

Heading into the future



Paul Moore reviews underground load & haul equipment around the world, with new larger truck options as well as greater lithium battery model availability being stand out trends

Starting with the big three and looking at underground trucks, there have been several interesting updates. Since the successful launch of **Epiroc's** MT65 in 2016, it has remained the highest payload capacity underground truck in the world. The company recently presented a summary of recent improvements "that have made the truck even better and further improves the value for the customer." The new engine dramatically lowers emissions, enabling more sustainable operations. The latest engine technology meets Tier 4 Final/Stage V requirements and is certified to comply with the North American standards CANMET (Canada) and MSHA (USA). NOx has been reduced by 45%, and diesel particle matters have been lowered by 80% compared to a Tier 2 engine. Lower emissions improve the working environment and reduce the need for ventilation, leading in turn to lower operation costs and a smaller environmental footprint.

"Another great advantage of Minetruck MT65 is its new Ejector dump box option for compact envelop applications. We developed this solution to cover more applications with the same load frame. The modular design is a pin-on solution that attaches to the load frame, which makes it possible to swap between standard and Ejector dump boxes as needed." Daniel Sandström, Global Product Manager, Underground division at Epiroc states: "We keep a constant dialogue with our customers around the world to receive feedback from the field. These updates are the direct result of this feedback."

An additional load-weighing display can be placed in the cabin window so the loader operator is able to ensure that the truck is fully loaded every time. This will not only help maximise the payload but also minimise the risk of overfilling/overloading. This information can also be monitored through Epiroc's proven telematics system Certiq. Certiq monitors and

records vital machine information, which helps to both improve productivity and reduce unnecessary wear.

In the market, SOMINCOR recently received the first of six units of the brand-new MT65 with a 760 hp Stage V Cummins engine for the Neves Corvo copper-zinc mine in Portugal. These units were the first to leave Orebro with this new engine.

It is also worth pointing out that the MT65 is also ready for automation. The Rig Control System (RCS) Control System already allows users to control the operation and add different automation solutions. With Epiroc's Certiq telematics solution, machine data can be used to optimise production and maintenance.

Moving on to **Caterpillar**, it has released a new underground articulated truck that, it says, features increased payload, advanced emissions controls, enhanced comfort and serviceability. The new Cat® AD63, the largest underground truck in the Caterpillar product line, features a 5% increased payload and more torque for enhanced production capabilities, compared with its predecessor, the AD60. The new AD63 also can be configured to meet the strictest diesel engine emissions regulations – for both regulatory compliance and improved underground air quality, the company says. Additional new features enhance operator ergonomics, maintenance access and safety, and data collection for machine health monitoring, according to the company. The new model will be available in late 2020, according to the company.

The AD63 is powered by the Cat C27 diesel engine, which produces 588 kW, meets EU Stage V emission standards and is approved by CANMET for use in underground mines, the mining OEM said. The truck does not require diesel exhaust fluid (DEF) to meet these standards, with the emissions control system maintaining the ability to use diesel particulate

The Talpa Maden battery LE110 has massive potential around the world in narrow vein mining

filters, such as the Cat Wall Flow Filter, to further reduce particulate emissions. The AD63 powertrain also features a new torque converter gear ratio to increase peak torque and improve gear retention on variable grades, according to Cat. "The optimised transmission shift strategy results in smoother uphill driving and greater operator comfort," it said. "The new torque converter also increases rimpull when driving away from a stop."

The AD63 engine package has extended altitude capability – from negative 3,048 m to positive 1,524 m – while the new engine cooling package maintains capabilities at high ambient temperatures. A new design and routing for cooling air, meanwhile, improves serviceability, and the radiator core has serviceable tubes for fast repairs.

In the AD63 cab, the ducted ventilation and air conditioning system gives the truck operator full control with nine adjustable louvers for comfortable cooling and efficient defogging. The HVAC system is powered by a battery electric system so it can be operated when the engine is not running, which pays off in less engine idling and lower operating costs, according to Cat.

The new cab arrangement features a forward-facing trainer seat offering increased space and comfort for the trainer, Cat says. The tilt cab feature gives maintenance personnel the ability to tilt the cab for access to the cab side of the engine for easier and faster access to components. And, outside the cab, a redesigned access ladder and fold-flat handrails enhance safety during maintenance.

The new AD63 incorporates Product Link Elite™ as standard equipment to enable data collection and equipment health monitoring. "The system enables sharing data across multiple destinations, reduces gaps in data or lost data due to network issues, and has direct connectivity to Caterpillar and Cat dealers for remote support and services, such as condition monitoring," the company said.

The AD63 also has external displays showing the weight of the truck contents to the loader operator. "Instant feedback for the loader operator enables more efficient passes and optimum truck loads," the company said, adding that displays are on both sides of the truck.

In addition to new technology, Caterpillar has added the option of a new lightweight dump body, with 38.3 m³ capacity. The AD63 also maintains commonality with other AD60 bodies.

Nathan Wescombe, Commercial Manager – Hard Rock Vehicles, Caterpillar told **IM**: "The AD63 replaces the AD60 and is designed and built to help miners improve productivity and

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Caterpillar's new AD63 features a 5% increased payload and more torque for enhanced production capabilities, compared with its predecessor, the AD60

reduce cost. For example, faster cycle times—even in challenging operating conditions—increase TKPH (tonnes hauled per kilometer per hour). Additionally, increased payload contributes to greater production and lower cost per tonne. The new truck also accommodates people in ways that can reduce costs. Improved service access reduces mean time to repair. Powertrain components are accessible with the tilt cab, and careful routing of hoses and exhaust further aid access. The truck also features superior ergonomics for the operator and redesigned suspension for a more comfortable ride. Electric heating, ventilation and air conditioning (HVAC) can be used when the machine is not running so the operator can remain comfortable while saving fuel. The new truck also has external payload displays to assist accurate loading.”

