

# Load, haul, dump...and charge



As always in our annual round-up of underground primary fleet technology, we take a global view – this time focused on battery electric being the long term industry driver. Paul Moore reports

**J**ust like in surface mining – in underground load and haul, the unmistakable long term trend is towards both autonomous operation and electrification with batteries and everything that goes with that in terms of infrastructure. However, while there are a number of trials and test phases underway, with a few exceptions like Kirkland Lake Gold's Macassa, Newmont's Borden and the in-development Glencore Onaping Depth, there are still very few mines designed around full or near full battery electric fleets. That said, many major underground projects are now citing battery electric mining as a considered approach at feasibility stage.

Before getting into battery electric progress, it is good to highlight the fact that Stage V diesel engines still represent a major step forward for underground operators in medium term emissions reduction. As an example, in early 2020, the Toro™ LH517i and LH621i became the first Stage V compliant underground loaders from **Sandvik**. Earlier this year in 2021, when it introduced the new the Toro™ LH410, this model also got a Stage V engine as a new option, and a wide range of other new features. The company told **IM**: "Currently, more of our loaders and trucks are being outfitted and tested with new Stage V engines. It is expected that we can share more news about product upgrades and new product releases later this year."

Sandvik follows the European Stage V exhaust emission legislation for off-road engines to reduce the number of diesel particles in the exhaust. The Diesel Particle Filter (DPF) helps to improve air quality underground in the power range 130-560 kW. Passive DPF regeneration takes place during normal operation to minimise equipment downtime. For the larger equipment

in power ranges higher than 560 kW, the requirements are different and therefore the solutions will be different.

Additionally, loaders and trucks with a Stage V engine have built-in fire prevention solutions to reduce the risks relating to fire underground. This equipment is designed with corrosion, heat and water resistance materials, are quieter and fuel consumption is reduced by an average of 3% compared to lower stage engines.

"Our customers are expecting to get value for their investment: a productive, reliable truck or loader with excellent performance and overall low cost of ownership. As there are no uniform standards, this is why extensive customer field tests and following legislation and national certification standards, such as Canmet and

*The R1700XE is the first battery powered/zero emissions equipment for the Cat underground hard rock mining LHD product line*

MSHA, help us prove that our vehicles meet their needs and are the best in their class. There were more than 10,000 hours of testing in underground mining conditions across multiple customer sites before making the Stage V an available option. The Stage V engines are now globally available as an option on certain Sandvik loaders and trucks; and as described, more and more equipment will have this engine option available."

Since the successful launch of its Minetruck MT65 in 2016, Epiroc has maintained the Minetruck MT65's position as the highest



*Sandvik continues its program to develop Stage V compliant underground loaders and trucks for the mining industry*

## Cat to unveil R1700 XE LHD & MEC500 Mobile Equipment Charger

Underground mining continues to be an early adopter of sustainable mobile equipment solutions. The new Cat® R1700 XE LHD, with its 15 t payload and 24,190 kg lift and tilt breakout, features a battery electric design that **Caterpillar** says delivers superior productivity in underground applications with the benefits of no engine heat or exhaust emissions. It offers an 18 km/h top speed. The new Cat LHD offers 100% battery electric propulsion, which generates significantly less heat. An Autodig function optimises loading and traction control to extend tyre life. Liquid cooling allows the batteries to be cooled while the machine is put back in operation, increasing machine uptime availability. To maximise runtime, batteries stay on the machine. Using the portable Cat® MEC500 Mobile Equipment Charger, the R1700XE can be fully charged in less than 30 minutes using a single charger or in less than 20 minutes using two chargers. “There is a need for a clean and safe working environment underground, which currently requires installation and maintenance of complex and expensive ventilation systems for clearing exhaust emissions. With less emissions from the machines like the new Cat R1700XE, mines can reduce the dependency on these ventilation systems. The new R1700XE LHD and MEC500 charger are a key part of the vision to an all-electric mine.” The R1700XE is the first battery powered/zero emissions equipment for the underground hard rock mining LHD product line. It offers remote control operation capability. MINExpo 2021 attendees will get a first look at the R1700XE this September in the Caterpillar Central Hall exhibit 6229 at the Las Vegas Convention Center. Targeted commercial availability for the R1700XE is Q4 2021 with deliveries in early 2022. Looking in more depth at the MEC 500 (Mobile Equipment Charger) for the R1700 XE - a first of its kind in the industry, the new Cat® MEC500 Mobile Equipment Charger is designed to charge quickly and safely wherever it is needed. Unlike static charging stations, the 1,600 kg portable charger can be moved to where it is needed via towing, fork truck, or the R1700XE. It eliminates the need for regular battery handling and swapping, allowing for more efficient charging and production. Its 500 kW capability delivers an impressive range of 300-1,000 V and up to 700 Amps. The adjustable output can be used to trickle charge or quickly charge the R1700XE – this fast charger can be used as a single unit to deliver a full charge to the R1700XE in less than 30 minutes or in parallel to charge the LHD in less than 20 minutes. The charger is built rugged meeting ISO2867 rockfall protection and IP66 rating for water and dust protection. Key components are isolation mounted against vibration or seismic activity. It is sealed against humidity with enclosed air conditioning. The MEC500 Mobile Equipment Charger will also be on display at MINExpo.

*The MEC500 Mobile Equipment Charger's adjustable output can be used to trickle charge or quickly charge the R1700XE – this fast charger can be used as a single unit to deliver a full charge to the R1700XE in less than 30 minutes or in parallel to charge the LHD in less than 20 minutes*



payload capacity underground truck in the world. It has now 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. Our 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.”

### NEXGEN SIMS

Moving back into the battery electric arena and the highly successful SIMS program has been replaced by NEXGEN SIMS which is being led by Epiroc and started up officially on May 1, 2021. It builds on the successful EU-sponsored H2020 SIMS project, also coordinated by Epiroc, which ran between 2017 and 2020. SIMS played an

important role in advancing sustainable mining operations, partly through the use of battery-electric machines.

