THE MAGAZINE FOR INDUSTRIAL VEHICLE TECHNOLOGY, DESIGN & ENGINEERING

NOVEMBER 2016

iVT

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- All-electric powertrains
- Autonomous haulers
- Off-world opportunities

PLUS Stage V latest

MINING SPECIAL

Unearthing new markets

Don't miss out on the huge opportunities being opened up for OEMs as mines expand rapidly

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iVT Industrial Vehicle Technology International

NOVEMBER 2016 VOL 24 No. 4

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CONTENTS

COVER STORY **p10-44**

MINING SPECIAL

You'll find this issue packed with 34 pages of mining vehicle technology, from the recent announcements at MINExpo, right through to what could one day happen in space

p30

p40

NEWS & REGULARS

"At MINExpo, executives from every major mining company told us they know battery power is the future and they have to plan now for the coming transformation from diesel to zero-emission vehicles" **p24**

CASE STUDIES & SPECIAL FEATURES

Vol. 24 No. 4

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CONTENTS

PRODUCTS & SERVICES


p61


p63


p64


p66

FOREWORD

The scale and scope of mining activities on our planet is quite simply staggering. Mining vehicles are the heaviest terrestrial vehicles on Earth – the very biggest of these being the 14,300 ton Bagger 293, a one-off giant bucket wheel excavator that has been in use in a brown coal mine near Hambach in Germany since 1995. It is also the world's highest land-going vehicle at 96 meters (315ft) tall and it requires five operators to keep it working at its task of shifting up to 218,880 tons of soil per day. When the construction of this monster was completed, it snatched its world records from sister vehicle, the Bagger 228 (pictured, below), which is the same height, but 1,000 tons lighter, and which was completed in 1978.

The cost, scale and longevity of such machines is testament to the indispensable nature of the mining industry. As long as the human race is building things, we are going to need to extract materials from the ground with which to build them. But these vehicles are also indicative of an industry that is used to planning for the long term, and not accustomed to rapidly adopting new technologies. All that is changing as vehicle designers in the mining industry, as elsewhere, are hit by the double-whammy of truly viable all-electric drivetrains, and rapidly advancing autonomous technology.

And of course, as this is our mining special, we investigate the history and future of both of these technologies in the pages that follow. On page 24 you'll find out how electric powertrain manufacturer Artisan has big ambitions – it has already partnered with multinational giant Atlas Copco to power its new Scooptram ST7 mining vehicle and is moving to becoming a vehicle OEM in its own right.

On page 14 we take a look at the mining market as a whole and discover that, while autonomous haulers are already used in some mines, they represent a tiny percentage of the total number of vehicles in operation. All that is set to change as 'smart mining' becomes the buzz phrase behind which lies greater efficiency, safety and increased profits.

Standing next to one of the gigantic haulers that are key to the functioning of mines around the world, it isn't hard to be amazed by their sheer scale. The world's largest, highest payload capacity haul truck is the Belaz 75710, which weighs 360 tons and can carry a load of up to 450 tons.

But put this, or any mine hauler (there's a case study of Liebherr's latest on page 20), into one of the vast open-cast mines in which they typically operate and suddenly they don't seem that big anymore. In fact, these monsters look like tiny toys lost in a grooved sandpit, carved into the mineral-rich landscape. It's enough to make you wonder how long it will be until Earth's resources finally run out. And when they do, where the human race will be left then…

The only logical answer is that, providing we've not blown ourselves up or been annihilated by a stray asteroid, we will have to turn to other worlds for our resources. It's a subject that's not as far-fetched as it might sound. NASA has already constructed a working off-world mining vehicle prototype, and is currently on the lookout for OEMs to help it to take the design further. Elon Musk, CEO of Tesla and SpaceX, has a concept Interplanetary Transport System that could take people and heavy equipment all around the solar system. And two companies, Planetary Resources and 3D Systems, have succeeded in 3D printing complex shapes using only materials from a meteorite. You can read more on p30.