Cat Product Link Elite is standard equipment on the AD63. The hardware facilitates data collection and equipment health monitoring, which in turn is designed to help reduce unplanned downtime and increase machine availability. The hardware readies the machine for linking to Cat MineStar technologies.

Lastly, **Sandvik** is continuing its sustainability drive, announcing that it is trialling its first Stage V compliant underground truck at the Boliden-owned Tara zinc mine in Ireland. The company, in December 2019, launched its first Stage V compliant underground LHDs for hard-rock mining applications following extensive testing. Back then, it said its newest intelligent loaders, the Sandvik LH517i and Sandvik LH621i, would receive the Stage V treatment in early 2020.

Now, Sandvik's flagship heavy underground truck, the TH663i, equipped with brand new Stage V Volvo Penta engine technology, is undergoing an extensive field trial period at Tara, allowing the company to obtain first-hand customer feedback on its technical and operational performance. Sandvik said this was “an integral part of Sandvik's way of working and customer-focused mindset”. The Stage V engine in the 63 t truck is expected to deliver lower emissions, contributing

to reduced mine ventilation rates.

Pia Sundberg, Product Line Manager for Trucks at Sandvik Mining and Rock Technology, says thorough field tests are valuable to both the OEM and customer: “We want to allow enough time for sufficient testing of new technology, since it is of benefit to both sides. Possible hiccups that can often occur

when developing something new are identified prior to the product being fully commercialised, which enables us to serve our customers better in the long run. Based on the feedback that we receive, we are still able to do some modifications if necessary and thereby make sure that the TH663i meets expectations when it is released to the market with the latest engine technology at a later stage. Of course, there is also some additional new technology on the test truck that we are testing at the same time.” The TH663i also benefits from the recent improvements in Sandvik's AutoMine® offering, as AutoMine for Trucks now enables autonomous truck haulage not only underground but also on the surface.

A basis for battery

In the battery world, at Epiroc there have been numerous developments following the beginning

of its phased introduction of its Generation 2 models. Australia's Cobar copper mine, operated by CSA Glencore, has been operating a battery ST14 LHD since early this year. The mine produces over 1.1 Mt/y of copper ore and produces in excess of 185,000 t/y of copper concentrate, with battery solutions ideal for its conditions being one of Australia's deeper mines at depths of 1,800 m plus. The mine is accessed via decline from the surface and a 1.2 km shaft. Stopping areas at depth are accessed by declines from the base of the shaft resulting in long travel times. Rock temperatures are greater than 55° so diesel machines are not the ideal option. Cobar is initially using the machine to feed its Level 9 crusher but is exploring other battery machines as well. The project represents just the next chapter in a relationship between Cobar and Epiroc lasting over ten years through its main current fleet of MT6020 and MT5020 trucks.

In Europe as part of the SIMS project, a battery MT42 and a battery ST14 have been working at Agnico Eagle's Kittila gold mine in Finland. The machines have achieved impressive results with operators noticing less heat generation and vibrations, and better air quality within the operating environment. SIMS has now ended but the machines remain at the mine to maximise the trial hours originally agreed. As with other sites across the board that are testing battery machines of different types, moving forward will depend on

Talpa Maden's ultra compact battery LHD ready for global market

Turkey's **Talpa Maden** based in the Izmir district of Çigli is the country's leading mechanised underground load and haul equipment manufacturer and its lithium battery LHD LE110 project is exciting for the industry as it is one of only a few examples of this type of BEV equipment in the world especially at this compact size of a 1.25 m width (length 4.9 m, height 1.67 m) and a tramming capacity of 1 t.

The first battery LE110 machine was delivered to a Turkish narrow vein chromite mine in late 2018. The initial request came as the mine was having a hard time with ventilation costs and in addition introducing mechanisation was a serious issue for them since the market offering at the time did not have a compact machine that met their requirements in size.

Talpa says its machines are designed and engineered from the ground up and that its new battery powered LHDs are not only cheaper to maintain, but they're also tough and reliable, requiring less maintenance than a diesel fleet. The first prototype was disassembled outside and carried piece by piece through the small diameter shaft. It was reassembled underground, and since then it has been working in tough conditions at -240 m in narrow galleries where it is vastly increasing productivity in the mine. Following the first prototype the customer has now bought three more machines. Talpa told **IM** it has been testing this model for a high number of working hours and is confident that the LE110 is now ready for international market.

The company adds: “Our battery powered LE110 costs less to maintain and operate than diesel equivalents, primarily because of the simple, efficient and highly reliable design. Electricity is cheaper than diesel and there is zero cost for fuel transportation and storage. Venting out the heat and toxic fumes generated by the diesel equipment costs a fortune. Switching to all-electric provided the customer with a safer working environment while cutting ventilation costs and increasing production by nearly three times.”

Usually a major complaint about BEV technology is the perceived downtime for charging. Talpa states: “The options for fast refuelling are to either quick charge or swap batteries completely. The 2020 model offers a fast battery swap system of 20-30 minutes and a total recharge time of two hours. Estimated operational time is around 4-6 hours depending on the conditions.”

how best to optimise the spread of charging stations and also where there are mixed fleets, looking at whether batteries can be interchanged with other brands or types of mobile equipment.

