

Celebrating the workhorses

Paul Moore looks at the best selling ultraclass trucks on the market, as well as giving some updates on new technology for trucks and truck fleets

Taking the larger class trucks into account only, the bestselling machines in the market today are the Caterpillar 793, the Komatsu 930E, the Hitachi EH3500, the Liebherr T282/T284 and finally the BELAZ 7530 series, for which the basic specifications are shown in the attached table. All of these have had different variants since their initial launch and range in payload from the 168 t payload Hitachi up to the Liebherr 363 t model. The reasons for their success differ, for example, Liebherr has focussed only on this 363 t size, and as such has really been successful in this

bracket. For Caterpillar and Komatsu their bestselling models sit between others in their own line-ups, and simply offer the size class that offers the combination of good matching with available excavators, proven running costs, and flexibility across commodities and mine types, from copper to gold, coal and oil sands. The following discussions highlight each company's workhorse truck and some of the reasons why they think it has proven successful in terms of design, efficiency and flexibility. The table summarises the main specifications for each.

Liebherr and the T282 story

Ultra-class trucks have proven to be a more productive means of moving material. As the designer and manufacturer of the first 363 t (400 short ton) class mining truck, Liebherr has been at the forefront of this successful industry solution. Since 1998, over 350 of the T282 series (T282A, T282B and T282C plus now the T284) trucks have been delivered to customers worldwide. As proof of the durability of this mining equipment, one of these original T282A trucks commissioned in 1998 is still in operation at a US coal mine. The initial T284 pre-series

The best sellers

	Engine	Drive	Payload (t)	Gross weight (t)	Net weight (t)	Power	Speed	Tyres
CAT 793F	Caterpillar C175-16	Cat mechanical	226.8	386/390	149 to 170 depending on config	1,976 kW	60 km/h	40.00R57; 46/90R57; 50/80R57
Hitachi EH3500ACII	Cummins QSK50C	Hitachi AC IGBT	168	309	140	1,491 kW	56 km/h	37.00R57
Komatsu 930E-4	Komatsu SSDA16V160 (manufactured in partnership with Cummins and equivalent to QSK78)	General Electric GTA-41	292	502	210	2,014 kW	64.5 km/h	53/80 R63
Liebherr T284	MTU 20V4000 or Cummins QSK78	Liebherr Litronic Plus AC IGBT	363	600	237	3,000 kW	64 km/h	56/80 R63
BELAZ 7530 series	MTU DD 16V4000 or Cummins QSK 60-C depending on variant	Belaz DC/AC or AC/AC from Siemens or GE	200 or 220	152 or 156	352 or 376	1,715 kW	43 km/h	40.00R57; 46/90-57



truck is currently undergoing testing sessions at the Barrick Cortez gold mine where it joined other T282 models.

Operating at high altitudes and in extreme climates, other examples of the trucks operating include those at work in mines in Australia (operated by Thiess at Jellinbah, Lake Vermont, coal); Brazil (Vale Carajas, iron ore); Canada (Synkrude, Mildred Lake, oil sands); Chile (Codelco Radomiro Tomic, copper); Indonesia (Kaltim Prima, coal); South Africa (Kumba, Sishen, iron ore) and the US (Asarco Ray, copper).

Liebherr states that operators around the world have praised the trucks for their cab layout, visibility, and overall comfort. Customers appreciate the truck's acceleration, speed on grade and safety.

The company told IM: "An obvious advantage of the ultra-class truck is its ability to consistently and effectively move the largest amount of material. In order to make this opportunity cost-effective for customers, this large amount of material must be moved in the most efficient and safe way. Maintaining its status as being the most fuel-efficient ultra-class mining truck has been the focus throughout the development of the T282 series and continues with the T284, Liebherr's newest ultra-class mining truck. Liebherr engineers designed the truck to be durable and light weight in order to establish a higher payload to empty vehicle weight ratio, which results in faster acceleration and cycle times. With an empty vehicle weight of 237 t and a gross vehicle weight of 600 t, the T282-series trucks can hold over two and a half times their empty vehicle weight as payload."

In 2003, the T282B mining truck was launched with a design that allows for maintained durability while requiring lighter

steel structures and castings. T282 series trucks from that point feature castings only in high stress areas of the frame, such as the integrated hoist carriage, cross member, and dump body pivot in order to maintain its low empty vehicle weight. This design concept makes the truck lighter, which combined with low operating costs maximizes customer's productivity and profitability.

