

Paul Moore reports on the increasingly integrated use of cameras, as well as the development of collision avoidance systems based on radar and GPS

ARGUABLY at an earlier stage of evolution than health monitoring, this is an area that clearly has operational safety in mind, which all major manufacturers are working on, and some new solutions are going to appear on the market this year. Many of these developments have parallels with ongoing work on autonomous truck systems, for which the latest news is the successful commissioning of a test fleet of Komatsu 930E-AT trucks at Rio Tinto's West Angelas iron-ore operation in Australia's Pilbara.

Haul-truck operation can involve long periods of boredom followed by short periods of intense focus during loading/unloading in particular. The strain on the operator's attention can be increased through poor visibility; eg from fog/dust and even rapidly changing road networks as the mine develops. The suppliers of the systems mentioned here are not claiming that technology is the complete solution, but that it can go some way towards mitigating errors when used in the right context.

For example, cameras are ideal tools for enhancing visibility, but need to be integrated selectively. Proximity alarms are good for warning of another vehicle before it comes into view, but alarms should not divert attention from vital manoeuvring decisions. GPS can enhance awareness through a bird's eye view of all the machine positions, but cannot be relied upon 100% due to gaps in availability. The key is to enhance awareness without producing unsafe levels of confidence as a result.

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CATERPILLAR

In terms of camera-based systems, Caterpillar's Work Area Vision System (WAVS) is already available for all large Caterpillar mining trucks. The system uses as many as three closed-circuit cameras to expand the view of the operator by displaying the camera view on a 7in LCD screen in the cab. The system can be integrated with the truck systems to switch to the appropriate camera. For example, when the machine is shifted into reverse, the rear-view camera is displayed automatically.

Caterpillar's Jim Humphrey, market professional – mining, told *Mining Magazine*: “The Caterpillar camera design is robust as the camera can withstand 15Gs of vibration. The camera includes an internal heater for removing condensation, snow and ice, and



Rear-view camera screen, Caterpillar 992 wheel loader

the photochromic lens darkens in ultraviolet light. WAVS also includes an optional high-pressure spray to clean the rear camera, and the washer fluid fill point is at ground level for easier serviceability.”

Specifically developed and designed for use in rugged applications and environments, the WAVS can be easily installed with any 12v or 24v DC system. The system is described as a “worksites asset” that improves safety by increasing an operator's awareness of their surroundings.

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and will be available commercially for Caterpillar large mining trucks in the second half of this year. The manufacturer has also stated that these systems will provide important input for its Autonomous Haulage System.

Caterpillar's Tom Fenelon, senior project engineer – mining, told *Mining Magazine* that Caterpillar has site awareness built into the CAES line of GPS products for track-type tractors, rubber-tired dozers, hydraulic excavators and motor graders. This system provides peer-to-peer visibility on the screen of other CAES-equipped machines operating nearby. This capability is being extended to draglines, drills and trucks by using GPS combined with wireless networking to improve jobsite awareness for operators.

MODULAR MINING SYSTEMS

Modular Mining Systems Inc's (MMSI) anti-collision offerings are referred to as Proximity Detection Modules (PDM). One of these, which has been available since December 2007, is used with the ProVision machine guidance system for shovels, excavators and drills. The other, primarily aimed at more mobile equipment and trucks in particular, is the proximity-detection module for the DISPATCH mine-management system, which will be available in mid-2009.

PDMs are “targeted at customers who wish to minimise avoidable equipment collisions”. Using existing on-board hardware and wireless communications infrastructure, the system's context-awareness is designed to minimise false alarms.

When the on-board field computer determines that another unit of equipment or a fixed hazard is within a configured warning zone (distance), an alarm is generated on the on-board graphical

available later this year. Mr Humphrey said Caterpillar has developed a short-range, object-detection system that integrates with WAVS and automatically switches to show the operator the appropriate camera view. He explains: “The technology is designed to augment safe work practices and promote operator awareness of critical vehicle zones and blind spots. The radar-based system is designed to aid the operator before the truck pulls away from a stopped position. It has a range of 20m and is primarily intended to detect light vehicles.”

The company said it had examined a large number of mining accident records and, as a result of working with “a large mining company”, Caterpillar had determined that such accidents required attention. The radar-based system is undergoing field testing

console. For ProVision mobile units, alarms include an audible warning and text notification, and any encroaching equipment is displayed in real time on the on-board map view. For other mobile units, audible warnings and text notifications are displayed.