Canada is also a major battery focus in mining. In 2019, Vale revealed its PowerShift program, focussed amongst other things on electrification technologies of mine equipment to increase productivity while at the same time reducing emissions. It has stated it will have over 30 battery machines operating by 2021 (including Epiroc and other brands). In 2018, Vale had already successfully trialled an Epiroc ST7 battery at Coleman nickel mine in Sudbury, followed by commissioning a battery Epiroc MT42 at Creighton Deep in 2019.

Sandvik is working on a battery-assisted version of its highly successful tethered machine the LH514E which will be known as the LH514BE (see *World Prospects* pages for more details). Sandvik is also preparing to launch a new 3rd generation 18 t battery loader (LHD) in Q4 of 2020. The all new loader is the result of **Artisan Vehicle Systems'** innovation and battery system experience, matched with Sandvik's decades of engineering expertise and a global infrastructure. The model offers battery self-loading swapping as with the Z50 truck, and has been developed in close collaboration between Sandvik's Turku engineering team and that of Artisan in the US.

Barrick recently confirmed trials of a 50 t battery-electric haul truck it mentioned in its 2019 annual report had commenced at its Turquoise Ridge gold operation, in Nevada. This trial involved an Artisan Z50, the largest battery-powered underground haul truck currently on the market. A Barrick spokesperson said the trial of the 50 t payload truck was expected to be finalised in the June quarter of this year, "with the option to extend, should the KPIs not be met."

Automation aspects

Epiroc recently released a new offering for LHD automation that, it says, brings new standards of productivity and safety to underground mining. Scooptram Automation Total allows for multi machine loader automation, with its Traffic Management System creating a common information environment that controls multiple fleets of loaders, according to the company. "The Traffic Management system is the core of Epiroc's Scooptram Automation Total package," Epiroc said. "This system operates the fleet and eliminates the risk of collisions in common drifts." The automation area is fully isolated with safety barriers that shut off the system if personnel or unauthorised vehicles accidentally enter. Yet, it is possible to bring new vehicles into the area and add them to the Traffic Management System without stopping production, using the check-in/check-out procedure, the company said.

Vladimir Sysoev, Global Product Manager Automation at Epiroc, said: "This is a great step forward in our development of world leading automation and information management solutions. Scooptram Automation Total is really a game changer when it comes to increasing safety for underground operators and at the same time levelling up the efficiency." The company says Scooptram Automation Total takes safety, productivity and cost effectiveness "to another level and makes superior performance a reality". It allows operators to control and monitor vehicle progress throughout the mine from a safe distance in a comfortable operator station.

In terms of examples, trial operation or full operation with autonomous ST18 LHDs being conducted by Epiroc (as opposed to others running auto using OEM independent systems) is underway at a number of locations, including Newcrest's Cadia East panel caving operation, Hudbay's Lalor mine in Canada and in Europe with Somincor at Neves Corvo. The autonomous ST18

at Neves Corvo is adding about three hours of work for each of the two daily shift changes. It means that, during the six non-productive daily hours, the ST18 remains in full operation, supplying the primary crusher installed inside the mine through previously defined loading points. The automation capacity is total. The operator on the surface has only the task of filling the bucket and triggering the automation. From that moment on, the ST18 carries out the entire journey to and from, unloading and returning without any human intervention. The machine has strategically placed cameras and laser vision support.



Due to the growing demand of underground mining companies for battery electric vehicles (BEVs), specifically deep mines, **DUX Machinery** is currently producing battery-powered versions of its small-sized LHD's and dump trucks, which will all feature an Onboard Quick Charger. The first DUX BEV to be introduced will be the DSL-300E compact profile scoop loader with 3 t tramping capacity, followed by the DT-5E compact profile dump truck with 5 t payload capacity, and electric drive package which will be identical to that of the DSL-300E. A bigger 12 t model DT-12E with basic articulated carrier is also being designed. DUX is known for its flexibility in design and custom-built equipment that meets the specific requirements of end-users worldwide.



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Barrick recently confirmed trials of an Artisan Vehicle Systems Z50 50 t battery-electric haul truck have commenced at its Turquoise Ridge gold operation, in Nevada

Sandvik says it has released a new solution that will allow automated underground trucks to continue seamlessly through ramp portals to the surface to complete the dumping cycle. Having offered a sneak peek of this product at the *Digitalization in Mining* event in Brisbane, Australia, in December 2019, the company has now gone public with the launch. AutoMine® for Trucks is a first for autonomous ramp haulage applications in the underground mining industry, providing autonomous truck haulage not only in underground environments but also now on the surface, according to the company. “It turns Sandvik’s intelligent mining trucks into unmanned robots; robots that keep running,” Sandvik said.

For many years, mining operations across the world have benefitted from Sandvik’s intelligent AutoMine systems for autonomous and unmanned truck haulage. “They help to reduce equipment damage, repair work and add the highest levels of efficiency and fleet utilisation, giving a lower cost per tonne,” the company says. They are scalable for different mining applications and can be supervised from remote locations.

Riku Pulli, Vice President, BU Automation, Sandvik Mining and Rock Technology, said: “Continuously setting the industry standard, we have now developed the industry-first, fully autonomous underground trucks that can operate in mining levels and mine declines including both underground and surface sections. These trucks are set to revolutionise the mining industry, bringing significant improvements in mine’s productivity and safety.”

A key requirement for an autonomous ramp haulage application is to enable the capability for trucks to operate autonomously not only underground but also on the surface. With this product release, Sandvik has unlocked this capability for its customers, it says. The different elements of the newly added capabilities have been tested at many of mine sites with existing experience of AutoMine for Trucks, a Sandvik

spokesperson confirmed.

