

TRUCKING ALONG

John Chadwick and Daniel Gleeson look at haul roads, bigger rigids (along with trolley assist and automation) and ADTs, operator fatigue, vision systems, maintenance.....

Mark Richards of Caterpillar's Global Mining Division highlights three variables for its impact on the haulage cycle efficiency – haul road design, maintenance and payload.

For haul road design, the base concepts that should be explored include "road profiles and the actual haul road profile versus the design. Optimum grades are typically set when considering a system's capabilities (power/rimpull) and the underfoot conditions. A combination of these two gives the effective resistance. Typically manufacturers design their products with 'sweet' spots in mind to provide optimum productivity and lowest cost per tonne (typically focused on fuel burn per tonne). Elements such as super elevation also influence the efficiency of haulage systems. Correctly designed and constructed super elevations mean that trucks can maintain constant speed and fuel burn.

"Haul road maintenance does have an impact on haulage system performance. Continual maintenance, ancillary equipment operator skill levels mean that haul roads can change on a daily basis. Underfoot condition and changes in geological conditions can lead to some areas on haul roads that change faster than others and increased attention to these areas tend to impact overall haulage profiles.

"Similarly payload has an impact on fleet productivity. The target payload is typically part of the initial design requirements, but additions to truck configurations or changes to variables such as tyres are rarely taken into consideration as fleets age. Most manufacturers have recommended payload management policies.

Caterpillar's 10/10/20 policy is an example. But even management within this liberal policy does have an impact on productivity. Take an example of a 793D on a 10% grade and 2% RR. The difference between target payload and a 20% overload means a reduction in speed of typically 16% with a further penalty in fuel burn of over 18%. Whilst on an individual unit this may seem attractive, managing payloads to an upper limit is impractical and variability means that across a fleet the speed differential has a bunching effect resulting in overall lower fleet productivity.

Caterpillar hits 50,000 and.....

Earlier this year Caterpillar achieved the very significant milestone of 50,000 off highway trucks at its American plant in Decatur, Illinois. This is the plant where off highway trucks have been produced since 1963. Number 50,000 was a 777F, a versatile 91-t-capacity truck that sees many applications in mining and quarrying.

"Today, our large mining trucks are moving more than half of the material—rock and ore, coal and oil sands—at mines around the world," said Chris Curfman, President, Caterpillar Global Mining Division. "While Caterpillar wasn't the first company to enter the off-highway truck market, our product quality, durability and unparalleled support have enabled us to become the market leader. Along the way, Cat trucks have helped build the modern mining industry. Reaching the 50,000-truck milestone exemplifies our commitment to providing what mining customers want and need."

Caterpillar started its nearly 50-year history of off-highway truck manufacturing with the 769, which had a target payload of 31.8 t and was powered by a 298-kW Cat® engine. That single model offering has expanded to 10 models currently, and the Cat power and truck capacity has expanded beyond that tenfold increase. The biggest of the bunch is the 797F, which will be commercially available later this year. The 797F has a 363 t capacity, and the C175 engine produces 2,983 kW.

The 777F that marks number 50,000 is representative of the new generation of Cat trucks being manufactured in Decatur—with designs to enhance operator comfort and safety and to reduce cost per tonne. The new models also feature Cat engines with ACERT® Technology, an advanced system that combines technologies to produce responsive power while reducing exhaust emissions.

Introduced in 1974, the 777 model represents more than 20% of the 50,000 milestone. The 777 shipments follow the trend of the more recent truck models. Caterpillar began producing off-highway trucks in the early 1960s, but it wasn't until the 1980s that Cat truck sales started outpacing the competition and quickly growing. Cat produced nearly 36,500 trucks between 1980 and 2007—three times as many as the nearest competitor, it says.

To help continue that trend, Caterpillar has invested in a massive research and development program that should bring improvements to every current mining truck and will guide the introduction of two AC drive trucks. The 793F

AC and 795F AC will complement the line of mechanical drive trucks.

All Caterpillar off-highway trucks are produced at the Decatur facility—one of Caterpillar's largest plants. It has been in operation since the 1940s, when the company supported US efforts in WWII by producing engines to power tanks, then manufacturing engines and power trains for Caterpillar D7 track-type tractors. A new plant built in 1954 was used to produce motor graders and wheel tractors. In the mid-1980s, a complete modernisation led to the unique Assembly Highway, which is still used today to produce trucks. Decatur also produces motor graders and wheel-tractor scrapers.