Back down on Earth, you won't want to miss our new-look *What's New* section, which aims to keep you informed about the latest industrial vehicle news in a quick-fire format. Just turn the page to begin your new journey.

Tom Stone, editor, iVT International


Martin Roll

Coming up in the February 2017 issue of iVT

• ConExpo 2017 preview • The latest construction vehicle case studies • New powertrain technology • And much, much more...

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Explosive stuff!

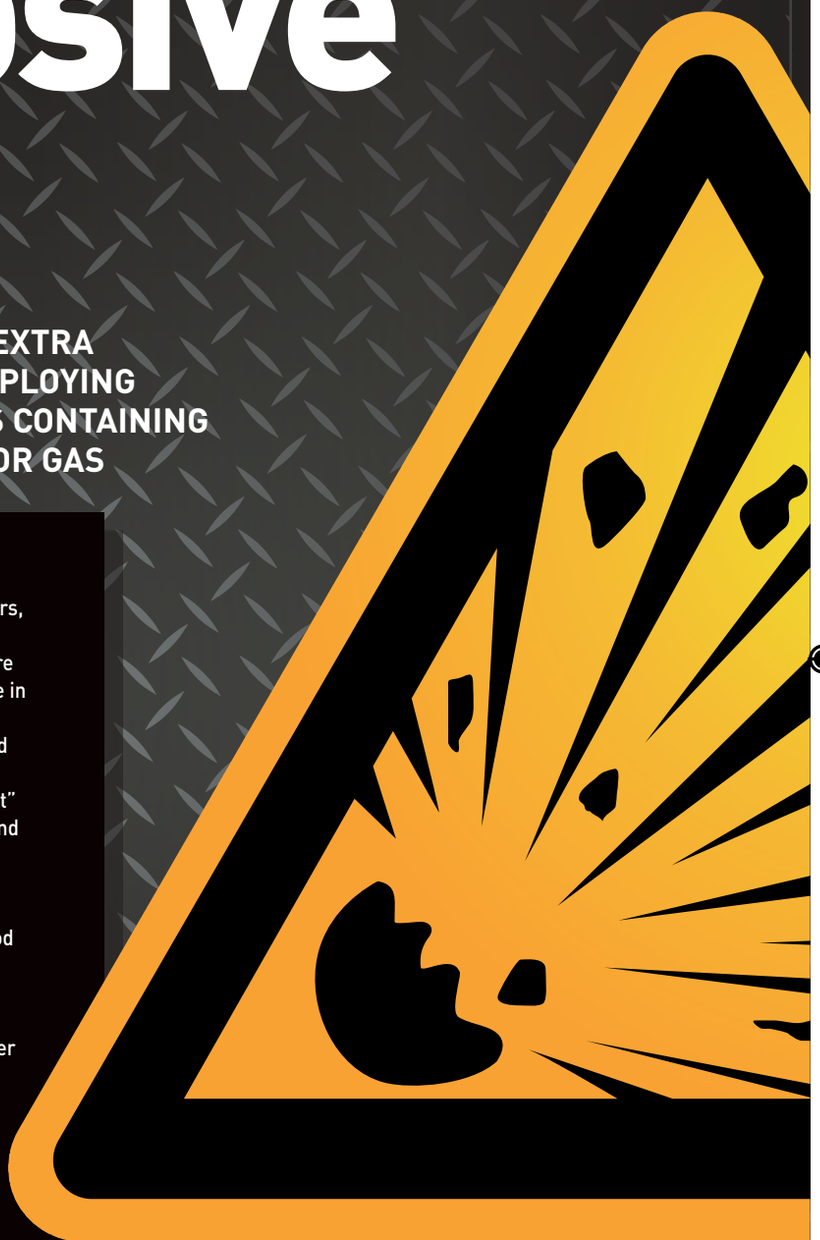
NEW EU REQUIREMENTS MEAN EXTRA CARE MUST BE TAKEN WHEN DEPLOYING LIFT-TRUCKS FOR USE IN AREAS CONTAINING POTENTIALLY EXPLOSIVE DUST OR GAS