A core innovation behind the new capability is the smart handover technology that allows trucks to switch from underground to surface navigation mode in real time. This allows trucks to continue through the ramp portal seamlessly to the surface to

complete the dumping cycle.

GHH’s comprehensive offering

The newly unified **GHH Group** is a major supplier of loader and truck products to the underground mining and tunnelling industry with production facilities for these ranges of products in Germany and South Africa. GHH Group also has numerous agreements with a number of partner companies around the world that expand the product offering portfolio significantly and provide a total offering solution to customers including drills, bolters, long hole production rigs and utility vehicles. Together with all its partners, GHH Group’s diesel and electric loader offering boasts capacities of between 1 and 21 t, with bucket sizes from 0.59 to 14 m³, while the trucks cover capacities from 20 to 45 t, and bowl sizes from 6.1 to 24 m³. GHH load and haul machines are created to work in narrow vein, low profile and mid-seam mass mining and construction applications.

GHH has recently launched some new products and upgraded some existing products to further expand and strengthen the load and haul offering. It told **IM** these have focussed not only on new technology and new emissions regulations, but taking safety principles in design to a new level and focusing on data analytics. Reduced noise, improved ergonomics, operator comfort and reduced whole body vibration; ease of maintenance and a low total cost of ownership, have been central in the developments and played a significant role throughout the design process.

The MK-42 is the most recent addition to the GHH truck family, boasting a maximum payload of 45 t, 460 kW engine in Stage V emission class, with optional Tier 3 and Tier 4 Final engines and excellent ergonomics, operator comfort and safety. It has been designed for use in harsh underground mining environments, as the perfect three pass loading partner to the GHH LF-14 loader. “The compact dimensions and largest dumping angle in its class provide for excellent

manoeuvrability and high efficiencies in productivity, through efficient cycle times. The MK-42 has a streamlined, innovative Product Design, with the Red Dot Design Award behind its name. With key benefits like a built in operator training seat in the cabin, for safety and productivity improvements with ‘on the job’ training versus a simulator, low maintenance repair costs and high production efficiencies the MK-42 is one of the most competitive trucks in its class. Exclusively for Russia, GHH also markets a special version named MK-A45 which is customised for specific options.”

GHH says it is also constantly improving its products with the aim of striving to stay aligned with latest safety requirements and innovations, regulations and legislation and customer needs. The MK-A20, 20 t truck is now available in Stage V, and has two optional operators seating arrangements – one for tunnelling and one for mining. The MK-A35, which is a typical tunnelling machine, although readily used in mining applications with the low version machine, now boasts a bi-directional driver seat and cabin and is available with a Stage V engine.

From the diesel loader offering GHH has recently launched the LF-14, 14 t loader, for mass mining and tunnelling operations as well as the LF-3, 3 t loader for narrow vein operations and the SLP-8, 8 t loader for low profile mining. The LF-14 has both narrow and wider cabin options providing versatility for use in specific applications and to provide for improved visibility and operator comfort. The LF-14 is available with Tier 3, 4 and Stage V engine packages and has simplified, mine proven electrics that are IP 67 rated for exposed components.

The LF-3 is a competitive 3.5 t machine, available with both air cooled and water cooled engines, Tier 2 and Tier 3 compliance, with a maximum of 72 kW and an operational altitude of up to 4,500 m above sea level. “The LF-3 is compact in size allowing for high manoeuvrability and is a simple, reliable and robust machine with the customers quoting that they are extremely happy with the high availabilities.”

The SLP-8 is a true 8 t loader designed to operate in 1.7 m high production or development ends. With the 178 kW and claimed best power to



The GHH LF-14 is available with Tier 3, 4 and Stage V engine packages and has simplified, mine proven electrics that are IP 67 rated for exposed components



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Sandvik's Chinese mid-tier JV - LGMRT

Lingong Mining Machinery and Rock Technology Co Ltd (LGMRT) is a JV formed between Lingong Group and Sandvik in 2016 to supply the mid-tier market. Its range include underground diesel LHDs like the UL70, a 3.5m³ diesel model developed by LGMRT, with a rated load of 7 t. The prototype machine on which the model is based is Sandvik's EJC145. There is also the 6 t UL60, 5 t UL50 and 4 t UL40. For electric LHDs there is the UL70E is developed from the Sandvik LH306E, whose predecessor was the well-known EJC145E; and the UL50E. There are two truck units, the 12 t UG120 and the 20 t UG200 based on the Sandvik EJC20.

The products have been selling well in China. At the -458 m working level in a copper mine in Jiangxi, four units of the UL70 LHD as of August 2019 had been operating for 450 days without breakdown. There are also four UL40 units working in Jiangxi copper operations. Elsewhere, the LGMRT 3 m³ electric LHD, the UL70E is working at a mine in Hami, Xinjiang, starting first at the -600 m level but then deeper underground at the -1,125 m level. At Laiwu iron ore mine in Shandong in February 2019, one UL70E unit was delivered, which is mainly used on the -114 m working level to load 20 t trucks of the same horsepower.

Sales overseas include LGMRT's UL60 which started operation in a Zambia copper mine in March 2019. LGMRT reports good feedback from the client because of its large breakout force and low fuel consumption.



LGMRT UL60 in Zambia

weight ratio of all low profile 8 t loaders, "excellent ground clearance of 300 mm and with operational capability at 28% grade it makes tramming in harsh underground mining far easier, maximising traction and ensuring high performance. The ergonomically designed, air-conditioned operator's compartment has unsurpassed visibility while providing maximum operator comfort and minimising fatigue."