The 777F that marks the milestone achievement is destined to Prodeco coal operations in Colombia. This is Colombia's fastest growing coal exporter, producing high quality steam coal at the rate of more than 12 Mt/y. Expansion plans call for production to reach 22 Mt/y. The 777F will be the 112th 777 delivered to Prodeco. In total, 61 new 777F trucks and 22 new Cat 789C trucks will go to Prodeco to expand the haulage fleet.

"Cat entered the market in 1963 with a truck that performed better, ran faster, hauled more, lived longer, operated more safely and had unmatched global support throughout the Caterpillar dealer organisation. The basic fundamentals that made that possible in 1963 remain the foundation of Cat trucks today," said Stu Levenick, Caterpillar Group President. "We will continue to build on our strong foundation and will leverage the technologies of today and tomorrow to provide the superior value that our customers have come to expect from the market leader in large mining trucks."

Soon after, on April 21, Finning achieved a significant milestone with the delivery of the 200th 797 truck in Canada. The 797, one of the world's largest mining trucks, was first introduced in 1999. While it took Finning eight years of steady growth to reach the 100th truck delivery mark, it has taken only an additional two years to double the 797 fleet.

"Delivering 200 797 trucks in ten years is a significant achievement. It demonstrates both the exceptional quality of the Caterpillar product and our employees' commitment to providing great product support," said



XEMC's latest offering is the SF33900, a 220-t truck.

Mike Waites, President and CEO for Finning International. "The rapid growth in mining equipment sales over the past two years surpassed our expectations. The resulting large fleet of machines represents the foundation for Finning to grow our parts and service business while maximising productivity and operating efficiency for our customers."

Dave Parker, president of Finning (Canada): "We have a tradition of going the extra mile for our customers that is embedded in our values and history. Reaching this goal recognises our unwavering focus on exceeding our customers' expectations when they purchase Caterpillar equipment."

Finning International is the world's largest Caterpillar equipment dealer.

Caterpillar's first commercial off-highway truck. Since this was made the company has produced over 50,000 rigid frame trucks



And from China...

Hunan XD Heavy Equipment, part of Xiangtan Electric Manufacturing Corp (XEMC), is a well established Chinese manufacturer in the large truck market and has been making trucks for over 30 years. Its first electric drive haul truck, the SF3100, a 108 t capacity machine, came out in 1978. Since then more than 2,300 108 t and 154 t trucks have gone into Chinese operations like the Huolinhe and Yiminghe coal mines in Inner Mongolia, Anshan Steel's Dagusha iron ore mine and the Dexing copper mine.

The SF32601 is the latest 154 t truck, equipped with an electronically controlled Cummins K1800E engine developing 1,343 kW. The electric drive is equipped with a microcomputer control system and intelligent centralised display. There is also a new hydraulic system. Hunan XD says this has greatly reduced maintenance requirements and increased reliability and vehicle life.

Trolley assist

When will trolley assist take on its rightful priority? We've finally seen a new system installed, at the Lumwana mine in Zambia (JM, March 2009). Komatsu clearly sees the potential. Last year it introduced the 860E-1K electric drive truck. With a nominal payload of 254 t it is available with a factory installed trolley-capable option.

Its power plant in the 860E is the Komatsu



SSDA16V160, a 2,015 kW, 16-cylinder, two-stage turbocharged diesel. To address the ecological impact, this engine was designed to be Tier 2 certified.

The trolley system can be used on either 1,600 or 1,800 V lines, allowing the 860E to propel uphill faster while the engine RPM reduces, thereby saving fuel and extending the life of the engine compared to non-trolley. In both applications, the Komatsu-designed drive system produces a maximum speed of 64.5 km/h with a 35.52:1 final gear ratio powered by the latest Siemens control package. The unique, liquid-cooled IGBT AC-drive system from Siemens provides advanced features and a smooth application of torque and traction.

Another idea ahead of its time, but likely to become well accepted is Liebherr's TI 274. When creating the concept for this large truck, the development team concentrated on innovative methods of reducing its empty vehicle weight, while simultaneously maximising productivity. The TI 274 has a payload capacity of up to 290 t. It is equipped with six tyres as are all conventional mining trucks, however, when it comes to the design concept, innovations have been incorporated which are unique. This unique mining truck remains a long term Liebherr R&D project and is projected for full availability in 2010.