The company adds: "For optimum reliability and availability, Liebherr designs and builds many custom-built systems and major powertrain components that are used on the T282 series trucks. In 2010, Liebherr launched the T282C mining truck with a newly-designed AC drive system. Developed and built by Liebherr to further reduce fuel consumption and boost productivity, the proven Litronic Plus AC drive system determines the optimal way to extract power from the diesel engine."

This drive system provides continuous

acceleration and dynamic braking without shifting gears. By incorporating efficient load management, the T282C mining trucks meet production targets faster, and as a result minimise associated costs such as fuel, tyres, labour, and spare parts. "The combination of this efficient Litronic Plus AC drive system, the truck's high-power engine and low gross vehicle weight leads to fast haul cycle times with higher speeds on grade if compared to other trucks in its class. In addition, this vertically-integrated solution allows for optimal distribution of electrical, mechanical and hydraulic power to other key areas of the truck. This vertical integration advances supply chain coordination and facilitates the allocation of resources according to customer needs. T282 series trucks offer reliable engine options with the latest fuel injection technology for cleaner combustion and reduced fuel consumption. Liebherr's newest ultra-class mining truck, the T284, supports engine options with power ratings up to 3,000 kW. With application-specific recommendations from Liebherr, customers are able to select the engine that will allow the truck to meet productivity targets while minimising fuel consumption. "

The Liebherr T284 mining truck also features the advanced Traction Control System. Its four-wheel speed sensing capability automatically adjusts torque to the rear wheels to maximise traction when cornering, accelerating from a standstill, or traveling down wet or icy roads. Developed by Liebherr exclusively for mining trucks, this system enables operators to consistently maintain steering control and truck stability.

Caterpillar 793 milestones

More than 3,000 793s have been sold in the last 10 years, and most of these are still operating.



Of these more than 1,500 Cat 793D and 793F models have been sold in last five years alone, which exceeds the total of all other brands sold in the size class. More than 1,000 793F models have been sold as of March 2014. In terms of the date of commercial launch of the first model and subsequent models, the 793 appeared in 1990 and was sold up to 1992; followed by the 793B from 1992 to 1996; the 793C from 1996 to 2004; the 793D (2004 to present into less regulated countries); and the 793F from 2009 to present in more regulated countries. Mines with large fleets include many of the large BHP Billiton and Freeport McMoRan mines amongst others, from Grasberg to Escondida, Sierrita, Morenci, Area C and many others; as well as many other mining groups in Wyoming and Australian coal, Scandinavian copper, Chilean copper and many other locations and commodities elsewhere.

Caterpillar marked the completed assembly of the 1,000th 793F truck in 2013, less than six years after manufacturing the first F Series 793. Caterpillar data showed that the milestone production figure is greater than the combined manufacture of all other brands of 227 t size class trucks during that same time span. "This product is at the heart of Caterpillar," Tom Bluth, Vice President of the Caterpillar Mining Products Division, said during a ceremony at the Decatur, Illinois, USA manufacturing facility. "Reaching this milestone so quickly is an outstanding accomplishment, and I thank the assembly team as well as those who developed the truck and those who support the trucks working in mines around the world."

"The success of the 793F supports our belief that it is the most productive mining truck in a wide range of applications," said Sudanshu Singh, Product Manager, Large Mining Trucks. "That success is due in large part to the collaboration of many teams in the Caterpillar organisation – all directed toward designing, building and supporting a leader in the mining industry."

In the 2000s Caterpillar made significant investments in the Decatur truck plant to deliver the best quality products. The first 793F mining truck, manufactured in August, 2007, was sent to a gold mine in Canada and continues operating reliably today.

The 793F is powered by the Cat C175-16 engine with gross power of 1,976 kW, and it has maximum operating weight of 390 t. The mechanical drive train helps make the 793F the fastest truck on grade in its size class, according to Cat. The 793F develops 235 more horsepower than its predecessor, the 793D, which used a 16-cylinder Cat 3516B engine displacing 78 litres.

The 793F is the fifth generation of the 793, builds on the proven, 20-year performance record of its predecessors with a powerful new engine,

choice of power train options, choice of body systems and a completely redesigned operator station.

The 793F also offers enhanced serviceability through its ground level service points and 1,000-hour hydraulic filter service intervals. Other changes promote safe operator and technician access – wider walkways, flat upper deck, rear access ladder and a three-way lock-out tag-out box mounted on the bumper.