Maintenance is also made easier with added perks like electric brake wear sensors and easy access to well laid out components. The payload weighing system gives visibility into productivity and allows for improved performance management. The SLP-8 is also available in an LF-8 configuration with higher profile cabin and with Stage V engine package. The GHH low profile family also has the SLP-14H, a 14 t, 1.8 m high, 265 kW low profile loader and the best power to weight ratio in its class says GHH. It is available in Tier 4 Final and at the end of 2020 in EU Stage V.

In an attempt to further grow the load and haul offering and provide for a total solution offering GHH is also developing a new 7 t loader, the LF-7, which will prove to be competitive in its class with 164 kW and the capability to operate at 25% slope. The loader will also be a perfect three pass loading tool with the MK-A20 truck.

GHH told **IM** it has also been focusing on battery technology development and has a number of platform battery designs in progress for future planned implementation into their modular product offering. This technology development is

further expanding into other alternative propulsion offerings. One of the most recent in progress developments in battery equipment is the LF-19EB, a 19 t tethered electric, battery loader designed and developed for specific customer needs. "The 250 m cabled LF19EB loader will not only reduce emissions, for compliance to European regulations, but provide for improved health and safety for operators and workers. It will significantly minimise cable handling when moving up to 2 km on battery power between working areas, by adding a battery back-up for 'inter-stope' tramming, and to operate far from the shaft entrance."

The loader's system uses its own existing electric infrastructure, during loading and downhill tramming, to recharge the battery, thanks to the regenerative brake system, which converts kinetic energy into electric potential energy which can then be re-used when accelerating. This loader will ultimately provide for all the benefits of a tethered electric loader with almost none of the

drawbacks, and will definitely support mining customers in their drive towards electric and hybrid solutions and a reduction of their total environmental footprint. Higher worker satisfaction will also be realised through reduced noise, vibration and heat. The LF19EB will also improve the productivity and reduce operational running costs.

GHH has also recently added GHH inSITE, an "add-on" data analytics product offering, for further value-add to customers. Using artificial intelligence to learn and optimise data analytics making sure that customers use correct data, at the correct time, to give them insights to make informed decisions.

Rham's hydrostatic advantage

Olifantsfontein, South Africa-based **Rham Equipment** is a true innovator in the underground load and haul space, having a lithium battery LHD program in final testing. The latest version is a battery variant of its popular low profile 20 HD MK10 7 t class machine, known as the 20 HEB, which is part way through a one year trial with a chromite mining operation in the country. Testing of the machine has shown that its hydrostatic drive system, which is of a unique in-house design, gives 40% regenerative capacity to the wheel motors to the point where it has been possible to use a smaller size of LiFePO₄ battery pack. The trial customer (as well as others in the platinum and chrome mining industry) are keen to take the machine into regular production as well as acquire more machines, but Rham MD Kevin Reynders told **IM** that it does not want to rush the development and will continue testing to the end 2020 to be able to assess a full 3,500 to 4,000 cycle life of the battery.

From a charging point of view, the Rham battery



Peruvian specialist in narrow vein mining solutions, **Overprime Manufacturing**, recently released its new XLD30D underground truck. It has a 2.6 m³ truck body with a 6 t capacity. It is equipped with a Deutz BF4L914 engine offering 72.4 kW at 2,300 rpm as well as Donaldson filters both primary and secondary and a Rexroth hydrostatic transmission. The machine is 5.74 m long but only 1.38 m wide and 2.1 m high, having an operating weight of 7.14 t and a total loaded weight of 13.25 t. It has an outer turning radius of 4.5 m. Overprime told **IM** that the machine is working at a narrow vein mine located at 4,500 m but the mini dumper has had no problems to the extent that they are looking at ordering another one

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Chinese contract miner JCHX successfully develops and trials two battery underground LHDs

A newly developed and produced 3 m³ lithium-battery-driven LHD from mining contractor JCHX through its JCHX Hubei division has been successfully trialled since end-November 2019 at the Miyun iron ore project near Beijing, "with satisfactory performance and impressive capability." JCHX says the LHD features longer working duration, with continuous loading of 65 buckets, a short charging cycle with double-port design full charging in 30 minutes, a high breakout force, easy manoeuvring, robust bucket boom for easy mucking, less noise & zero emissions. The working environment for the operator is also improved significantly as a localised high temperature caused by the engine no longer exists.

The development team chose to make the colour of the LHD similar to the JCHX flag, while the product was named as 'King Ant' with the corresponding Chinese name registered at the Administration for Industry & Commerce. JCHX stated: "In recent years, as part of government policy and national reform, more attention has been driven to environmental protection, sustainable mining development as well as green mining technology become the irresistible trend. Re-design and upgrading of mining equipment based on new-energy to be clean, zero-pollution, highly-efficient and automated is inevitably a necessity. Under such circumstances we believe a lithium-battery-driven LHD has distinct advantages in terms of safety, environmental friendliness, operational convenience, maintenance accessibility, as well as automation."