By integrating structural support into the design of the dump body and by shifting the hoist cylinder connections to the front end of the chassis, the forces exerted by the payload are directed straight into the ground. This result in an optimisation of the chassis weight since the hoist cylinders are no longer attached to the centre of the frame and the dump

body no longer rests on the frame. Castings are used in areas of the frame subjected to the greatest stresses, making the truck strong and avoiding excess concentrations of stresses in any one area.

The front of the TI 274 is visually similar to other Liebherr mining trucks. The difference from earlier models is in the placement of the hoist cylinders, which are now positioned further forward and support the weight of the dump body and payload continually – not just during the dumping process. The hoist cylinders have an additional external support mechanism in order to direct the majority of the exerted forces away from the internal components of the cylinder and to absorb load impacts. In addition, the TI 274 has hoist cylinder guides which limit lateral cylinder movement during operation. At the rear dump body support

A further design feature of Liebherr's TI 274 is the improved stability at the rear of the truck. The dual axle design permits a greater distance between the rear suspension and the support points on the dump body than is possible with conventional designs



When will trolley assist take on its rightful priority?

points, a specially designed transverse beam in the dump body itself performs the function of the rear cross member found in conventionally designed frames.

The TI 274 has two independent rear axles on which the four wheels are driven independently of each other by their own wheel motors. Each of the four rear tyres can rotate at different speeds from the others, providing better traction control in adverse ground conditions and also reduces tire scrubbing when cornering. This innovative drive concept is effective in preventing individual tyres from being overloaded. The rear axles can oscillate by approximately 4° left and right from the centre line in order to ensure that each tyre retains the same tire-to-ground contact on uneven terrain. This not only reduces tyre wear but also means that smaller tyres can be fitted than on other trucks in the same size class without losing any load capacity.

ADT advances

Bell Equipment's new Mark VI D-Series upgrade for its Articulated Dump Trucks (ADTs) focuses largely on electronic upgrades and enhancements to the operator station to further improve safety, ease of operation, noise level reduction and vehicle protection. Along with the standard features of the Mark VI upgrade, customers are also able to choose from a variety of new safety-focused options including tyre pressure monitoring, reverse cameras, lockout kits and full ISO handrails.

The new B45D aims to fill a gap that exists in the market for an ADT that has a larger payload than 40 t, thereby providing more options to meet site and customer specific needs. It is based on the B50D and, as such, it shares the same proven components that have been used in that 50 t machine since 2002. It is fitted with the powerful 16-litre Mercedes Benz OM502LA engine but has an output of 350 kW

as opposed to the B50D's 390 kW rating. The width and low centre of gravity creates exceptional stability and the B45D is able to run on 29,5R25 tyres at full speed and with a load.

The truck has wet disc braking on all six wheels and active front suspension is standard with comfort ride walking beams as an option on the rear.

Volvo's A40E articulated hauler (ADT) is being put through its paces at the Gurovo Beton operation, 130 km south of Moscow in Russia. Three A40Es have been introduced as part of the mobile machinery modernisation at the



The B45D is ideally suited to rugged mining, quarrying or bulk earthworks applications. Bell Equipment's prototype B45D has been run at four test sites in South Africa as well as in the United Kingdom in muddy underfoot conditions typical of Europe, where it has surpassed all expectations

operation, which has seen a new fleet of Volvo equipment arrive. The 39 t machines are being used alongside Belaz rigid haulers and are having a big impact. "The Volvos have better operating capabilities in the slippery conditions of spring and winter, meaning that we can maintain production," says Alexander Sergeevich Bobkov, who is responsible for the

equipment at Gurovo Beton.

The A40Es are equipped with Volvo advanced combustion technology Tier 3 Volvo engines that offer high torque at low revolutions to maintain fuel efficiency and reduce noise levels. They also come equipped with fully-automatic nine-speed fast adaptive transmission. An optimised gear shifting pattern has a precise overlap of ratios to provide constant power transfer. The machines have all-wheel wet disc brakes for improved stopping power and longer service life, a quality that helps it cope with the operation's "slippery conditions."