The cross-flow engine design uses four turbochargers, an air-to-air aftercooler and an electronically controlled common-rail fuel system that senses changes in operating conditions and regulates fuel delivery for optimum fuel efficiency. The C175-16, with a 20% torque rise, allows the 793F to climb steep grades at productive speeds and to effectively negotiate poor underfoot conditions. The electronically controlled cooling system incorporates a MESABI radiator featuring a flexible-core design that is extremely durable and easy to service.

The 793F electronically controlled six-speed planetary transmission, with an integral lock-up torque converter, drives through the massive rear-axle differential and double reduction final drives, which together provide an overall reduction-ratio of 29:1.

The 793F standard braking system combines three brake functions (primary, secondary and parking) with an automatic, hydraulically actuated retarder operating on all four corners of the truck. These sealed, oil-cooled assemblies use a number of 874.5 cm diameter friction discs stacked alternately with same-diameter steel plates. Compressing this assembly with a hydraulically actuated piston (primary braking/retarding) or via spring pressure (secondary/parking brake) slows and stops the truck.

The 793F continues to offer the Additional Retarding option designed for long, steep downhill hauls. This option includes the Extended Life Wheel Stations package and adds a second oil-to-water cooler for brake oil, a second water pump in the brake-cooling system and larger-diameter cooling lines. Equipped with the Additional Retarding option, the 793F typically can negotiate downhill grades one gear higher, compared with trucks having standard brake/retarder assemblies. The higher gear normally allows an approximate 25% increase in attainable speed.

The 793F is offered with three body options: X-Body; MSD II (Mine Specific Design); and Gateless Coal Body. The X-Body uses a particularly heavy-duty design and accommodates a larger volume than previous Cat dual-slope or flat-floor bodies—but design enhancements keep the weight of the new body the same as previous bodies. The X-Body is

designed primarily for new mine sites, where materials of different densities frequently must be hauled.

The MSD II Body is configured based on an evaluation of parameters at specific sites, including material density, material abrasiveness, impact potential, type of loading tool, haul road conditions and conditions at the loading and dumping sites. The MSD II Body then is custom designed to yield the best balance of payload capacity and durability when working at established mine sites, where material density likely will be consistent.

When hauling coal is the primary task, the Gateless Coal Body can be used to achieve consistently large payloads. The body is designed to retain full loads without the additional weight and complexity of a tailgate. The Gateless Coal Body is designed to be used without liners.

Of course in recent years the 793 platform has grown with the CMD autonomous version that was first tested and developed at the company's own Tinaja Hills site in Arizona, then at the first trial user, BHPB Navajo coal mine in New Mexico, followed by new iron ore fleets at Fortescue Metals Group and at BHPB mines in the Pilbara. Caterpillar and Fortescue Metals Group at the 40 Mt/y Kings mine, commissioned eight Command for Hauling Cat 793F CMD trucks in the second quarter of 2013. The mine plan calls for a progressive ramp up to 45 autonomous trucks. Working closely with Fortescue and its mining contractor, Leighton Contractors, both Caterpillar and the Cat dealer in Western Australia, WesTrac, are providing a full solution for managing, operating and supporting Cat MineStar System and Command for Hauling.

BHP Billiton recently celebrated the official opening of its new Jimblebar iron ore mine 40 km east of Newman in the Pilbara region of Western Australia and opted to extend its Jimblebar autonomous truck trial to the neighbouring Wheelarra operations. Jimblebar has been using six Caterpillar 793F CMD autonomous trucks since August 2013 and from mid-2014, the trial will be expanded to include a second circuit. Wheelarra will also have a six strong CMD fleet in the second trial at its Wheelarra 4 pits with the autonomous trucks used to dump ore into a new mobile crushing station.

The first of the true ultraclass – Komatsu 930E

The Komatsu 930E was the first two-axle rigid mining truck to be offered with a payload capacity in excess of 300 short tons (272 t), making it the world's first true ultraclass mining truck before the appearance of the Caterpillar 797 in 1998, two years later. It was also the first true AC drive truck, with previous electric drive



Komatsu 930Es approaching the shovel loading area at the Debswana Jwaneng diamond mine

trucks utilising DC drive traction. There are now more than 1,700 930Es in operation around the world of the different variants, all of which have been manufactured in the Peoria facility in the US. The 930E as the 930E-2 was initially launched in 1996 with a 2,700 hp engine. Today's 930E-4 is now available with a 2,700 hp 60 litre engine but the 930E-4SE is also now available, equipped with a 3,500 hp 78 litre engine. In addition, the 930AT is offered as an autonomous haulage truck.