The news comes after the earlier commissioning of a battery-driven LHD (referred to as JCY-2) in July 2019, also manufactured by JCHX Hubei and successfully operated in the transverse drifts at the Lujiang iron ore project in Anhui Province, which are quite long with a comparatively small section profile, which leads to greater ventilation demand. To combat diesel LHD emissions, dust and heat generation, the JCY-2 LHD was developed by JCHX Hubei and commissioned at Lujiang. During 2.5 h of operation at the 8-0 ore pass on the 296 m level, the battery was reduced from 100% down to 47%; totally 14 draws (approximately 34 m³) weighing 120 t were loaded during the process with the loading point located 160 m from the ore pass. The fan was not activated during the operation of JCY-2, while the ambient temperature remained unchanged, no gas was discharged and dust emission was largely decreased.

"The satisfying result of operating JCY-2 strengthened the demand and willingness of Lujiang Project to adopt green mining methods. According to the charging data, it only takes 35 minutes to charge from 20% up to 100%, with power requirement of 60 kW/h. The power consumption during the loading process shows JCY-2 can meet output demands. In the meantime, by using such equipment the energy consumption greatly drops and zero emission is almost achieved."

system can do a quick charge through an onboard charger by plugging directly into a DC socket. This will charge the batteries from flat to full in two hours. This method can lead to unbalanced cells in battery system so the company has found that this can be avoided by doing a longer 8 hour charge every second week coinciding with the machine's scheduled maintenance.

What is clear from its journey in battery LHD development is the speed at which battery evolution is happening. Today's batteries packs are half the weight that then where a few years ago but with double the

power at 160 kW/h.

The new

lithium battery chemistry means 20% more inherent battery power. To an extent this could be seen as a problem as new machine development takes at least a couple of years by which time battery tech moves on – another reason for letting the new LHD test run its course.

In the absence of activity by other major OEMs, Rham is also looking to bring the advantages of battery operation to the South African room and pillar coal mining market in the form of a flameproof rated battery LHD. Currently the coal mines are having to pump cool air to get rid of CO₂ and battery units will minimise these costs. The Rham design, again with the hydrostatic drives and wheel motors, is almost the same size with a similar structure to the equivalent diesel machine, whereas competitors have had to look at a complete design change to allow space for the battery packs.

For those customers still wanting to use the diesel 20 HD, this machine has improvements such as use of a DPF to help users meet emissions targets as well as making it to some extent

"automation ready" with the ability to operate for example with teleremote for when customers want to go down that path. Rham has already trialled teleremote, an LHD operating during the "gas cleaning" cycle between blasts, several years ago, but the issue of any kind of automation remains sensitive in the

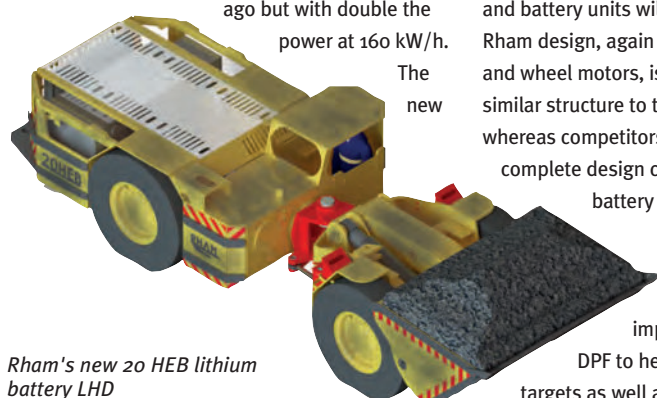
South African market. One option is to be able to show customers how teleremote works by setting up a working system in a test mine and just such an operation is in the planning between MEMSA and the Mandela Mining Precinct project.

The hydrostatic drive system has also shown when compared against other machines in the same mine of equivalent size/capacity and even a similar engine, that it gives much lower fuel consumption as it is only delivering the power that the LHD needs during high intensity parts of the loading cycle – 16-17 litres per hour versus well over 20 for alternative machines.

A final note on the future, it is well known that Anglo American is working with a number of parties on its FutureSmart Mining™ project. On the surface this of course includes its "hydrogen truck", a converted Komatsu 290 ton FCEV haul truck that will be powered by a hydrogen fuel cell module from Ballard paired with a Williams Advanced Engineering scalable high-power modular lithium-ion battery system. Underground, Anglo is looking now mainly at liquid organic hydrogen carrier (LOHC) technology, a fuel liquid technology that is much safer to use at atmospheric pressure. It is an oil product that is loaded with hydrogen, which is then released through a reactor from the oil before it enters the fuel cell. In short, it is a battery extender – the fuel cell charges the battery to power the machine. There are three main projects for an underground loco, an underground ultra low profile dozer and an underground LHD, with Hydrogetics the common partner on the fuel cell side. Rham is the OEM partner for the 8 t LHD project, and DOK-ING on the ULP dozer.

Lastly in market terms, Rham remains firmly South Africa focussed, mainly due to the huge market size – there are literally thousands of working LHDs especially in the platinum mines, mainly spread currently between GHH, Rham, Sandvik, Aard and Epiroc in hard rock. In coal Sandvik have tended to dominate the LHD space.

The potential of its innovations goes beyond SA, but will require a lot of investment in service infrastructure etc. One potential market is Russia – Rham already partners with Chetra, marketing its mining dozers in SA, and working with Chetra to offer its LHD solutions is one option. Product wise, the company also offers battery utility vehicles and underground trucks in mining, which are much easier to deal with having more of a constant power demand as opposed to LHDs that have several spikes in power demand. And it has



Rham's new 20 HEB lithium battery LHD

built its first blasthole drill for surface mining to compete with the Epiroc DM30 and Sandvik DK25 in SA – the DK25 for example can drill a 171 mm hole, while the Rham drill of the same class can reach 250 mm.