With full suspension (FS), the entire Volvo E-

Series ADT range provides improved off-road performance, empty or full, allowing the hauler to travel at much higher speeds – which, in turn, increases productivity. The Volvo FS system has automatic levelling and stability



SSABs prototype has been tested since 2008 in Sweden. The truck body has been in operation for a total of 820 hours and transported over 86,000 t of rock. "The trial results show that load capacity increased by about 9%. The reduced weight also results in less wear on the engine and drive trains," says Hans Konradsson, Manager of Market Projects at SSAB Plate

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control on all wheels and, instead of traditional rubber suspension, a hydraulic cylinder is fitted to each wheel. It continually monitors the load and ground conditions, adapting the suspension to fit prevailing conditions, absorbing rough spots and giving a smooth and stable ride with minimal bounding, rolling, or shaking. The design improves safety by providing significantly more ground contact, with vibration levels considerably lower than conventional machines.

SSAB has developed a brand new design for a free-hanging dump truck body that can haul a substantially higher load, but weighs only half as much as its traditional counterpart. This prototype body for an ADT is made of Hardox 450. The U-shaped free-hanging body design makes maximum advantage of the properties of the steel for a more wear-resistant and impact resistant product.

"For end customers the design offers an increased load capacity and lower weight when empty, lower fuel consumption, and fewer and shorter maintenance breaks. The new design also offers advantages to manufacturers, such as shorter production time and simpler, less expensive production process," says Per-Olof Stark, Vice President Marketing, Sales and Product Development SSAB Plate.

The long haul

Haulmax is a specialised producer of extended haul off-highway trucks and says "the product outperforms the majority of on-highway trucks



Volvo's A40E has a speed drop box with longitudinal differential and 100% lockup to reduce power losses and improve traction and fuel efficiency

used for this purpose on mine sites and provides a more productive and cost effective solution than OEM-produced off-highway haul trucks on such extended haulage applications."

Many mining companies have begun to exploit smaller orebodies on their leases. Often these are located quite some distance from the primary orebody and established processing plant. Rather than relocating processing plants many companies are choosing to move the material produced over extended distances via road. Due to their design normal off-highway trucks are predominantly limited to cycle distances of up to 9-10 km. These also require

wide haul roads to allow for passing. On-highway trucks, which are occasionally used for this purpose, are often unable to cope with mine road conditions, and have limited carrying capacities.

The Haulmax product was developed to meet this need. The company produces trucks with the capability to operate cycle distances up to 50 km, with a narrow design which allows for use on haul roads around 15 m wide, and a large carrying capacity comparable to many OEM produced trucks. Narrower roads cost considerably less to build and maintain, especially as they become longer.

The latest 3900 series, to replace its previous 3770 and 3775 models, is available in three base configurations; the 3900-G as a prime mover, the 3900-D as a ridged frame dumper or the 3900-T incorporating a dump trailer. Each model features a complete Caterpillar® power train including a high torque Cat® C27 ACERT™ low emissions engine, a seven-speed power shift transmission, oil-cooled multiple wet disc brakes on both rear drive axles and 21.00 x 35 radial tyres. Carry capacity ranges from 85 through to 130 t.

Haulmax's latest 3900 series (3900D pictured here) is available in three base configurations, which replace its previous 3770 and 3775 models





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A low profile and flat chassis rail design allow the units to be fitted with service modules such as water, fuel, and lube, or as a tow tractor. Operator cabs are ROPS/FOPS compliant, and the dual rear wheel drive axle design gives excellent braking capabilities, making the trucks ideal for long downhill haulage applications. This is further enhanced with the incorporation as standard of an Automatic Brake Retarding System. Standard options on the vehicles include; a cold weather package, automatic lubrication system, reverse camera, onboard weighing system and rapid fluid evacuation and fast fill system. The dump bodies are of ribless construction using high tensile steel with smooth contours to minimise material carry back.

Haulmax estimates some 95% of all serviceable parts are Caterpillar with whom it works closely to ensure that the computer matched powertrain components optimise longevity, reliability and mechanical availability. The ultimate result is to lower the cost per tonne of haulage over extended haulage distances. Haulmax trucks are able to be supported by the global Caterpillar dealer network.

Haulmax endeavours to provide the latest technology through its products. Design updates are made constantly to ensure they meet industry expectations of reliability, safety and operator comfort. The introduction of the Cat ACERT low emission engine was a direct result of the company's conscious efforts to meet the latest environmental standards. R&D is based on continual customer and dealer feedback. The company's long term plans include both larger and smaller models for even longer haul distances.