Among mines with large 930E fleets are Goldcorp's Penasquito in Mexico (gold), Antofagasta Minerals' Los Pelambres, Xstrata/Anglo Collahuasi and Codelco Andina in Chile (copper), DeBeers Jwaneng in Botswana (diamonds), and Rio Tinto KUCC Bingham Canyon in the US (copper).

All the 930E trucks have Komatsu engines but these are developed in partnership with Cummins through the Industrial Power Alliance between the two companies centred on Komatsu's Oyama Plant in Japan.

The 930E-2 was followed in 2000, launched at MINExpo, by the 930E-2SE featuring a 3,500 horsepower Komatsu SSDA18V170 engine that allows the model to operate at almost 4,000 m with no derating. Then in 2003 the 930E-3 appeared, powered by a 2,700 hp Komatsu SSDA16V160 engine, followed by the current 930E-4.

Komatsu told *IM*: "The 930E is known throughout the industry for its ability to run at high availability and low operating cost per tonne. Because of its technology and reliability, the 930E is often used for remote and difficult applications. The 930E was the first mine haulage truck to offer AC

drive technology. It is a proven design and efforts continue to make it even better. Current engineering effort is focused on meeting Tier 4 final emission requirements and continuing to improve fuel economy. "

It was in January 2011 that Komatsu America celebrated the 1,000th unit, stating at the time: "The Peoria factory has a long history of innovation. In fact, the first electric drive mining truck was built in 1967 where the current 930Es are assembled today. The trucks produced in the 1960s were limited to a 120 t payload capacity and are dwarfed by today's modern trucks both in size and capabilities. Today's mining trucks are equipped with state-of-the-art satellite diagnostic systems, air-cooled Insulated Gate Bipolar Transistor Systems and best-in-class



Komatsu 930E at Anglo American Los Bronces

productivity features. Komatsu has a genuine interest in its customers' success and the 930E is a prime example of that focus. Prior to its release date in 1996, the 930E underwent extensive testing to evaluate its design quality prior to production. The engineering of the 930E exemplifies Komatsu's standards for providing machines with the highest quality and reliability."

In autonomy terms, the present Rio Tinto iron ore production plan calls for the movement of 3 Mt/d of material a day at 20 different mines by December 2015, no less than half of it using autonomous trucks and mining systems. But the story began in Chile, with a five strong 930E-AT autonomous fleet that was trialled at Codelco's Radomiro copper mine from late 2005, then an 11 strong fleet at Codelco Gaby from 2008.

In its proving phase with Rio Tinto at West Angelas Pit A, the Mine of the Future has shifted 60 Mt with the 930E-AT. Over the coming three years, the plan is for the 25 initial Komatsu 930E-4AT 290 t Autonomous Haulage System (AHS) trucks to be joined by 140 others, following the signing in November 2011 of a memorandum of understanding between Rio Tinto and Komatsu President and CEO, Kunio Noji. These will form up the largest driverless mining fleet in the world. Ten autonomous Komatsu trucks are now deployed at Yandicoogina, and another 15 are at Greater Brockman.

Hitachi and the EH3500

The model that Hitachi has sold most of is the 168 t class EH3500ACII (208 delivered) and its predecessor EH3500DC (introduced 2001, 42 delivered) and R190 models (introduced 1987, some 128 delivered).

The ACII model was delivered from 2008 up to the end of January 2014, and the EH3500AC-3 model will be officially released later this year, with the new Hitachi Drive Control system and choice of MTU or Cummins engine. The Hitachi autonomous trial is being conducted with the EH5000AC-3 at the Stanwell Meandu coal mine, but is likely to include the smaller EH3500AC-3 going forward.

When the ACII was introduced, improvements included a new Hitachi system monitor and diagnoses of all onboard controls including the Hitachi drive system and engine, which is also now used on the AC-3. Data links offer complete integration, while a single colour LCD clearly details machine functions. Downtime was minimised with faster and more reliable troubleshooting and analysis. A new Hitachi load monitoring system offered benefits such as better equipment utilisation on the jobsite, accurate unit and fleet production



results, and benchmark unit statistics against fleet results. Cycle time, distance and cycle count can all be measured and recorded to further improvement of job productivity. The Hitachi load monitoring system is fully integrated with the Hitachi vehicle monitoring system and display interface, avoiding potential failure or error common in aftermarket systems. With the acquisition of Wenco in 2009, Hitachi has been able to further enhance its offering with the EH3500 in terms of fleet monitoring technology.