An update to EU standard EN 1755:2015 has been announced that will require forklift suppliers, OEMs and users to pass a more stringent series of checks before vehicles are deemed safe to use in Zone 2, Zone 21 and Zone 22 hazardous areas. It will become mandatory from November 2017. Zone 21 and 22 areas are defined as places "in which an explosive atmosphere in the form of a cloud of combustible dust" may occur; Zone 21 being where this is more likely, and 22 where it is less likely. Zone 2 hazardous areas are places where explosive gases or mists may occur for short periods of time.

Common areas that fit these definitions include food production and storage facilities as well as chemical factories. "A spark from unprotected electrical equipment on a forklift, excess heat from the engine, motors, brakes or other components, can ignite a layer or cloud of powder in the workplace," says Steve Noakes, engineering manager for explosion protection conversion company Pyroban.

The updated standard must now be considered in conjunction with the other relevant regulations: ISO 3691-1:2011 and ATEX Directive 2014/34/EU, which was also recently updated, in April 2016.

Here we summarize the key points that should be noted in all the currently active standards...



The right labels

Directive ATEX 2014/34/EU
Mandatory April 2016

This replaced ATEX Directive 94/9/EC regarding equipment and protective systems intended for use in potentially explosive atmospheres. Its rules affect manufacturers, suppliers and importers – those producing or bringing a product to the market when new. Suppliers must ensure new products are labeled with the updated ATEX Directive number and should be aware that the component level certificate is now called 'EU Type Examination Certificate'.

Static electricity risks

Directive EN 1755:2015
Mandatory November 2017

The biggest change is for equipment operating in Zone 2 hazardous areas where static electricity is now considered an ignition risk during 'normal' operation. Therefore seats, armrests, roll-up cabin sides and other externally accessible plastics need to be anti-static as a minimum. All tires (where travel speeds are greater than 6km/h (4mph)) on 3G trucks should now also be anti-static and there must be conductivity to the ground either with two straps from the chassis to ground, or by using conductive tires. The location and quantity of conductive tires or earthing straps should also be marked on the chassis.

Gas detection is still included, but performance requirements are strengthened. Changes that affect all categories of equipment (2G, 3G, 2D and 3D5) include more detailed assessment of non-electrical components such as pumps and transmissions in line with EN 134636. Safety control systems should also meet PLc or SIL 1.

Written consent required

Standard ISO 3691-1:2011
Published September 2011

This international standard guides best practice for modifying forklifts with safety in mind, which includes explosion protection conversions. Under this standard, truck modification is not permitted without prior written approval of the original truck manufacturer in order to ensure all potential implications that may affect the overall truck safety have been considered. In the case of explosion protection, even if a modified truck meets the requirements of the ATEX Directive, it may not comply with ISO 3691-1:2011 unless written manufacturer consent has been obtained. **iVT**