Rio Tinto Iron Ore has placed orders with Haulmax for specialist service units which will be used at its operations in the Pilbara region of West Australia. One will be used to carry a multi-compartment service module, and others will be permanently affixed to 150 t capacity low bed trailers. The module and trailers for the vehicles are being supplied by outside manufacturers.

Operators' view

Suppliers have continuously improved the operators' view, with improvements in rear view mirrors, cameras and manoeuvrable seats all helping the issue. Nonetheless, when it gets dark or dusty and operators are located up to 5 m and more above the ground accidents can happen. FLIR Systems' PathFindIR thermal imaging cameras help prevent accidents by detecting miniscule temperature differences, which are used to create a clear image that appears on an LCD display in the operator

cabin. The first installations were on trucks operating in open-pit coal mines, however, Eddie Smith, Managing Director of Tyrsome, a South African company focused on providing specialised auto electrical components for mining machinery, sees applications way beyond coal. "No matter if the trucks are being used in coal, gold, diamond or any other type of mine, they always need to operate in dusty conditions. They can all benefit from having a thermal imaging camera installed."

Smith continues: "They are easy to integrate and are being mounted on the front of the truck. The images the PathFindIR is producing are displayed on a large LCD screen inside the truck's cab. The driver has the ability to switch on the thermal imaging camera at all times but the thermal images are automatically displayed on his screen once he goes faster than 17 km/h. In this case we want him to look at the thermal images regularly, not only during the night, but in the daytime as well since the PathFindIR helps him to see in the dusty, and sometimes foggy, conditions."

Orlaco's innovative RLCD monitor was displayed at Internat 2009. This monitor meets the highest requirements: IP67 water-resistant and an EMC resistance of 100 V/m. The monitor is used in combination with Orlaco's CMOS camera systems, suitable for a light sensitivity of 0.25 Lux. The camera/monitor system is equal to the challenging conditions of mine work, with both camera and monitor being resistant to shocks and vibrations.

Operator fatigue

Caterpillar launched a fatigue technology review project in January 2006, with the company conducting an in-depth review of available and emerging fatigue detection technologies. To make the most out of this review, the published research will be presented at conferences, encouraging and seeding new fatigue research across the industry.

Out of the 21 technologies reviewed four out of the six 'top-tier' technologies measured eye-blink behaviour, with two out of six looking at machine behaviour – primarily steering. After evaluating these technologies the company carried out follow up evaluations of three of the top six using an interactive driving simulator. The findings showed that technologies with multiple measures of fatigue should provide a more robust system. Three of the top rated technologies are immediately available: ASTiD™, HaulCheck and Optalert™. Of these technologies the report classed only ASTiD and Optalert as fatigue detection technologies, with HaulCheck only measuring lane position and vehicle proximity; notifying the operator only after they have deviated dangerously out of their lane, regardless of their level of fatigue.

ASTiD, developed by Fatigue Management International, is designed to detect the early effects of drowsiness. It comprises two linked systems and uses a software algorithm that incorporates sound scientific research into sleep and sleepiness. The first system is 'knowledge based' and provides an electronic template predicting hour by hour the likelihood of the driver falling asleep over a 24 hour period. The template which is researched based, is also influenced by prior sleep. The second is a

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New FleetCommander hardware includes an upgraded on-board display that is easier to read due to 18% more viewing area and higher resolution. The easy-to-use touch screen enables operators to input information without memorising keypad functions

'steering sensory' system able to detect: (i) monotonous driving and (ii) vehicle movement (steering) characteristics typifying sleepy driving. Information from (i) and (ii) is processed and fed into the knowledge based system. The knowledge based system forewarns the likelihood of falling asleep at the wheel, whereas the steering sensory system warns the driver when he or she is doing so.

Optalert analyses operator blink characteristics continuously by using invisible pulses of light to detect eye and eyelid movement. Tiny light emitters and receivers are built into the frames of Optalert glasses worn by the driver. The glasses are connected to the Optalert Vehicle System, installed within the vehicle, which processes all the information being transmitted from the glasses. Whenever the system detects the onset of drowsiness – usually before the driver becomes aware of it – a loud beeping noise and a voice message warns the driver immediately. BHP Billiton has recently agreed to launch a project to manage fatigue at the San Juan and Navajo mines in New Mexico, USA. The initial stage of the implementation project will see 12 mine operators fitted with Optalert across both mines.