In addition to real-time notification to operators, proximity 'close calls' are relayed to the dispatcher as exceptions, and can be logged for later analysis and reporting.

PDMs use the GPS position of a piece of equipment, which is updated continuously on board as it moves around the mine. Enabled equipment also monitors the location of others; when other units are detected within a configured distance they are grouped together. Units within the same group send and receive position updates more frequently with other members of the group to increase tracking precision. If equipment is closer than the configured threshold, a warning or alarm message will alert the operator.

The system can be configured in Auto, Central and Manual mode to balance the level of management against the amount of communications traffic. Distances for the two levels of alarm can be set, based on the equipment unit type, and alarm events can be configured to send exceptions to the dispatcher if required.

Chris McElman, product manager, open-pit, at Modular Mining Systems, told *Mining Magazine*: "We are currently beta-testing the DISPATCH Proximity Detection Module; a GPS-based, proximity-detection system for haul trucks. This system extends an existing solution that was originally implemented on our ProVision machine guidance solutions for shovels, dozers and drills."

He added: "Our RoadMap position and safety tracking system will eventually serve as an additional platform for GPS-based proximity detection. Although haul-truck to haul-truck collisions are a concern, collisions between haul trucks and light vehicles represent a significant hazard as well. An upcoming release of our RoadMap solution will inform haul trucks working in congested areas, such as shovel pads and crusher areas, that a light vehicle is in the area."

Both PDM products are completely independent of the FrontRunner autonomous haulage system being used at Gaby and West Angelas. While Komatsu owns Modular, the PDMs are OEM-independent and can be fitted to any brand or model of truck that is equipped with a DISPATCH or ProVision field-computer system (ML or newer).

The current solution relies solely on GPS, but a concept that integrates GPS-based proximity detection with on-board cameras was shown at MINExpo in 2008 and will be available as a commercial product late in 2009. This solution utilises the GPS-based proximity alarm notifications to automatically trigger on-board cameras.

Mr McElman continues: "In the future, we will integrate additional proximity-sensor triggers using separate technologies such as RFID and radar. By building a pluggable architecture for interfaces, we expect to be able to support multiple proximity-sensor systems, depending on customer preference."

Modular argues that the major hurdle in adoption of these solutions so far has been the unit cost and that its GPS-based approach provides a more affordable

solution by leveraging a mine site's existing investment in on-board computing, telemetry and a central reporting application. Operators also prefer an integrated solution that uses a single, on-board console, rather than adding more screens. Modular also believes that false alarms continue to be a significant issue with radar-based systems.

good instrument for this approach is the smarter use of cameras, which will be an integral part of the truck's control system. This expands the possibilities of overall control and usability, not only for the driver but also for service and operations in general." While some machines, such as the new MT6300AC truck, already have on-board cameras, the aim is to supply

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OTHER PLAYERS

Among the other three main haul-truck players – Hitachi, Terex and Liebherr – plans are also afoot to further develop solutions in this area.

Liebherr told *Mining Magazine*: "Even though we invest heavily in R&D to incorporate the latest technologies into its trucks, sometimes this alone is not enough. We also keep an open mind and listen to customers. From this we have learned that it is important to offer the latest technologies, but equally important to allow customers to utilise their existing systems instead of adding new ones to their operations. This is applicable but not limited to the camera and collision avoidance systems." The company said its approach seeks to optimise the customer's management of inventories and suppliers.

Alois Poettker, head of R&D at Terex Mining, told *Mining Magazine*: "Terex has started an initiative to enhance the functionality and safety of our trucks. A

an integrated system with smart features, such as the rear-view camera automatically showing on the dash when the truck is reversing. The new system is expected to be unveiled in 2010.

With regard to cameras on Hitachi mining equipment, these are now standard on its Dash-3 construction series and mining ACII-series trucks. On the new EH5000ACII model, three cameras are offered as standard and a fourth is available as an option viewed on a 10.4in LCD display. The cameras on all Hitachi trucks are robust as they can withstand more than 15Gs of vibration and are waterproof to IP69 (can be water submerged).

In terms of collision avoidance, Eaton Corp has done some testing of its Vorad system on one of the EH5000 fleet at the Cerrejon coal mine in Colombia, and Hitachi states that it has been working with the aim of establishing an OEM option that could be offered, though nothing has been finalised.



From left: camera monitor on upper panel, new Hitachi EH5000ACII truck; LCD dash display



From left: screenshots from the new DISPATCH Proximity Detection Module from Modular Mining Systems