CONSTRUCTION FOCUS

Building success

SIMULATION TESTING

New software set to speed up product design process

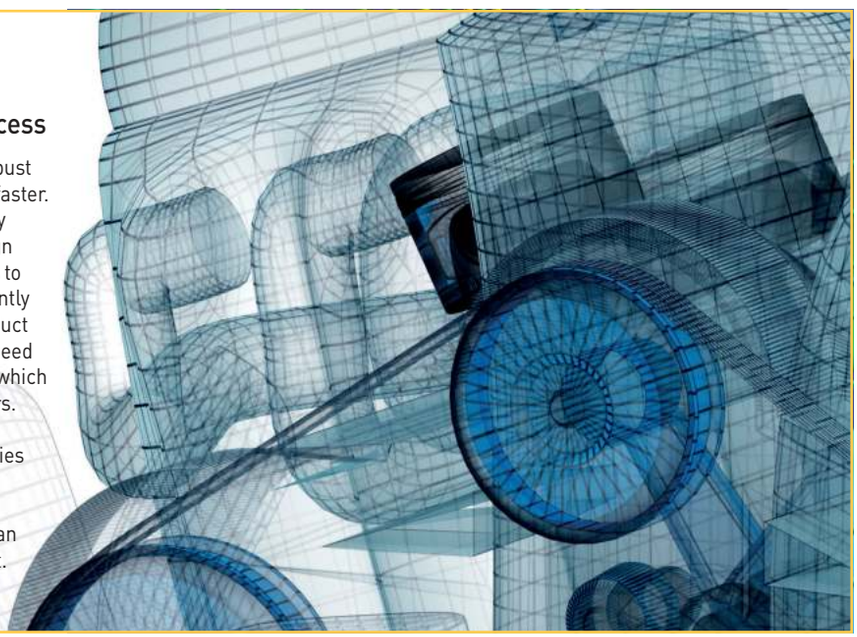
An agreement has been made between Ansys and Caterpillar for the production of software that enables multiphysics analyses to be performed with a single engineering simulation solution platform.

With Ansys' unified simulation platform solution, mining and construction equipment engineers and designers can optimize products in a virtual testing environment. This means that physical prototype testing times can be reduced and product development cycles shortened so that more robust products can be delivered faster.

Using simulation at early stages of the product design process enables engineers to work together more efficiently and to better innovate product design by eliminating the need for manual data handling, which can cause delays and errors.

The technology enables organizations in all industries to imagine high-quality, innovative and sustainable product designs that have an accelerated time to market.

www.machineryoutlook.com



COMPACT POWER

Wacker Neuson launches new mini-excavator

German OEM Wacker Neuson has announced the launch of the ET16, a new tracked mini-excavator that will replace its 1404 model by the end of 2016.

A powerful and fuel-efficient three-cylinder diesel engine (13.2kW) and a traveling speed of up to 4km/h allow for quick switching between different working positions and make the mini-excavator a fast and flexible helper on the construction site. The vehicle also benefits from a digging depth of approximately 2,240mm and a maximum dump height of 2,500mm.

The ET16 also features a telescopic undercarriage, which can be extended from 990mm to 1,300mm. The lower setting allows access to narrow passages, while the higher level helps to ensure greater stability.

The ET16 can reach difficult to access spots without problems, and is therefore particularly suitable for site work indoors, in inner-city areas, or for landscaping.

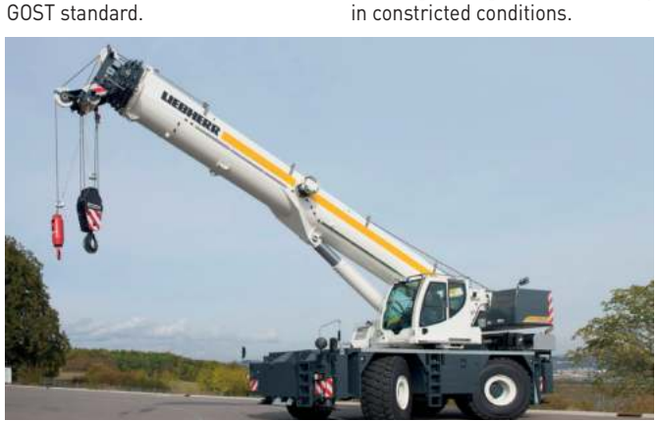
INCOMING CRANES

Liebherr announces two new rough-terrain cranes

Liebherr has announced it will unveil its new LRT 1090-2.1 and LRT 1100-2.1 rough-terrain cranes at ConExpo in Las Vegas, Nevada, in March 2017.