HaulCheck may have not come under Caterpillar's fatigue technology recommendations; however it has already found a customer in mining. Alcoa is retrofitting a fleet of Komatsu 730E trucks in the Huntly and Willowdale mines in Western Australia with HaulCheck. This installation will ensure larger trucks can safely work on restricted-width haul roads.

Automation

Applicable both to the trucks here and the drills in that article of this issue, Caterpillar has released FleetCommander 3.0, which includes software and hardware upgrades that expand

capabilities for improving day-to-day mine site operations. MineStar™ FleetCommander is a comprehensive surface mine monitoring and control system that uses technology to improve productivity and lower costs. Real-time interaction with mobile field equipment allows mine managers to improve machine utilisation, manage operators, track material movement and monitor production in near real-time.

Caterpillar reports that FleetCommander "has proven its value in mines worldwide. Operations that switched from manual control to FleetCommander typically have experienced a 10-15% productivity improvement. One mine implemented FleetCommander for managing its shift change process and gained 15 truck loads per shovel each shift. MineStar FleetCommander 3.0 builds on proven results and delivers an additional 5% productivity improvement compared to previous versions."

The core truck assignment engine has undergone significant enhancements. Key improvements are closer integration with the mine model and optimisation of the assignment algorithm. With these enhancements, mines are seeing even greater productivity improvements when they allow the system to assign trucks automatically with no restrictions. Letting the assignment engine run automatically also allows mine controllers to focus on other operational needs.

The new blending functionality included in the assignment module enables the controller to specify the type and quality of materials delivered to the dump, stockpile or processing plant. FleetCommander 3.0 assigns trucks based on the specified ore and productivity targets. The new feature is fully integrated with production planning and key performance indicator (KPI) summaries.

To enhance tyre management, the controller can set a maximum tk/h for an individual truck or a class of trucks. The feature is integrated with KPI summaries to allow complete tire management performance reviews.

New software also supports decision making by evaluating 'what if' impacts of making changes to the production plan during the current shift. The software helps controllers make decisions that can optimise productivity.

The new embedded dashboard enables mine controllers in the office to view shift-based and real-time KPI and production variance information. Graphics such as gauges, histograms and trend lines promote easy interpretation of data.

The upgraded site editor and computer-aided-design capabilities eliminate the need for an external mine site design program. New features enhance the ability to create and

maintain accurate digital site representations.

Caterpillar says this update "is a key building-block technology in the development of a Cat® equipped autonomous mine." The assignment engine is a key element providing closer integration with the digital mine site model. Additions are targeted to future management of the Cat Autonomous Haulage System and Autonomous Drill System.

Mobile maintenance

Mincom has launched a maintenance mobility inspection solution - Mincom Mobile Inspections Manager - that can help save up to two thirds of maintenance costs by introducing preventative maintenance regimes and proactively managing assets in the field, in real time. The Mobile Inspections Manager transforms paper-based inspections into a scripted, electronic process on a multifunction device.

Real-time onsite inspections are crucial to ensure continuous uptime and avoid asset failure. "Having the ability to inspect a physical asset on site using an intelligent application on a mobile device enables field workers to quickly, efficiently and accurately inspect assets," said Jennifer Tejada, Chief Strategy Officer for Mincom.

"Through proactive asset inspection, companies can identify any risks up front; enable any real time corrective action to be executed and ultimately avoid catastrophic failure or downtime that can cause dramatic negative business impact. Making this shift is one of the biggest hurdles faced by many organisations, as they tend to focus on addressing the symptoms rather than looking at ways to avoid major asset failures."

The Mobile Inspections Manager standardises and automates the inspection and data capture process, eliminating double-handling and paperwork, improving asset data collection and accuracy, and maximising the efficiency and effectiveness of the inspection process. The solution further transforms asset inspection by allowing customers to take advantage of a wide range of technology such as RFID, GIS, GPS and camera together with specialised asset management applications.

It also enables asset audits, providing greater audit transparency by improving the review of information from the field and enabling the enterprise to update and maintain an accurate asset register. Tejada: "If you take a mine, of the 1,000 workers there, 600 may be responsible for maintenance. Having access to real-time data in the field with an employee base of this scale helps reduce downtime, increase productivity and improve safety while lowering overall capital expenses and operating costs." **IM**