Notable mines with EH3500 fleets include the Calenturitas coal mine in Colombia with 18 trucks, while a new order for 10 EH3500ACII is in the process of being delivered to the Kondyor platinum mine in Russia. Other major users include Talvivaara nickel mine in Finland, Ferrexpo Poltava iron ore mine in Ukraine (whose sister mine Yeristovo is the Operation Focus in this issue), the ENRC SSGPO iron ore operations in Kazakhstan, the Stanwell Meandu coal mine in Australia, the Rotem Amfert Negev phosphate mine in Israel and the trolley version running at FQM Kansanshi in Zambia. “Speed on grade is significantly higher than the mechanical drive trucks” states Comiskey Earthmoving in Australia, another user, while SSGPO states: “The braking envelope of the EH3500 AC drive is far superior to anything we have ever seen.”

Hitachi itself tells *IM*: “Built on the proven design of the Euclid product, long established as the bench mark in rigid frame trucks, the EH3500ACII is the result of the latest technologies being successfully integrated with industry know-how and experience, driven by a continual improvement process that delivers the highest production levels at high availability and lower fuel consumption rates relative to cost per tonne moved. All backed by a comprehensive dealer support structure on a global basis.”

Truck technology updates

Cost pressures on the industry mean getting the most out of these already bestselling models through the right components, ancillary solutions and fuel strategies.

With increasing complexity of trucks, mine networks are all important. Truck fleets are one of a mine’s largest depreciable assets and fleet management software is often used to keep the mine truck fleet moving. In order to ensure maximum utilisation and production, mines employ a host of applications to ensure asset utilisation and productivity.

Todd Rigby, Vice President Business Development at **Rajant** tells *IM*: “The old adage is true; you get what you pay for. As a result it is no surprise that many mines decide to invest in the highest-quality vehicles and fleet management applications—regardless of the price. The wireless network can be thought of as the glue between applications and equipment. Therefore, mines should put an equal level of consideration towards their wireless network. However, that can prove challenging since it’s difficult to quantify its value.

The most expensive solution with the lowest rate of return happens when a mine opts for a cut rate network that doesn’t perform, and then doing a rip and replace to install the proven premium network they should have installed to being with. A mine’s wireless network is mission critical. If it fails to perform, the mine will not achieve expected return on investment for any of its applications.”

Rigby argues that mines need to consider the three C’s: Coverage, Capacity and Continuous connectivity. “If all three of these elements are not present, you will have issues with your applications. Whether your mine is open pit or underground, your wireless network is the most important factor to insure you achieve the expected ROI from your application investment.” The hardware that makes up the network has to be tough to put up with the harsh environment. Extreme weather, dust, moisture and vibrations are just some of the environmental factors a communication device needs to put up with day in and day out in a mine. “Don’t assume because a manufacturer says their equipment is rugged, that it is. Talk to customer references and review product specifications.”

Once the mine finds a network that offers rugged reliability, it also needs to see if it has the bandwidth to handle current and future applications. “You need to be sure that you will be able to run all your programs over the network without it being overwhelmed. You can verify this by speaking with references. The wireless network manufacturer should be able to provide you with customer references similar in size and applications you want to run. Investing in a wireless network is similar to buying insurance, which comes in lots of levels of quality. Cheap insurance might meet legal requirements, but be a nightmare if you had to file a claim. Whereas, better insurance might have higher premiums, but give you peace of mind, that any claim will be handled painlessly. Because your wireless network is mission critical the wrong purchase decision can be costly. Rajant’s Kinetic Mesh Network, which offers reliable, resilient, scalable and continuous broadband connectivity.”

Doran Manufacturing recently introduced a new tyre pressure sensor which it states is specifically designed for OTR tyre applications in mines. “This sensor was meticulously designed and manufactured to combat the extreme operating conditions of OTR tyre applications.” says Jim Samocki, the General Manager. “The strong performance and reliability results that we’ve seen during on-vehicle field testing combined with successfully passing tests to meet or exceed rigorous SAE standards at an independent a2La accredited testing facility confirms our intention to offer a great new alternative for our dealer partners and TPMS customers in the OTR tyre market.”

The OTR tyre pressure sensor includes a patent pending, seal design with a built-in filter to protect internal sensor components from rim conditioners and other liquids present in many OTR tyres. The innovative seal design with brass housing provides consistent valve core depression and temperature resistant seals.

A high performance lithium-ion battery is also included for enhanced tolerance to temperature extremes and to provide reliable RF signal



Doran OTR sensor and Smartlink tool

transmission for an extended period of time.