Paus's PFL progress

The Paus LHDs PFL 8, PFL 10, PFL 20 and PFL 30 it says are especially designed for the customer needs in the toughest underground mining operations. The company says its machines “particularly convince the industry by their reliability and power.” All the loaders are available with various diesel or electric drives (battery, cable). Furthermore the loaders can be controlled via a radio remote control for safer operation conditions.

All vehicles of the PFL series are equipped with a driver's cabin with easy and ergonomic side-access. “By this solution, the times in which the operator had to access his workspace from the articulated joint – exposing the operator to an increased danger – are over. The ergonomic and large operator's cabin not only fulfils ROPS/ FOPS requirements, but can also be equipped with a very large number of safety features such as collision warning systems, fatigue warning systems or 3P seat belts to protect the operator in the best way possible. If the vehicle has to operate in extremely unstable mine areas, all loaders can be easily and quickly converted to a radio remote controlled vehicle so that the operator's health is not at risk at any time.”

The side arranged seat gives the driver an excellent overview when loading and manoeuvring, with a comfortable body posture. “An air-suspended seat not only guarantees the comfort of the operator, it also increases health protection when loading in rough terrain. The operator's platform is equipped with two joysticks. One multifunction joystick for the direction of travel and gear shifting and a second joystick for the working hydraulics. All operating elements are easily accessible from the driver's seat and can be perfectly surveyed even in poor light conditions. The large and clear display provides information on all important vehicle data at all times.”

The extremely compact loaders by Paus it says have extremely high break out forces and excellent loading efficiency. In addition, the optimised vehicle widths and small turning radii allow a fast hauling of the mineral being extracted. For example, the PFL 8 - with a payload of 1.5 t the smallest Paus loader - can already be used in track widths of 2.2 m. The hydrostatic drive in combination with a powerful and low-emission engine offers a high productivity and a reduction of the life cycle costs of the machines. The larger Paus loaders - such as the PFL 20 with a payload of 4 t and the PFL 30 with a payload of 6 t - are

The largest machine in the Paus LHD range, the PFL-30

assembled with an optimised hydrodynamic drive train for very high penetration forces. The loaders are equipped with the most up-to-date engine technology to guarantee sustainable mining and low ventilation volumes.

Paus machines support the operator with intelligent vehicle and service solutions in order to guarantee a high durability and low life cycle costs among high safety standards. With the new Paus Connect feature, machine operations can be controlled and analysed. “With the support of the Paus Diagnostic Display, which indicates maintenance intervals or enables the operator to simplify troubleshooting, the already high durability of Paus machines can be increased even more. It enables a fast parameterisation of the machine to react to changing operating conditions. Paus Connect can inform the mine control room about the positioning and productivity of the machine with appropriate data, for example via LTE technology. With the generated data, efficient maintenance jobs of the service staff can be controlled exactly and necessary maintenance times can be optimised.”

Additionally, the data can be transferred to Paus for error analysis and/or remote maintenance, so that necessary services can be handled in the shortest possible amount time. All maintenance points of the machine can be reached from the ground, which means that components can be changed quickly and easily. Lubrication points that are difficult to access are automatically lubricated by the optionally available central lubrication system. And: the hydraulic and electrical systems are easily accessible via flaps inside the operator's platform for easy maintenance.

In order to promote sustainability in mining, to guarantee the required amount of fresh air and to enable ventilation costs when expanding existing vehicle fleets, Paus also offers the PFL series as cable or battery-powered versions. Already in the early 1990s, Paus developed and built vehicles for emission-sensitive areas with electric drives. Today, Paus LHDs are offered with a modular battery concept which allows both quick charging and changing of battery packs. In addition, the machines are equipped with “onboard charging” systems and regenerative braking systems to ensure high availability and short charging times. “Of course, safety is also a priority in this drive technology as Paus uses a modern, self-monitoring battery system with insulation monitoring. The installed batteries meet the highest safety standard ECE-R100.”



ARMZ Aramine collaboration bearing fruit

ARMZ Mining Machinery says it has become the first and only company in Russia and the CIS producing lithium-ion battery-powered mining equipment through a collaboration with France's **Aramine**. The company, part of ARMZ Uranium Holding Co, has started producing the mining equipment in Krasnokamensk, in the Trans-Baikal Territory of Russia, at the site of Priargunsky Industrial Mining and Chemical Union (PIMCU, PJSC is a part of ARMZ Uranium Holding Co). The project is being implemented under an industrial partnership agreement ARMZ Uranium Holding Co and Aramine, signed in April 2019. As part of this pact, ARMZ Mining Machinery is the project operator.

ARMZ said the production from Krasnokamensk will cover the internal needs of ROSATOM State Atomic Energy Corp (of which ARMZ is a part of), and let the company enter foreign markets with ‘competitive products. The ARGO LHD 140B is designed specifically for underground work in narrow-vein deposits, according to ARMZ. Based off the design of the Aramine miniLoader L140B, it has a width of 1.1 m and a bucket carrying capacity of 1.3 t. A 50 kW engine and a lithium-ion battery pack provide high mobility and continuous operation for up to four hours; at the same time, offering low noise, minimal heat transfer and no gas contamination in the mine. The machine significantly outperforms the requirements of the Russian standards in industrial safety, according to ARMZ.

Ivan Kiselev, Director General of PIMCU, PJSC, said: “New LHD machines will let us efficiently and reliably carry out operations for the loading and transportation of ore inside the stopes. The transition to a new battery-powered narrow-vein equipment is an economically viable solution aimed at reducing operating costs and improving the quality of ore mining.”