The new three-year project, called NEXGEN SIMS, will support new technologies, methods and processes that will enable a more sustainable and efficient carbon-neutral mining operation. It stands for Next Generation Carbon Neutral Pilots for Smart Intelligent Mining Systems and will run until April 30, 2024. The total budget for the project is €16 million.

A key aspect of the project is to develop autonomous carbon-neutral mining processes. This includes the use of battery-electric mining equipment, full utilisation of 5G for optimal connectivity and positioning, autonomous material handling, AI-powered traffic and fleet control, and collaboration among machines. Epiroc machines that will be part of the project include the Scooptram ST14 Battery loader and the Minetruck MT42 Battery hauler, among others. The project is also focusing on the mine worker of the future - ‘the modern miner’ – including safety, for example by developing autonomous mine inspection technology.

The project is being coordinated by Epiroc, and the other project partners consist of mining companies Boliden, Agnico Eagle Finland, KGHM Polska, K+S and OZ Minerals; services and system suppliers Ericsson, Mobilaris MCE, AFRY and KGHM Cuprum; and universities Luleå University of Technology and RWTH Aachen University – all based in Europe, except for OZ Minerals which is based in Australia.

“Collaboration and partnership among stakeholders that have different areas of expertise is increasingly important to successfully advance complex digital and automated systems that will improve the mining industry’s environmental impact, work environment and productivity,” says Helena Hedblom, Epiroc’s President and CEO. “We are proud to be part of and to lead the NEXGEN SIMS project, which will play a crucial role in this positive development.”

### Epiroc’s future mining journey with customers

Chile’s Pucobre and India’s Hindustan Zinc represent great examples of how closely the big OEMs are working with customers on the application of the latest underground primary fleet technologies.

In 2017, Chilean selective underground miner Pucobre, which runs three mines, all within a 20 kilometre radius of the city of Copiapó, signed a contract with **Epiroc** to replace its entire fleet of trucks with 20 Minetruck MT65 trucks and six Scooptram 18 loaders. Faced with falling ore grades and fluctuating copper prices, the company needed to increase production and cut costs.





*Epiroc recently completed a ST1030 battery conversion in Sudbury, Canada*



The trucks offered the capability to transport 25 t more per trip than Pucobre's previous vehicles and the loaders' doubled scoop capacity to 18 t. The new trucks contributed to Pucobre's monthly mineral extraction increasing from 333,000 t to 460,000 t, and the company has set itself an ambitious three-year development plan (2019-2021) to boost productivity by 40% and reduce costs by 25%.

This required setting up a training centre with simulators, a maintenance workshop and Epiroc staff permanently on site to jointly solve problems that arise.

Epiroc has implemented its 6th Sense technology, which includes Certiq telemetric software. Data is fed from trucks to Pucobre's Mine Operations Center on the surface. Corrective action can then be taken in real time and protocols implemented to improve equipment usage in the future.

Pucobre also implemented the concept of Short Interval Control (SIC), which reduces slack between activities to increase uptime which, in turn, gives more production with the same crew and fleet.

Epiroc and Pucobre have also entered into a strategic supplier/customer partnership, unique in Chile, with Epiroc guaranteeing mechanical availability over the lifetime of the new fleet, which is nine years in the case of the trucks and 5-6 years for the loaders, in order to help Pucobre meet productivity KPIs.

Epiroc plans to test its first battery-powered truck in Chile in 2021, which gives six hours of autonomy and will cut fuel consumption and require fewer spare parts. In addition, Pucobre is piloting a tele-remote LHD loader, which can continue to operate while drivers take breaks.

Moving to India, and Hindustan Zinc Ltd has signed a Memorandum of Understanding with Epiroc for 'Zero Emission and Sustainable Mining by introduction of Battery Electric Vehicles (BEV) in underground mining.' HZL's underground mines are in Rajasthan & include Rampura Agucha, Rajpura Dariba, Sindesar Khurd, Zawar and Kayad.

This will help HZL to explore the possibility of introducing battery operated vehicles in underground mines which will help reduce carbon emissions, enabling the mine operations to become more environment friendly. "Industrial activities around the globe are fast moving towards building sustainable partnerships that bring efficiency and expertise to business. It's imperative for any partnership to share same values to be successful, and both Hindustan Zinc as well as Epiroc India share the values of safety, sustainability, innovation and technology in running operations."

Commenting on the MoU, Arun Misra, CEO, Hindustan Zinc said: "At Hindustan Zinc, we are committed to Smart, Safe and Sustainable operations and we believe that as a leader it is incumbent on us to be catalysts for transformation towards adopting sustainability driven business solutions. This partnership with Epiroc fortifies our commitment to green and responsible mining and takes us further in the right direction to achieve carbon neutrality, in line with our emission reduction Sustainability Development Goal for 2025."

Jerry Andersson, Managing Director, Epiroc India added: "A safer and cleaner mining starts only if someone takes the first step. Epiroc has always been a leader in mining technologies. We showcase the BEV in underground mining with the broadest offerings and a mission to deliver the world's greenest machines. Our memorandum with Hindustan Zinc is a step on our mutual journey for a safer and more sustainable mining operation to come."

India has also been part of one of Epiroc's first battery retrofit projects. At Epiroc's Engineering centre in Bengaluru, Karnataka, India, a team led by Sathish Selvan recently helped a team in Sudbury complete the battery conversion of a 10 t class ST1030 Scooptram..

## **Sandvik and Artisan continue forward charge**

Sandvik-owned Artisan Vehicles and Sandvik itself have been highly successful in getting battery machines on the ground so underground mines can see and feel the benefits of battery

electric. Three great examples in North America alone are New Gold's New Afton, Pretivm's Brucejack mine and Sibanye-Stillwater.