In addition to innovation in the seal design, the Doran OTR tyre pressure sensor incorporates a high-impact nylon housing with a spin-welded cap and proprietary potting material which encapsulates and protects the internal components from vibration, impact and extreme temperature changes.

The new OTR tyre pressure sensor also provides the capability to be scanned with the Doran SmartLink hand tool to provide digital pressure and temperature data during walk-around tire inspections.

Maintenance of trucks is also an importance issue. When Taseko's Gibraltar Mine added 18 Komatsu 930E trucks to its operations, one of our "workhorses" this month, major consideration was how to maintain them safely and efficiently. The company is using a WMH-D Multi Handler, distributed by SMS Equipment and manufactured by **B&D Manufacturing**. "The WMH-D is purpose-built specifically for 930Es and functions as a work platform by mounting directly onto the truck – after tyre removal – using the truck's bolts," SMS Equipment Product Support Representative Jamin Price pointed out. "First and foremost, it greatly reduces the risks associated with component removal and installation. Because it's bolted on, there's little chance of it tipping over or falling down. The Multi Handler is self-propelled and height-adjustable, and service personnel can control it with a wireless remote, so they can put it in place from a safe distance, away from potential pinch points," he added. "Because it works similarly to

scaffolding, once it's bolted on, it further reduces safety risks associated with working from a ladder."

The WMH-D is designed to make removal and installation of components, such as front extensions and spindles, hoist cylinders and rear suspensions, much easier. Multi Handler accessories include a pedestal boom, spreader bar and tools for removal of front struts, brake hub spindles and rear wheel groups.

"About 200 truck components need to be changed out every year, so having a tool such as this that's both safer and maximises production time is essential," said Price. "The change-out of a wheel motor is a perfect example of how the WMH-D can reduce maintenance time and labour. Typically, that item would take four technicians three days to complete. Using the WMH-D, the number of people needed is cut in half, and they can generally have it done in 12 to 16 hours."

Price noted that the WMH-D Multi Handler at Taseko's Gibraltar Mine has a heavy-duty frame, certified to hold 50 t. "The WMH-D is a great tool for mines looking to increase both production time and safety. Other models are available from SMS Equipment, and they come in AC or DC drive, as well as diesel."

The market is following progress with LNG use in large mining trucks. For the onboard LNG fuel storage component of the EVO-MT 8300 and EVO-MT 9300 systems, **GFS Corp** has developed a diesel/LNG combo tank and a hydraulic/LNG combo tank that are plug and play and hang on the original factory mounting positions. With either the 830E or 930E truck, there are various configurations that the customer can choose from depending on the duty cycle in the mine.

The diesel/LNG combo tank is the same dimensions and occupies the same space claim as the OEM diesel tank. Using a GFS custom, proprietary design, the combo tank provides 600 gal of diesel fuel and 300 gal of usable liquid natural gas. The hydraulic/LNG combo tank looks very much like the diesel/LNG combo tank and hangs from the OEM hydraulic tank mounts with minor modifications to the lower frame mount. Even after this minor modification the original hydraulic tank can still be reinstalled on the truck should the need arise. The hydraulic/LNG tank provides 246 gal of hydraulic fluid and 300 gal usable of liquid natural gas. Both tanks will be supplied with all of the Komatsu fittings and hoses needed in order to provide a true, bolt on, plug and play installation.

On an 830E truck the customer could opt to purchase the diesel/LNG combo only. This would get the typical mining operation through a 12 hour shift with sufficient LNG on board.

Alternatively, the customer could purchase the hydraulic / LNG combo tank and retain the factory diesel tank. This configuration would

again provide sufficient LNG for a 12 hour shift, while retaining full diesel tank capacity in the event of an interruption of LNG supply. A third option is to use both combo tanks to accomplish once per day refuelling on a 24 hour schedule.

Komatsu 930E operators typically would mount both combo tanks to accomplish twice per day refuelling schedules. However the system is offered with the option of either one of the combo tanks for those operators with lighter duty cycles.

The EVO-MT 8300 System has been installed and operational on three trucks at two locations since December 2013. One of these locations is using the Komatsu DC drive trucks and the other, described in the just launched GNA-authored Wyoming LNG Roadmap Report, is Arch Coal's Black Thunder in Wyoming, which is using the AC drive truck. One customer is already planning to begin conversion of the balance of their 830E fleet. GFS is in advanced stage discussions with several other mines that plan to do fleet conversions or minimally a pilot program.