The models will be launched as the first mobile cranes that meet global safety standards and comply with all global regulations such as the US standard ANSI B30.5, the European EN 13000, Australian Standards (AS) and the Russian GOST standard.

Both cranes are powered by a Cummins diesel engine that meets current emissions regulations. The engine develops 194kW (264bhp) and supplies a maximum torque of 990Nm (730lb-ft). A 6-speed powershift transmission from Dana and large 29.5 R25 tires guarantee the required off-road capability for the cranes. Their maximum speed is 25km/h (15mph), and all-wheel and crab steering ensure easy handling and high maneuverability in constricted conditions.



Technology that Transforms

STAGE V VISION

Our Vision for Stage V

Cummins introduces the F3.8, B4.5, B6.7 and L9 engines for 2019 EU Stage V emissions regulations, with ratings from 100-430 hp (75-321 kW). Offering over 10 percent more power and almost 20 percent more torque averaged across the range, with the simplicity of EGR free architecture and Single Module™ aftertreatment technology. The Cummins Single Module combines DPF, SCR and urea-dosing in one unit, providing up to a 50 percent reduction in envelope size and a 30 percent reduction in weight compared with Stage IV exhaust aftertreatment.

Cummins has the power to transform your equipment – and business. To learn more about our Stage V technologies visit us at **cumminsengine.com/StageV** or follow us **@cumminseurope.**

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AGRICULTURAL OUTLOOK

Farm hands

From November 9-13 the EIMA International Agricultural and Gardening Machinery Exhibition took place in Bologna, Italy. Here we bring you the vehicle highlights

Case IH Optum CVX
Winner of 2017 Tractor of the Year

6.7 liter
six-cylinder FPT engine

Idle speed management, cuts engine speed from 850rpm to 650rpm if the tractor stands still without moving for two minutes

11,000kg
unladen vehicle weight

Continuously variable Case IH CVX transmission

16,000kg
maximum gross vehicle weight

Tony 9800 TR
Showcased by Antonio Carraro

87hp
4-cylinder engine with a synchronized PTO set at 540/540E

Fully reversible with four electronically controlled speed ranges

3.4-liter
Common Rail F5C engine with ECOBlue Compact HI-eSCR technology and Low Rate EGR

New Holland T5.120
Winner of 2017 'Best Utility' in Tractor of the Year Awards

491Nm torque
at 1,500rpm

15,600 lumens
light output from high-power LED lights

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160D-7E

It is time to look at Hyundai's most popular model.
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The best of MINExpo

ON SEPTEMBER 26-28, LAS VEGAS, NEVADA, HOSTED THE ONCE-EVERY-FOUR-YEAR GATHERING OF THE WORLD'S MINING INDUSTRY. *iVT* WAS THERE TO REPORT ON THE BEST INDUSTRIAL VEHICLE INNOVATIONS ON SHOW...

TERRAMAC SHOWCASES CRAWLER CARRIERS

Terramac's RT9 (pictured above), RT14 and RT14R crawler carriers were showcased at MINExpo in Las Vegas. Terramac crawler carriers are set apart from other vehicles thanks to their rubber track technology that exerts minimal ground pressure while fully loaded, making them ideal for loose and wet ground conditions where heavy, wheeled or steel track machines are likely to get stuck. Flotation from the units' rubber tracks leave a minimal footprint with less disturbance on the soil, while providing reduced slippage to conquer adverse conditions, climb faster on rugged terrain and reach remote areas.

Mine operators rely on the mid-size RT9 and larger RT14 straight frame units for their customization options and key features. "Terramac crawler carriers help you tackle any jobsite challenge that comes along," said Matt Slater, director of sales for Terramac. "We customize electrical power sources and frame adjustments on the RT9 and RT14 to suit any configuration."