Pretivm Resources Inc is now at the start of a process to replace 13 diesel-powered 30 t payload underground haul trucks with battery electric zero emissions trucks at its Brucejack gold mine in northwestern British Columbia, Canada, approximately 65 km north of Stewart. For now, the plan is still at a trial stage, with one model under consideration being the 50 t class Z50 truck with self-swapping battery capability from Sandvik-owned Artisan Vehicles based in Camarillo, California. A unit recently arrived at the mine for testing. The project is being partly funded thanks to a C\$7.95 million investment from The CleanBC Industry Fund and is set to see emissions cut by 64,400 t CO<sub>2</sub>e through 2030.

Following shipment from Camarillo, California, the first Sandvik electric 18 t LH518B loader in the world is now underground starting field tests at New Gold Inc's New Afton block cave gold-copper mine in British Columbia, Canada. Sandvik says initial feedback from operators is that it is unbelievably quiet & they really like the instant torque. The loader features Sandvik's AutoSwap technology, which allows easy battery exchange in about six minutes, as well as AutoConnect, which allows the operator to complete a battery swap without leaving the cabin. New Gold has said that that the introduction of these vehicles is an important step in its C-zone development and greenhouse gas reduction targets. The LHD is being joined by 50 t class battery electric Z50 trucks and a battery bolter – the Sandvik DS412ie. The C-zone block cave zone is located approximately 550 m below Lift 1. Development towards the C-zone is underway with production planned to commence with the first of 143 planned drawbells in July 2023. The C-zone block cave will be producing from 2023-2029. Ore segregation is planned to improve mill grades while a second crusher and underground conveyor system extension for materials handling is to be installed.

At Sibanye-Stillwater's US PGM mining complex in Montana, which includes the Stillwater and East Boulder mines, the company recently told *IM* it is currently trialling an Artisan Vehicles A4, 4 t payload (1.5 m<sup>3</sup>/2 cubic yard capacity) LHD. This is an updated version machine as an initial unit was trialled in 2018-2019.

Sibanye-Stillwater states: "As we engaged Artisan with this machine, we agreed to a 200 run-hour period where we were able to address minor defects and bugs while we also trained people. The next sequence of 300 run hours is actually a performance period wherein we are matching unit productivity performance, reliability, failure rates and repair rates. As well,

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*Komatsu has released two new LHDs, the redesigned WXo4 4 t legacy model and the all new WXo7 LHD*

we are wanting to confirm battery charge and re-charge cycle.”

The company adds: “We are presently at 296 total hours on the machine – so 96 hours into the formal performance period. Unit productivity has been good. Reliability issues have remained – largely small issues and parts flow due to COVID have been very problematic. The machine is solid – but small things are still causing uptime issues. We are pleased in that we are realising about 5.5 hours charge time and generally a 2 hour re-charge cycle. This works well for us. The machine is stealthy, quiet and has plenty of power.”

At its California home base, Sandvik continues to invest in Artisan, with the company recently moving premises in Camarillo, to expand its production and testing capabilities. “We’re definitely growing in Camarillo,” Artisan’s Vice President of Technology, Brian Huff, told **IM** recently. “The move to a larger facility comes at the same time we are ramping up a lot of hiring in terms of engineering and manufacturing personnel.”

Artisan’s new facility comes with a test ramp with a 20% grade and a whole area for mucking on the property. “This will allow us to do a lot more development testing in a short period of time, giving us an advantage in terms of validation testing and trials of new designs and tools,” Huff said.

The potential for speeding up Artisan’s time to market will be increasingly important as more mines replenish fleets with battery-electric equipment.

A final note on new battery machines from Sandvik and Artisan going forward plus on how the two organisations will integrate further as more technology is developed. Sandvik told **IM** that work on its new 65 t class battery truck continues but an exact timeline has not been released yet: “The truck is in good progress however and it will be joining the Sandvik fleet; when the truck will be launched, it will have the Sandvik brand. The formerly acquired Artisan Vehicles is today an integral part of Sandvik, and it is a business unit that belongs our Load and Haul division. The name of this business unit (BU) that is focusing on battery electric loaders and trucks is today BU BHEV. When new battery loaders or trucks are released, they will be using the Sandvik brand.” And while others are making retrofit and integral part of their BEV offering, Sandvik says it is focussing on the 3rd generation BEV equipment “as these are designed from the ground up to be battery-electric, which is in our opinion the best approach to utilise the benefits that this technology allows.”



## Komatsu releases two new hard rock LHDs

**Komatsu Mining** in addition to launching an innovative common platform for underground hard rock drills and bolters, has released two new LHDs, the redesigned WXo4 4 t legacy model and the all new WXo7 LHD, developed from the ground up with a whole new chassis, Z-link kinematics, revamped powertrain and optimised ergonomic operator cabin with enhanced visibility to help boost productivity. As with the new drills, Komatsu yellow now replaces Joy orange.

The WXo7 replaces the old LT650 and is cited as ideal for small and narrow vein mines, particularly operations using cut-and-fill methods. An advanced and reliable powertrain is designed to deliver exceptional traction, optimised loading and low maintenance. Cummins QSB6.7 Tier 3 215 horsepower components include a new NRC, Dana electronic transmission TE14 and C3000 torque converter.

Ground-level maintenance design offers easy serviceability with vital maintenance components more accessible. “Facilitate faster, efficient repairs with added safeguards for your service crew. Data management features allow you to monitor, store and manage operational data to enhance servicing, troubleshooting, training and overall performance. Highest breakout force with up to 10% higher breakout force in its size class, the WXo7 can fill the bucket quicker for faster cycle times.”

With a large 64-gallon (243-litre) fuel tank, users can operate longer underground without stopping to refuel. The WXo7’s large fuel tank volume allows for longer working hour shifts and less refuelling handling and frequency.

The WXo7 operator compartments are ROPS/FOPS certified with generous space and comfort. Clear visibility provides enhanced protection for the operator and those around. Superior ergonomics, easy-to-operate controls and comfort features reduce fatigue on longer shifts. Safety features include open-door interlocks that activate brakes while deactivating boom bucket and steering functions.