Igor Semenov, Executive Director of ARMZ Mining Machinery, said the production of the ARGO LHD 140B means ARMZ Mining Machinery has become the first and only company in Russia and the CIS producing lithium-ion battery-powered mining equipment.

He explained: “We adapted the Aramine design

and specifications to Russia standards, organised the technological process: in-house production of the structural frame, arms and dippers, assembly of body parts, installation of components, start-up and commissioning of machines. Our next step will be the localisation of the production of lithium-ion batteries and the expansion of the product line with other types of underground equipment.”

The first serial vehicles have already passed factory tests, according to ARMZ, and were sent to the uranium mines of PIMCU, PJSC in April 2020. In 2021, the ARGO LHD 140B will enter the Russia market and will then gradually become available in other countries within the customs union, it said.

Fambition LHDs making waves in Chile and Peru

China's Qingdao **Fambition Heavy Machinery Ltd.**, often referred to just as Fambition, has been one of the best known names among the country's underground mining equipment OEMs for some years, but the company really took a step forward late last year when it delivered four 10 t (4 m³ bucket) class FL10V LHDs to Codelco in Chile. Two of these machines have gone to work in the El Teniente Division underground copper mine and the other two at the Salvador Division underground copper mine. They arrived in October and November of 2019 and are the first Chinese LHDs to be used by Codelco. The FL10V is an LHD using FAMBITION™ technology that is designed for large scale underground metallic mine production, requiring a minimum drift width of 4.2 m. All key components are international well-known brands including an DEUTZ engine, Kessler drivetrain, Dana converter drives and Parker hydraulic system which uses load sensing variable piston pump for higher efficiency and lower energy consumption. It applies CAN-bus technology with an onboard display to show real time operating parameters with self-diagnostics and troubleshooting. Peru-based Chao Zhang who heads up Americas sales for the company told **IM** that Fambition was chosen against other manufacturers, including other Chinese manufacturers, as it could offer the size class needed that matched the performance of the traditional major manufacturers but at a more competitive price and at the same time properly supported on the ground. Fambition has set up a new warehouse and office in Rancagua and has a team of ten people in the country including full time technicians at the mine. El Teniente's Maintenance Superintendent, Hernán Figueroa, pointed out at the handover ceremony of the first two machines that Codelco is very interested in generating business with China, as at the end of the day China is also the main client for its copper metal. From a machine point of view he said

Codelco made this purchase because it believes that “they are quite competitive from the technical and economic point of view in our tasks. We have good expectations. The components are of good quality, the engine, the transmission, the axle, and we believe that it can be a reliable machine and that it can give a good result.” b Rodrigo Quiroz, Superintendent of Mine Engineering said: “This equipment on average is 20% cheaper in investment and what we want to prove is the added lower cost of maintenance and operation, where thanks to the agreements and commitments made we expect attractive results.” He also wants progress in terms of technology from Fambition going forward. “The arrival of the Chinese LHDs is the first step in a path that in the future should focus on electrical technology. It is part of a range of initiatives to move there and we have asked Fambition that if you want to continue with us you must push automation and



Fambition delivered four 10 t (4 m³ bucket) class FL10V LHDs to Codelco in Chile in late 2019

electromobility. Thus, these machines in the future will be electric and autonomous, operated from Rancagua or from an office outside of the underground mine.” And a final note is that Fambition is not limited to Chile in the region, it has also recently set up an office in Lima, Peru in late 2019 with its own support team. Fambition has already had some LHD sales in Peru and says it looks forward to further building relationships with customers in the country as well as in the wider Americas region. **IM**

China's Alpha developing new remote control LHD

It is estimated that there are now at least ten OEM agnostic companies in China offering levels of automation of underground load and haul equipment from teleremote up to full automation. One of them is **Alpha Industrial Intelligence Holding Co Ltd.**, a Chengdu-headquartered group with an additional location in Kunming plus a base in Sydney, Australia. As an example of its projects, as early as 2011 it deployed a line of sight teleremote system at the Caijiaying gold and zinc mine on two SINOME ACY-3L LHDs. The mine used backstopping blasting starting with a slot raise at one end of the stope, and retreating blasting at both ends. For safety reasons, a significant part of the ore remained in the most distant part of the blasted areas could not be removed, which was resolved with this solution.

Moving to the present, Alpha now offers autonomous solutions across all machine brands but also told **IM** that it is also developing its own TLHD-WJ-2D diesel LHD, which it says adopts the most advanced manufacturing standards. It has two operation modes of vehicle local control and remote control, which are flexible and optional to ensure operation safety in dangerous areas. Through the built-in sensor, the operation status data of the LHD is also uploaded to the Alpha Cloud Intelligent Maintenance cloud to enable data fault diagnosis and predictive maintenance of the LHD. The LHD is being assembled at the Techgart Tianjin factory (Techgart is a shareholder of Alpha) and it is expected to be launched in July 2020. It is powered by a reliable Deutz engine and the bucket was produced with full machine automatic welding and is made of NM500 wear-resistant steel in the high wear parts, extending the service life. The gearbox has four gears for forward and reverse operation, which can efficiently adjust the power requirements.

Various sensors are installed on the equipment to monitor the running status in real time. An LCD screen on the remote transmitter can display signals and feedback with error alerts as well. Sensors follow engine parameters: oil pressure, engine temperature, engine speed; hydraulic parameters: hydraulic oil pressure, brake pressure, hydraulic oil; as well as fuel tank level, travel time, engine operating status, braking state etc.



Alpha's new TLHD-WJ-2D diesel LHD offers remote control and IoT condition monitoring



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