for developing equipment trends, plus the added value of monitoring equipment 24/7. Equipment monitoring is easily facilitated from a central location or control room, either on site or remotely, by a MineCare evaluator, who can handle online data from 80-100 machines. An individual can set up the data to see what they want to see, but all the data is available, and people can drill down as they wish and review historical data as well. Real-time monitoring not only proactively flags potential maintenance issues, but it can also show up areas where an operator requires additional or refresher training, such as the correct use of the brakes on grade so they don't overheat or shift points.

In Modular's opinion, there are really two major tiers to the use of the data. First is the real-time data, available to both maintenance and operational monitors. This data significantly contributes to the bottom line by reducing maintenance costs, ability to optimise equipment performance and to maintain optimum productivity levels at all times. Examples of real time monitoring (RTM) for maintenance issues could include one brake out of four on a haul truck showing up as being cooler than the other three, meaning it isn't functioning correctly, and for safety reasons this piece of equipment can be quickly pulled out of service and repaired.

Similarly, it could show up differences in exhaust temperatures between each cylinder, which could indicate problems with the turbo system, filters or other maintenance issues. From an operational view, at this point the operator might not notice that he is getting less power to the truck as it would decline slowly over the shift, but MineCare picks it up immediately, so a technician can be sent out or the truck brought in, so the problem is corrected immediately, rather than having to wait until the end of the shift.

The second tier for mining equipment data is for reliability centred maintenance (RCM) activities. RCM assists in solving the dilemma of choosing appropriate test intervals. When properly configured, OEM and UDF alarms can detect potential failures (the P in the P-F interval) for many failure modes. The remaining requirement is sufficient time to plan and schedule corrective work or, at the very least, shut down equipment.

Many mining companies have established internal asset-management groups to identify opportunities for continuous improvements, and included in these groups are reliability engineers. As such, these engineers take the historical data generated from equipment to identify root causes of maintenance problems. By monitoring specific equipment fleets or models, potential problems and reduced component lifecycles can be identified proactively with a particular component, equipment model or fleet. This information can be evaluated to similar model trucks or equipment fleets to make valid decisions.

Modular Mining's MineCare management system links on-board health-monitoring across disparate OEMs and third parties. Modular believes this link to communication infrastructure and central software applications, supported by mine-management systems, provides a true RCM solution. According to the company, the capability of the system to detect or prevent failures has been well documented by various mining companies around the world's mining regions, saving hundreds of thousands of dollars on maintenance costs and increasing productivity.

Modular estimates that its DISPATCH and MineCare products have an 80%-plus market share, with MineCare installed at over 40 mine sites in North and South America, Australia, Africa, Asia and Russia. MineCare can be installed in conjunction with the DISPATCH product or by itself. Additionally, if a mine is an existing user of DISPATCH, it will already have the wireless hardware in place.

MineCare has over 50 interfaces available for OEM and third-party vendor systems. It can be used with VIMS, as well as numerous other systems from Siemens, GE, Cummins, MTU/Detroit Diesel and others. Modular has also developed interfaces for P&H's Centurion system, Bucyrus shovels and drills, and other OEMs' hydraulic excavators and drills. This allows MineCare to function across mixed fleets of equipment.