The WXo7 also features Z-bar linkage and a reinforced boom design for superior breakout force enabling optimal penetration into the pile

and fast bucket filling. Loading 20 to 22 t trucks is also easier with excellent lift capabilities.

The control panel for the WXo7 is designed to be easy-to-use and informative. All the data and information operators need to perform, such as autogenerated diagnostic measurements, adjustments, and live data readouts, is readily accessible on a sleek control panel.

Based on the 4LD legacy machine, the redesigned WXo4 is described as “a reliable 4 t LHD for narrow vein applications. The WXo4’s high-strength steel frame design with heavy-duty, all mechanical powertrain can help you hit your production targets while keeping your costs down.”

The WXo4 has a Stage V low-emissions engine. This engine option offers power and performance benefits, along with low emissions for regions that can use ultralow-sulphur fuel. A ground-level maintenance design again offers exceptional serviceability with vital maintenance components very accessible facilitating faster, efficient repairs with added protection for service crews.

With a breakout force up to 20% higher in its size class, the WXo4 can fill the bucket quicker for faster cycle times. “The WXo4 leads the industry in the 4-tonne class with unmatched speed fully loaded on grade. This machine is powered by a dependable 133 horsepower Cummins QSB4.5 engine.”

“With a larger 190-litre fuel tank, you’ll have longer operational cycles without stopping to refuel. Your load-haul-dump cycles will achieve up to a 31% greater nonstop operation for continuous running and consistent productivity. The WXo4 features the largest fuel tank in its class.”

The operator compartment is ROPS/FOPS certified with generous space and comfort. It features open-door safety interlocks that activate brakes while deactivating the boom, bucket and steering functions. There are no high-pressure hoses in-cab for an added layer of protection. A fully enclosed, environmentally controlled cabin is an available option for added operator comfort.

A heavily reinforced boom design enables industry-leading breakout force and optimal cycle times. A rigid cast cross-tube, a hard line

for grease transfer to linkages, and integrated motion hard stops increase reliability. A new bucket design with an oversized spill guard offers cast or plate lip options, and the cast Z-link integrates lubrication channels and optimised geometry for added durability.

“Operators will appreciate the intuitive user-friendly touchscreen. Autogenerated diagnostic measurements and adjustments, as well as live data readouts ensure your operators have all the information they need for top performance.”

In addition to the models already discussed, the new WX<sub>03</sub> is also set to replace the LT270. The two hybrid big machines have a name change, the 18HD will become the WX18H and the 22HD becomes the WX22H. Lastly on underground trucks, the HX<sub>07</sub> will replace the 7TD and the HX16 is to replace the 16TD.

In orders, the underground mining services company Mas Errázuriz has acquired two 10 t class LHDs of the model LT1051 from Komatsu Mining, to be used in a copper mine in Chile's Region IV, and replacing competitive equipment.

Emerson Tobar, Account Manager at Komatsu Mining in Chile said the model's main attributes are being safe, robust and having a simple maintainability, which prolongs its useful life and reduces maintenance, in addition to its high break out force, which in the field gives a lot of confidence towards productivity. Komatsu says the LT1051 “is ideal for medium-size openings for both load-and-carry and truck-loading applications. The LT-1051 is perfect for height-restricted areas and can be equipped with an optional ejector bucket.” It adds that it is designed specifically for ease of use and maintenance, with simple operation gauges and a rugged long-life structure, providing the lowest possible total costs of operation including low capital costs.

The order is a boost for Komatsu's underground equipment business in Chile where it still has a relatively small market share. However, it does have a foothold in the future technology side as it already has large hybrid 18HD 18 t class LHD operating at Codelco's El Teniente underground copper operations which Codelco says has increased productivity by more than 10% and cut diesel consumption by 15-20%.

## GHH Group drives underground efficiency

As the trends in the mining industry move toward battery, electric and ‘environmentally friendly’ products, **GHH Group** says it continues to support the needs of customers. “Not only does GHH have a diverse fleet of loaders and trucks, covering low profile, narrow vein and mass mining product offering but in a drive to protect operators and the environment GHH also has one of the largest Stage V engine load and

*GHH Group's impressive MK-42 truck and LF-14 loader*



haul fleet amongst its peers. Nearly all the loaders and 100% of the truck range is available in Tier 3, Tier 4f and Stage V engine emission packages.”

GHH also offers flame-retardant and biodegradable hydraulic fluids setting an impressive pace in protecting people and the environment. The thermally highly stable hydraulics are 98% biodegradable thus reducing damage to the environment, in the case of hydraulic damage, and significantly reducing the ‘clean-up initiatives’ in the event of a spill. These fluids are also flame-retardant therefore also reducing the risk of accidents for the operators, machines and the production site by not allowing the flame to propagate.

GHH has been manufacturing tethered electric loaders for over 20 years and, in a further drive to support the environmentally friendly product range, is also focused on technology implementation to reduce costs, and time, associated with ‘panel to panel’ machine movement of tethered machines. To do this end GHH has developed, and relatively recently launched the LF-19EB tethered electric battery loader, which utilises regenerative battery power to tram panel to panel.

“The LF-19EB is first in a long line of new technology developments in the line of battery electric loaders that the company is working on. There is currently a new SLP-14E under development, due to launch towards the end of the year, which has a brand new, innovative direct drive electric drive train that will form the baseline for future developments. Axle to motor to axle with no gearboxes and direct frequency controlled – this design has significantly less components resulting in less maintenance, less breakdowns and ultimately reduced maintenance costs and improved availability and potential utilisation. And with very little hydraulics, except for the brakes and boom and bucket, the expected reduction in hydraulic related breakdowns soars even further. The

proven vertical coiling cable reel design, with spooling control, significantly improving the cable life is a standard on this machine. The SLP-14E is not only a technology trend setter but also provides for improved visibility and comfort for the operator, with a brand new ergonomically design cabin and frame layout. GHH is starting with the electric drive train and battery electric drive and moving towards full battery drive train designs in the development pipeline.”