An earlier press release had announced that Alpha Coal had placed a purchase order with GFS to convert the balance of their Caterpillar 793 fleet at Eagle Butte with the EVO-MT 7930 system. This order is progressing with the first four installs having occurred in the first week of May 2014 and the balance of the fleet, four at a time, being altered every two weeks thereafter.

The **Guardvant** OpGuard operator fatigue and alertness monitoring system provides automated, consistent, and verifiable monitoring of mining truck driver fatigue and distraction. "The benefits of the Guardvant OpGuard system not only include operators going home safe, but also reduced accidents and costs for damage repairs. In addition, fewer equipment related incidents equates to increased operational efficiencies due to improved equipment availability and reduced shutdown time attributed to accident investigations."

Pilot deployments have been a successful tool in helping mines evaluate OpGuard's performance, and have resulted in numerous full deployments in the last year. These operations include DeBeers Venetia and Voorspoed, Codelco Chuquicamata and Radomiro Tomic, Chinalco Toromocho, Sumitomo Minera San Cristobal, Cloud Peak Energy Spring Creek and others. Guardvant says it currently has a number of pilot deployments in progress and is confident the results "will demonstrate the excellent performance of the Guardvant technology."

The OpGuard algorithm monitors the driver's head and eyes for symptoms of tiredness or distraction. These symptoms include changes in PERCLOS (percentage eyelid-closure) and head movements which indicate a micro-sleep event, or that the driver's attention is diverted from the



Duratray SDB pf 172 m capacity with tailgate mounted on SDB Komatsu 830E

road in front of the vehicle for a period of time configurable by the mine. OpGuard alerts the driver when these events are detected.

The OpGuard algorithm instantaneously begins tracking (monitoring) as soon as the driver sits behind the wheel. The driver is not required to log-in or wear sensors, such as glasses or a hat, which makes adoption and implementation of OpGuard less intrusive and effortless for drivers. The OpGuard system may be interfaced with the mine's fleet management system (FMS) to enable the fatigue or distraction events to appear as exceptions on the FMS dispatcher display screen. An advantage of the OpGuard system is that the dispatcher can quickly validate the fatigue or distraction events by viewing still-shots or short video clips, which are sent when an event occurs.

The company adds: "Many mining companies have a zero harm safety goal and are looking for an integrated technology that will enable full situational awareness of operators. An example of this integrated technology includes Guardvant's OpGuard, and ProxGuard, our Collision Awareness System, both running on the Guardvant Mobile Server on-board computer. Combined together, OpGuard and ProxGuard improve the equipment operator's in-cab and external situational awareness."

Guardvant recommends that mines wishing to add operator fatigue monitoring as a component of their safety management program should perform a system trial, and evaluate the performance of the system based on characteristics such as: ease of use, low

Screenshot from the SAFEmine CAS system, in this case monitoring fuel levels at Cerrejon

maintenance, high tracking, low false positives, as well as consistent detection of fatigue and distraction events. OpGuard pilot deployments have enabled mines to successfully evaluate OpGuard's performance, as well as experience the operational benefits.

Controlling rock spillage, increasing the volumetric capacity and providing precise payload target are

some of the benefits attributed to the tailgate feature added to many dump bodies. As a response to client's enquiries and needs, **Duratray** now offers additional features to fit on dump bodies such as the mechanically-operated tailgate for coal and coal rejects. This design has been proven at mine sites in the Bowen Basin region of Australia and tested applications have obtained increased productivity in the Hunter Valley, New South Wales.

This light weight steel design of Duratray tailgate provides improvement and reduction of spillage on ramps when handling wet sloppy material with high water content.

At the Kumtor gold mine in Kyrgyzstan, Duratray has been awarded a contract to manufacture and assemble on site six units of Suspended Dump Bodies for Caterpillar 789C trucks. After site visits and inspections the maintenance and engineering teams from Kumtor and Duratray respectively identified several opportunities for operational improvements. Existing and target payloads were analysed determining that the Duratray SDB was an

attractive alternative to steel dump bodies in offering both high resistance to abrasion and increasing payloads significantly. The delivery of the first SDB units is now underway.