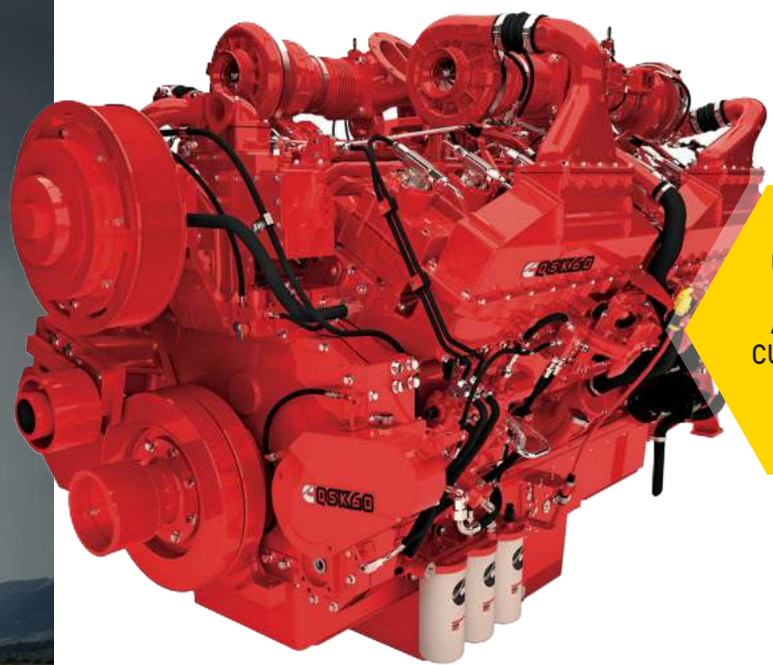
TOMCAR PROMOTES RUGGED PERSONNEL TRANSPORT

Tomcar used MINExpo to promote its rugged all-terrain vehicles, including the all-electric TM47E, for use on rough terrains and in harsh mining environments. The vehicles are ideal for transporting staff to and from workzones.

The Tomcar's military origins mean all the vehicle's parts are readily accessible, and easy to repair and replace in the field. The major components of the vehicle are symmetrical and interchangeable, reducing the necessary stock on hand, streamlining repairs and simplifying maintenance.

Tomcar is also extremely tough. The manufacturer claims it is the strongest vehicle in its class, with a fully welded steel safety cell that is integral to the frame, not just bolted in place. This level of structural integrity and safety is said to be unmatched by any other utility vehicle on the market today, making them a popular choice in military, commercial and consumer markets.

Rubber track technology exerts minimal pressure even when fully loaded



UPGRADES ENABLING LOWER FUEL AND SERVICING COSTS, ARE AVAILABLE FOR ENGINES CURRENTLY IN USE, PROVIDING IMMEDIATE COST SAVINGS

CUMMINS ANNOUNCES LATEST TCO INITIATIVES

Engine manufacturer Cummins used the Las Vegas event to announce several new initiatives focused on reducing miners' total cost of ownership (TCO) related to engine operation.

"Over 60% of a miner's TCO is tied to fuel, parts and service, and we have developed solutions that can be applied in a wide range of mining applications," said Zach Gillen, executive director of mining business for Cummins. "These upgrades lower fuel and servicing costs, and are available for engines currently in use, providing immediate cost savings to cash-strapped miners around the world."

Cummins fuel consumption reduction initiative, called Fuel Saver, is currently available for QSK50 engine and the QSK60 engine (pictured), with plans to extend it to other high-horsepower engines. "The improvements are achieved through base engine modifications, fuel system upgrades and electronic calibration changes. Our technicians will offer a tailored solution based on the customer's specification to achieve the best possible savings," said Gillen.