GHH has also recently launched its new LF-7, 7 t loader. It comes with the biggest bucket and the best power rating, with highest operating slope angles, in the 7 t payload class. All that combined in a super low emission, super compact package.

The loader and truck range are all available with PDS level 9 interface as well as automation ready and available with GHH InSITE, its digital analytics solution.

Understanding of mining machines technical conditions and efficiency of their utilisation with the use of modern digital solutions has been on the agenda for quite some time. Development of mines communication infrastructure and machine control system architecture allows tracking the processes and taking effective corrective measures, in near-real time, technically possible right now. Yet the question remains how to get people engaged in actively using the system without spending too much time on this process and getting the value add out of it at the end of the day.

GHH in cooperation with **talpasolutions**, from Essen in Germany, has developed GHH InSite Suite, a web-based end-to-end IIoT solution, allowing stakeholders at various levels in mining companies’ hierarchies to gain useful insights and manage the efficiency of single machines as well as entire fleets.

The real value of GHH InSITE in comparison with the similar systems on the market lies in not only ensuring the integrity of the collected and managed data but maximising the value add



## Minetruck Automation starts with the MT42

Epiroc recently launched its latest Minetruck Automation solution. Epiroc Software Developer Torkel Trampe stated: "Each machine is fitted with two lasers, one in front and one in back, that measure the surroundings. There is also an odometer to measure the driving distance, as well as an IMU, inertial measurement unit, that measures accelerations and turning speeds – so we can see how the machine moves. All communication takes place via WiFi."

Minetruck Automation improves both safety and productivity. The machine can be used in environments that may not be fully secure for manual operation. Trampe adds: "Because the machine can be operated remotely, customers can also cut down on a lot of work hours, since the operator doesn't have to travel to and from the site where the machine is located. Minetruck MT42 is the first truck to be automated, and other models will follow."

In terms of development challenges he states: "Many customers will want to operate the truck both manually and automatically and so we wanted to make that possible. For the manual control module, we partnered with an external supplier and then put a lot of work into integrating the two systems. There are lots of safety requirements that have to be met, and it is critical that the mine truck is as flexible and user-friendly as it is safe."

Minetruck Automation in summary allows control of Minetruck operation via WiFi from any remote location and permits manual, teleremote and autonomous driving. It has a common operator station as with Scooptram loaders, plus it is possible to operate several Minetruck and/or Scooptram vehicles from one operator station.



of the customised output reports for the customers. All the raw data generated by

machine and logger device is recorded, stored and transmitted completely, correctly and

consistently to the secure cloud-based platform. Back-end software architecture allows simultaneously handling the data from thousands of machines used by multiple accounts and processing it in order of arrival in real-time, creating valuable insights displayed as per user requirement on a single screen in rather sophisticated yet intuitive web-interface. GHH InSiTE is offered to clients as a service for a reasonable monthly subscription fee reducing the capital investment burden.

GHH says it is following the strategy to make the interaction between the company, as the supplier of heavy equipment, and the customer as close as

possible. Whether a simple notification of time to next service or more complicated assessment of the LHD bucket size for particular operations as well as many other features are available for display on the screen within a couple of clicks. "The product is gaining recognition with many small to big operations and is in implementation at several sites of GHH long-term clients worldwide."

Alongside the GHH inSiTE solution is the GHH inViEW tablet, which is available as an option with all machines as a service and maintenance diagnostic tool. With direct interface to the GHH inSiTE digital analytics as well as other 3rd party major components, like the engine and gearbox, without any special tools users will be able to get factory level diagnostic data immediately minimising time to fault find and support service and maintenance operational performance.

## LKAB bridges autonomous divide

LKAB says it is now running six autonomous LHDs at its Kiruna iron ore mine, in northern Sweden, with battery-powered and cable-electric machines set to arrive at the operation later in the year.

The company has been stepping up its automation efforts at the underground mine, going from three autonomous loaders in November to five in December and, now, six.

These loaders have come from both Sandvik and Epiroc, with at least three of these being 21 t Sandvik LH621i LHDs and two being 18 t Epiroc Scooptram ST18 LHDs.

"For the time being, the loaders are diesel-powered, but battery-powered Epiroc machines and Sandvik's larger electric loaders will be delivered this year," the company said. "Safety and loading capacity will be tested and assessed, so that the vision of a carbon-dioxide-free LKAB can be realised."

Magnus Lindgren, Production Manager for the remote-control centre at level 1365 in the Kiruna mine, said: "Our operators work in close collaboration with both Sandvik and Epiroc and, thereby, take part in these suppliers' development. We test the systems and provide feedback, so we can eventually take delivery of a better product."

LKAB conducts blasting at the mine each night. When the blasting gases have been evacuated and rock stresses have decreased, personnel can access the production area. With remote-control machines, LKAB can load, haul and dump crude ore without having to worry as much about these considerations.

Roger Lärkmo, Engineering Developer at LKAB, added: "Autonomous loading at night is optimal in terms of both safety and work environment, and from a productivity perspective. That doesn't mean manually-



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operated machines are a thing of the past; it just means that we have more tools in the toolbox. Many parameters have to be taken into the equation for our loading operations to deliver an even flow of ore to the processing plants.”

This summer, the Konsuln mine will take delivery of its first battery-powered loader, the 14 t ST14 from Epiroc. Epiroc says it will also deliver a Minetruck MT42 Battery for use at the main Kiruna iron ore mine for production, and in the Konsuln test mine.

Preparations were underway earlier this year for the ST14 Battery’s arrival at Konsuln, from planning of the drifts where batteries will be exchanged, to risk analyses and simulations, LKAB said.

During 2021, three of Sandvik’s larger 625IE electric loaders, which have a 25-t payload capacity, are also being delivered to LKAB in Kiruna. The company took delivery of a “renewed” Sandvik LH625IE electric loader for field testing in 2020.