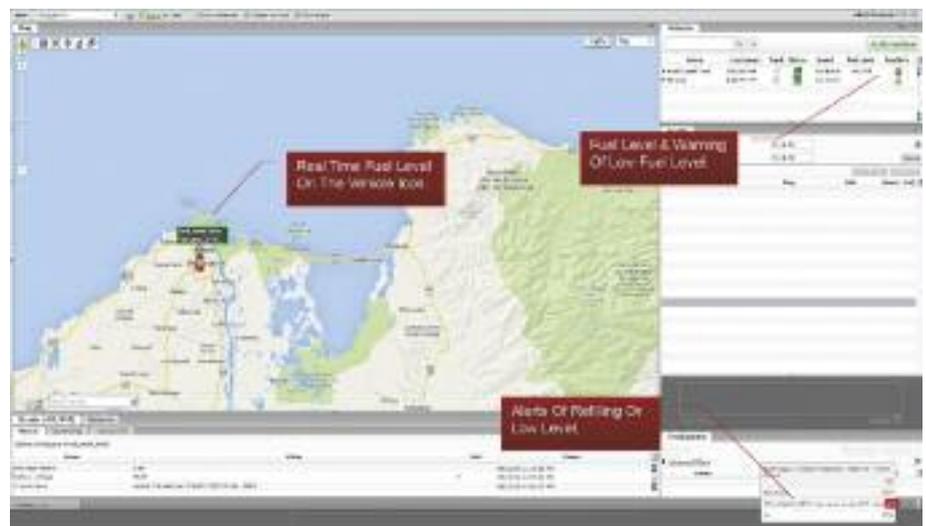
Duratray has also signed a technical support and maintenance services agreement for an indefinite period with Anglo American Group. SDBs and SDBs components acquired by a number of sites within

the Anglo American Group in South Africa will be serviced and maintained by Anglo American Field Service teams as a result of their technical skills and capacity to provide support across all mine sites.

Duratray will provide complete technical training and support to the Field Service teams in relation to the maintenance of the Suspended Dump Bodies including wear mat replacement, suspension rope adjustment, components handling and routine inspections amongst others.

Currently the fleet of Duratray SDBs operating at Anglo American sites in South Africa comprise those fitted on Komatsu 930E; Caterpillar 777F, 773F and 740; and Hitachi EH3500ACII trucks while in the next few months a fleet of Komatsu HM400-3 will be added to the list. Across Anglo Group sites in Africa, Australia and the Americas there are currently more than 100 Duratray SDBs in service.

Finally, at the Samarco iron ore mine in Brazil, **SAFEmine** has installed its Collision Avoidance System initially on 120 units of light vehicles, haul trucks and graders. Samarco states: "The system is easy to use and reports only the information needed, avoiding excessive amount of information overload for the drivers and operators so that the operators hear only the most important information. It avoids any chance of ignoring any vital signals when a behaviour change is critical. We have had no accident or incidents involving vehicles with the collision avoidance system. The system information is clear and easily comprehended by the operators



and drivers, and it is reliable.

At the Cerrejon coal operation in Colombia, SAFEmine with the Collision Avoidance System has conducted and is planning several more pilots. The company is looking for example into vibration issues. Operators of the haul trucks are complaining about back problems due to excessive vibration when the loader dumps the load onto the track. "With our CAS, we are monitoring vibration in the haul truck. Cerrejon is very interested in learning if this is an issue and SAFEmine has been working with R&D in ways for monitoring excessive vibration.

Cerrejon needs to water the roads to prevent dust from flying around. Up to now, they did not know where the water tankers were spraying water. We recently conducted a pilot and can now tell Cerrejon when the water pumps are on or off, and we can show where the tankers are on SAFEmine TRACK, a web interface that monitors the entire fleet, while we have also generated geo fences to help Cerrejon maintain real time control of where the tankers are."

SAFEmine is also working on a pilot to monitor the fuel level in the diesel tankers. Up to now, Cerrejon had to use yard sticks to measure how full the tank is. By installing a fuel level sensor, connecting it to the CAS main unit and using SAFEmine TRACK, SAFEmine can monitor the fuel level in each diesel tanker in real time.

The company is also working on a pilot to test the TrackingRadar (proximity detection sensors that detects all objects, protected and unprotected with SAFEmine CAS) in a mining truck tyre handler. The idea is to increase the tyre handler driver's awareness of objects behind them which are hard to see.

Finally at Cerrejon, SAFEmine is starting a pilot to study the effectiveness of their light vehicles using DriverID which offers more data on who is driving/operating the equipment and controlling who is authorized to start/drive a specific vehicle, while SAFEmine TRACK generates reports on trip durations for the light vehicles. SAFEmine comments: "We will be able to tell Cerrejon, which driver was on what light vehicle, how long was the trip and how long it stopped at a particular location. Cerrejon will use this information to increase the effectiveness of their light vehicle fleet." **IM**