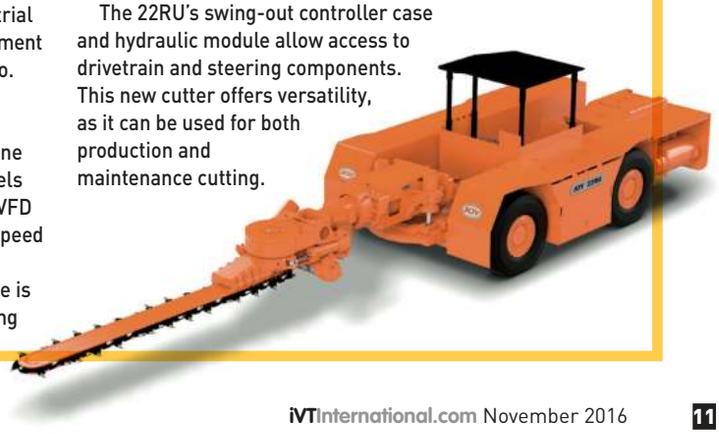
JOY GLOBAL INTRODUCES NEW JOY 22RU CUTTER

Joy Global continued the expansion of its offerings for the hard rock and industrial minerals markets, with the announcement of its new Joy 22RU cutter at MINExpo. The new cutter features proven Joy cutting mechanisms combined with a reliable traction driveline. The driveline has been redesigned from prior models using proven components, including VFD traction that provides variable tram speed and load sharing.

Improved mobility and performance is addressed by introducing crab steering – a 22.5° steering angle either direction – which dramatically improves repositioning capability along the face to help increase productivity. A horizontal cable reel makes cable handling easier and improves safety.

The 22RU's swing-out controller case and hydraulic module allow access to drivetrain and steering components. This new cutter offers versatility, as it can be used for both production and maintenance cutting.

Redesigned driveline provides reliable tram speed and load sharing



Scania showcased its fuel-efficient engines, including stone crushers

SCANIA SHOWCASES NEW PROFIT-BOOSTING SOLUTIONS

Scania had a wide range of mining products and solutions to promote at MINExpo. On display at the Scania stand were a range of fuel-efficient engines, such as screening devices, stone crushers (pictured) and gensets. They are part of Scania's new Site Optimisation program for potential customers. This constitutes a framework of tools and methods designed to support mining operators in improving their total operating economy.

"For mining enthusiasts like us, MINExpo is a very exciting event," said Björn Winblad, head of Scania Mining. "It's particularly exciting for Scania because I believe our offerings could have a huge positive impact on our mining customers' bottom line.

"We have expertise from industries such as bus and long-haulage transportation, and can bring that to bear in the mining industry. Our modular approach means that the services already exist which we can use to fulfill wide briefs," Winblad concluded.

LIEBHERR PRESENTS NEW R9200 MINING EXCAVATOR

Liebherr added a new 200 metric ton class machine to its mining excavator product range in the USA, at MINExpo The 16.3yd³ (12.5m³) bucket is the largest in its class, and offers sustainable performance while delivering peak fuel-burn efficiency, even in challenging conditions. It is designed to match mining trucks with payloads of up to 154 tons (140 tonnes).

The R 9200 is available in backhoe and face shovel configuration and is fitted with the Liebherr advanced bucket and GET solution to deliver superior digging performance and high fill factors, even in the most extreme mining conditions. This new excavator is powered by the Cummins QSK38 diesel engine that complies with USA/EPA Tier 2 or 4i exhaust emission limits and has a rated output of 1,086hp (810kW). The cutting-edge cab of the R9200 provides a panoramic view of the operation leading to efficient truck loading and safe machine positioning. The R9200 integrates an advanced electronic piloting control system that is intuitive and versatile.

CATERPILLAR UPDATES TERRAIN SYSTEM

Caterpillar announced improvements to its Cat MineStar Terrain system at MINExpo. The upgrades are expected to improve efficiency and productivity. Terrain combines GNSS guidance with integrated software that enables remote monitoring and fact-based decision making. Miners use Terrain to optimize production efficiency, enhance safety and reduce cost per ton. All Terrain products (for grading, drilling and loading) have been upgraded.

With the Terrain for grading update, the D10T (pictured) and D11T dozers can be ordered with factory-installed blade control capabilities integrated into the machine control system. Automating blade movement helps all operators move material faster and more accurately, with less fuel and rework required.