Lindgren said: “LKAB has been running loaders with electric power cables for more than 20 years, both manually operated and with remote control. Now we are going to test the new generation of electric loaders. These tests will begin in the autumn.”

Anita Orah Wardi, Project Manager for autonomous, smart and carbon-dioxide-free machines at LKAB, said the company was participating in development work early on, so it can understand and influence performance, loading capacity and, not least, the safety aspects.

“We are going to test to see how battery-driven and electric loaders compare with diesel-powered machines, and how remote-control machines function in comparison with manually-operated loaders,” she said.

“One of several objectives is that operators, regardless of the make or model of the vehicle, should be able to run remote-control vehicles via the same system and in the same production area. Then, we will be approaching a world standard.”

## JCHX develops battery LHDs in home Chinese market

After several years of development and testing, leading Chinese mining contractor and mine development company JCHX Mining Management displayed for the first time its new all lithium battery electric 2 m<sup>3</sup> and 3 m<sup>3</sup> underground LHDs at the 2020 Bauma China show in Shanghai. The machines were developed by its JCHX Hubei division.

JCHX says the machines use high-energy-density liquid-cooled lithium batteries as the power source, with ultra-high-efficiency switched reluctance motors and hydraulic control gearboxes. “The wet brake axle with spring brake and hydraulic release constitutes the transmission system of the whole vehicle, which has the characteristics of advanced transmission system and strong power. The unique working curve of its switched reluctance motor enables the vehicle to have strong power and high driving speed, and its operating efficiency can be increased by more than 10%.”

The 3 m<sup>3</sup> 7 t class machine has undergone more than a year of industrial tests in multiple scenarios and different conditions at the test minesite. JCHX states: “The test results are outstanding. It is a pure electric LHD with reliable quality, strong power and long-lasting battery life.”

The newly developed and produced 3m<sup>3</sup> lithium-battery-driven LHD from JCHX has been trialled since the end of November 2019 at the Shouyun iron ore mine in the Miyun District of Beijing, where JCHX is the contract miner and underground developer. JCHX says the unit has achieved a long working duration, with continuous loading of 65 buckets at a working temperature of 0°C which is compatible with the site requirements; a short charging cycle, with double-port design full charging only requires half an hour; plus a high breakout force and easy manoeuvrability. The robust bucket boom enables easy mucking plus of course there is less noise & zero emissions.

At Bauma China, JCHX said on this machine: “It can be used for more

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*JCHX all lithium battery electric 2 m³ underground LHD at Bauma China in Shanghai.*

than four hours of continuous loading operations or 70 buckets of ore pass operations. In a 3.2 x 3.2 section, it can complete the ore and waste discharge tasks of 2 sections. A full charge time is 30-40 minutes, and when the workers are on a shift change, the machine can remotely complete more work. The operating cost is about 60% of a diesel LHD of the same class.”

The working environment for the operator is improved significantly as local high temperatures caused by an engine no longer exist; JCHX: “to sum up this product achieved energy-conservation, environmental protection, low breakdown, improved safety and higher economic benefits at the same time.”

The new colour scheme of the LHDs refers to the JCHX flag/logo, while the product has been officially named as “King Ant” with the corresponding Chinese name having been registered at Administration for Industry & Commerce. The red, blue and white used on the body are the basic colours of the Jinchengxin (JCHX) flag. The red stripe shows J when viewed from the back, and C when viewed from the bottom up. The red and blue stripes cross and show X, which stands for JCHX, which is the English abbreviation of the company’s name. The King Ant name reflects the fact that it is an articulated machine, capable of lifting things far heavier than its own weight, implying a strong product carrying capacity.

JCHX adds: “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...redesign 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 our lithium-battery-driven LHD has distinct advantages in terms of safety, environmental friendliness, operational convenience, maintenance accessibility, as well as automation.”

The successful commissioning of the 2 m³ battery electric LHD (which was initially given the name JCY-2 during trials but is now also using the King Ant brand) was achieved on July 8, 2019 at the Lujiang pyrite mine near Hefei City in Anhui Province, which is owned by Anhui Jinniu Mining. At the time JCHX said: “JCY-2 is a battery-driven, free of pollution and highly agile LHD, which is designed and developed for the purpose of minimising environmental pollution, reducing equipment operation cost and protecting employees’ occupational health.”

JCHX says some of the transverse drifts at the Lujiang project are quite long with comparatively small sections, which leads to greater ventilation demands which was the main driver for the JCY-2 machine development. During 2.5 hours of operation at the 8-o ore pass on the -296 metre level, the battery was reduced from 100% down to 47%; 14 draws (approximately 34 m³) weighing 120 t were loaded 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. According to the charging data, it

## Getman's A64 underground primary fleet service platform

Getman says its service vehicles are designed to help perform key maintenance and repair functions throughout an underground mining operation, reducing the need for other production and production support vehicles to return to the workshop and helping maximise the time those vehicles spend in production and development roles. Part of Getman’s A64 product platform, its underground service vehicles protect operator safety through their purpose-built designs. Getman’s A64 Service Lube Vehicle offers three standard tank layout variations ranging from four to five tanks. They also may be customised for more or fewer tanks, based on specified requirements. All lube vehicles feature pressurised grease service, compressed air service, and include convenient delivery hoses with nozzles on heavy-duty spring return reels. The A64 Service Mechanic Vehicle offers a fully customisable mobile workstation and comes standard with toolboxes, compressed air service, a heavy-



*Part of Getman’s A64 product platform, its underground service vehicles protect operator safety through their purpose-built designs*

duty crane, deck space, and storage compartments for transporting replacement parts and work lights. Available racks for oxy/acetylene tanks, grease services, and vice clamps are available upon request. Additional equipment may be mounted based on specific needs. The A64 Service Fuel Vehicle includes a single 2,000 gallon (7,571 L) tank for refuelling operations underground and includes internal tank baffling for

improved performance during tramming. The high-rate delivery function includes a delivery line and nozzle mounted on a spring return reel for improved operation. Alternate tank sizes are available for enhanced manoeuvrability. The company told **IM**: “Getman A64 Service Vehicle’s purpose-built design keeps safety at the forefront. Features such as crane stabilisation eliminate the need for operators to physically handle heavy loads. All daily vehicle services and checkpoints are accessible from ground level and work areas are well-lit to ensure proper luminosity during servicing functions. Outward facing sight gauges are visible from ground level, and all mounted equipment is located on the perimeter of the rear deck, minimising the need for climbing on equipment.”

only takes 35 minutes to charge the JCY-2 from 20% up to 100%, with power requirements of 60 kWh.

Both machines are also capable of autonomous operation. "The vehicle control system adopts a CANbus network, which is divided into three parts: operation, transmission and man-machine interface. It is equipped with tailorable local remote control and automatic driving systems based on a SLAM algorithm...the unmanned, intelligent, and digital mining system can help customers realise the overall or partial unmanned operation of the mine and optimise the mine dispatch system."

## Russia Industry & Trade Ministry, ARMZ & Alrosa cooperate on tech

A multilateral cooperation agreement was recently signed between the Ministry of Industry and Trade of the Russian Federation, **ARMZ Mining Machinery, LLC** and diamond mining giant Alrosa. The document is aimed at developing partnerships for creation of domestic modern technologies, machinery and equipment used in opencast and underground mining, as well as developing the mining industry and heavy engineering in Russia.

"Our country has all the necessary conditions for the development of certain areas of mining machinery production: from growing domestic demand of the largest mining companies to



machine-building facilities capable of satisfying it. The active work of the Ministry of Industry and Trade of the Russian Federation is aimed precisely at the consolidation of these resources," noted Deputy Minister Mikhail Ivanov.

"Among other things, the signed agreement stimulates the creation of new models of mining machinery under the ARGO trademark. We already have a successful experience in providing battery-powered load-haul-dumpers for the largest uranium mining enterprise: E.P. Slavsky PIMCU, PJSC. I am sure that we will be able to replicate this experience for other mining companies in our country interested in high-tech

*The BQRS technology is a system for a quick replacement of a lithium-ion battery for Argo LHD 140 underground mining LHDs produced in Russia under a joint project of ARMZ and Aramine*

domestic machinery, such as Alrosa," commented Igor Semenov, Chairman of the Board of Directors, ARMZ Mining Machinery, LLC.

ARMZ Mining Machinery, LLC was established less than two years ago. During this period, the company implemented a project for the production of 140B lithium-ion battery-powered load-haul-dumpers from scratch. The machines have been tested and are successfully operating at the mines of E.P. Slavsky PIMCU, PJSC.



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In general, the facilities will allow producing up to 50 units of mining machinery per year.

As background in 2019, France's **Aramine** signed a partnership agreement with Russian uranium producer, ARMZ via ARMZ Uranium Holding Co (Mining Division of Rosatom State Atomic Energy Corporation) to allow the assembly of the L140B battery-powered miniLoader design in Russia by ARMZ Mining Machinery as project operator. It now produces the machine, referred to as the ARGO 140B, at the PIMCU mining complex in Krasnokamensk, in the Trans-Baikal Territory of Russia – it is significant as it made ARMZ Mining Machinery the first and only company in Russia and the CIS producing lithium-ion battery-powered mining equipment.

Recently the Expert Council on Sustainable Development of Rosatom State Atomic Energy Corporation also approved a project for the manufacturing and use of battery-powered load-haul-dumpers (LHDs) as promoting higher sustainability across the nuclear energy value chain.

“The world does not stand still; previously, the economy was driven by business goals, whereas today big companies are getting increasingly concerned for their ecological footprint. One of the most important items on the sustainable development agenda is to minimise the environmental impact. In particular, we are seeing a rapid transition of the mining industry to battery-powered equipment. The abandonment of diesel machines considerably reduces carbon dioxide emissions, while, inside the mine, the replacement of each load-haul-dumper yields tangible results,” said Igor Semenov, Chairman of the Board, ARMZ Mining Machinery, LLC.

The company says its estimations prove that the operation of battery-powered ARGO LHDs is more efficient than their diesel analogues in terms of sustainable development, primarily, due to zero air pollutant emissions. In addition, battery-powered equipment reduces noise generated by mining operations. Therefore, present-day technology significantly mitigates the negative impact both on workers' health and on the environment.

Seven lithium-ion battery-powered ARGO LHDs are currently employed in the uranium mines of PIMCU, PJSC — the largest uranium mining enterprise in Russia. This year, they plan to manufacture and introduce into operation another eight machines.

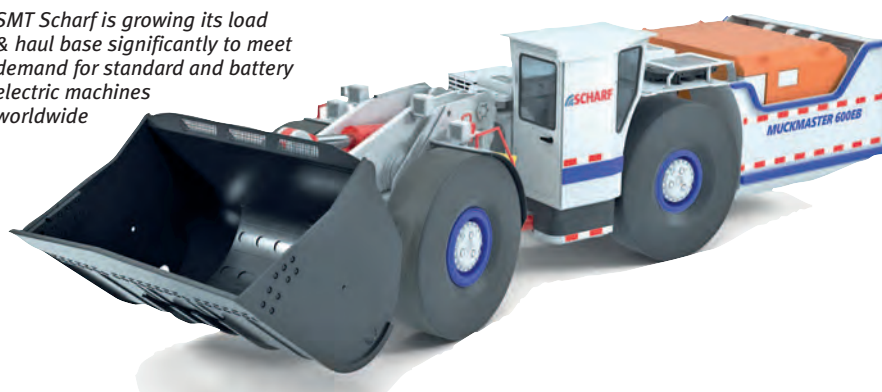
ARMZ adds: “According to forecasts, the battery-powered equipment market will actively grow and, in as soon as five years from now, similar diesel and battery-powered machines will cost the same, while PIMCU's transition to a battery-powered LHD fleet is proved to be



economically feasible even today. ARMZ Mining Machinery, LLC managed to cut the LHD price cost by 20% as compared to the overseas counterparts due to a number of organisational and technological solutions. In the future, the company will continue to work towards competitiveness with local facilities manufacturing lithium-ion batteries as the next project phase to be implemented in cooperation with RENERA, LLC (part of TVEL, JSC).”

ARMZ and Aramine also recently presented an innovative technology at the 15th International Exhibition MiningWorld Russia 2021. The BQRS technology is a system for a quick replacement of a lithium-ion battery for Argo LHD 140 underground mining LHDs produced in Russia under a joint project of ARMZ and Aramine. The battery replacement in a mine environment takes just 20 minutes. The technology has been tested in the underground uranium mines of

*SMT Scharf is growing its load & haul base significantly to meet demand for standard and battery electric machines worldwide*



Priargunsky Industrial Mining and Chemical Union, PJSC in the Trans-Baikal Territory and at production facilities of other mining companies. Igor Semenov: “Today, to ensure our competitiveness, we need to master, develop, and implement solutions that enhance productivity and sustainability. Robotisation and electrification are rapidly gaining popularity in the mining sector, both in open-pit and closed mining. Our battery-powered load-haul-dumpers

*The new SMT Scharf facility in Johannesburg adds nearly 3,000 m<sup>2</sup> of manufacturing space including six bays for rubber-tyred mobile equipment*

are also in demand by mining companies given the need to reach the ESG goals.”

## **SMT Scharf gets order from Polymetal for prototype battery electric fleet**

In the company's recently released 2020 annual report, Germany-headquartered rail bound mining transport and trackless electric mobile equipment major **SMT Scharf** gave some clues as to how it intends to grow its battery electric underground mining equipment business. Its long electrical expertise and investments such as acquiring RDH Mining Equipment in Alban, Ontario in 2018, enables it to meet market demand for electrically operated railway systems

and rubber-tyred vehicles. RDH was already one of the industry's most pioneering and successful battery electric players, with sizeable fleets at operations including Kirkland Lake Gold's Macassa gold mine.

SMT Scharf is advancing its battery electric strategy on several fronts. Last year, it entered into a strategic partnership with Anglo-Russian gold mining major Polymetal International in order to develop underground electric vehicles.



*SMT Scharf MM10T-EB LHD loading HM30T-EB truck underground*

As part of the first order worth a total of more than €4 million, it is developing and producing electric-powered LHDs as well as medium-duty underground trucks as prototypes. The vehicles that have been ordered will be deployed for underground gold mining in Russia and will be tested there as a basis for further vehicle deliveries of the same type. SMT Scharf aims to develop further electric commercial vehicles in the future. These first units are to be delivered to the company by October 2021.

RDH, now known as SMT Scharf Canada, has entered an exclusive distribution partnership with Parts Service Supply in Mexico. The Scharf Group views the mining industry in Mexico as an excellent fit for the group's rubber-tyred product line of machines due to the region's mining methods, and remote nature of mines. Founded on the principle of simplifying heavy equipment, the Scharf Group says it is committed to providing quality equipment that is both safe and simple to operate and service. The current product portfolio offers a fleet solution from utility vehicles, load and haul machines, through to drilling. SMT Scharf has a narrow-vein equipment line that has become a popular choice amongst Scharf's current Mexican customers and the option of customisation is frequently taken advantage of by those seeking machines specifically tailored to their mining operations for maximum efficiency. In the future there is battery electric potential there too.

In South Africa, SMT Scharf has opened of a new manufacturing facility located in Johannesburg. In conjunction with the SMT Scharf Canada subsidiary in Alban, Ontario, both entities will build both new and remanufactured underground mining equipment for customers around the world, including battery electric. The company said in May 2021 that in the future, electrically powered vehicles will also be manufactured or reconditioned there for mining customers from all over the world. "The new


demonstrated its commitment to the African mining sector. This new facility adds nearly 3,000 m<sup>2</sup> of manufacturing space including six bays for rubber-tyred mobile equipment. The location will also serve as the regional manufacturing and support centre for SMT Scharf's monorail and chairlift products.

Wolfgang Embert, COO stated: "Speaking of sustainability, as a specialist engineering company we contribute to better working conditions in mining raw materials underground with our innovations and customised transport solutions. In mining, the reduction of pollutants and associated improvement of working conditions underground is becoming increasingly important. Many companies are now looking intensively at using electric vehicles in underground mining. These vehicles significantly reduce the impact of heat, particulate matter, noise, and pollutants such as NO<sub>x</sub> and CO<sub>2</sub>. Electric vehicles are locally emission-free. This reduces the need for fresh air, in other words, the costly supply of fresh air and cooling underground, in the long term. This is of particular interest where additional cooling of fresh air is necessary due to large depths. This is the case in South Africa's gold and platinum mines, for example."

He adds: "In

manufacturing facility in South Africa will help us to further develop our electrical expertise within the Group, and meet demand for underground electric vehicles." With the establishment of the new facility, SMT Scharf doubled its output capabilities and has further

principle, we have proven battery and electrical expertise within the company and we can meet demand for electrically powered drive systems. One advantage of our modular product concept is that we can act flexibly and are able to equip and develop the vehicles individually according to customer requirements. In order to be able to meet the demand for electric vehicles that is anticipated, we have made considerable efforts in order to provide personnel with the necessary qualifications, as well create the requisite production facilities."

But the company is also under no illusions that there is still work to be done to convert underground mining to electric on a large scale. CEO, Hans Joachim Theiss comments: "Electric vehicles require significantly less maintenance than vehicles with combustion engines, and thereby contribute to cost savings long-term. Electric vehicles offer one disadvantage: they are much more expensive to buy than diesel vehicles, so mine operators give careful consideration to converting to vehicles with electric drive systems. Although the maintenance effort for electric vehicles is significantly reduced compared to conventional drive systems, electromobility poses significant challenges for the operators' day-to-day business in terms of infrastructure and employee qualifications." 

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