The newest version of Terrain for grading also includes a feature that tracks machine status (working or inactive), notes when a unit is inactive, and prompts the operator to select a delay code, explaining the inactivity.

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SUYOG KELUSKAR FUTURE MARKET INSIGHTS

MINE OPERATORS HOPE THAT GREATER VEHICLE AUTOMATION WILL LEAD TO SMARTER MINES THAT ARE SAFER AND MORE PRODUCTIVE

Rise of the machines

34.7%

The share the Asia-Pacific region has of smart mining turnover, making it the world's biggest market, followed by North America and Western Europe

The mining sector is in the midst of a technological revolution, with automation and smart technologies witnessing an uptick. The industry is gradually recovering from a steep downturn, so mine operators around the world are investing in smart technologies to boost productivity and improve safety. If automation receives the right investment, it has the potential to surmount the long-standing challenges of precarious commodity prices, lower-grade ores, spiraling operational costs and a lack of a skilled personnel.

For these reasons automation is being applied to load haul dumps (LHDs), trucks and even trains. Some of the key vehicle manufacturers, including Komatsu and Caterpillar, are working with mining giants, such as Rio Tinto and Barrick Gold, to develop

KOMATSU BREAKTHROUGH

A driverless autonomous haulage vehicle from Komatsu was unveiled in September 2016 at MINExpo in Las Vegas. The Innovative Autonomous Haulage Vehicle has a structure without a cab and was developed as an exclusively autonomous vehicle, having been designed to fully maximize the advantages of unmanned operation.

By distributing equal loads to the four wheels, whether or not the vehicle is loaded, and by using four-wheel drive, retarder and steering, the company is aiming for "high-performance shuttling" in both forward and reverse, thereby eliminating the need for three-point turns at loading and unloading sites.

There is a separate electric motor in each wheel to give independent control of traction and braking. The engine has been moved to the center and lowered slightly, putting the payload and center of gravity in the middle. This is designed to enhance weight distribution across all four tires, which helps with traction and braking control.

Komatsu says it expects its new autonomous vehicle to substantially improve productivity at mines where existing unmanned haulage vehicles face challenging conditions, such as slippery ground and confined spaces for loading. Another benefit is that the vehicles will be run according to their engineering design guidelines, without the hard braking and hard driving that human drivers can inflict.

With a gross vehicle weight of 416 tons, it has a nominal payload of 230 tons. A maximum speed of 40mph (64km/h) is claimed for the 50ft (15m) long, 27ft (8.5m) wide vehicle, which has a turning radius of 52ft (15.9m)

By continuing its efforts to optimize the performance of mining equipment and promote remote control and unmanned machine operation, the company believes it will be able to help its mining customers boost productivity levels.

Komatsu has yet to announce when and at which mine site the new vehicle will first be used.

On the Web

Watch a video of the Komatsu hauler at:
www.iVTinternational.com/komatsu

US$5.8bn

Value of the global smart mining market in 2014

US$13bn

Predicted value of the global smart mining market by 2020

autonomous vehicle technology for mining applications.

Vehicles are the latest stage of automation in mining and could transform conventional mines into 'smart mines' that are much more competitive and profitable thanks to a high level of automation. The global smart mining market is predicted to grow to revenues worth US$13bn by the end of 2020. The revenues from automated equipment are forecast to reach US$6.2bn by 2017. Mining excavators and LHDs continue to lead the segment and research indicates that autonomous trucks will be adopted extensively in the next few years.

Going autonomous

An autonomous haulage system (AHS) has been commercialized for mining by Komatsu. It enables ultra-class dump trucks – those with a capacity of at least 272 tons – to be operated without a driver. Vehicles fitted with AHS have a wireless network system, high-precision GPS, vehicle controllers and obstacle detectors. Komatsu says trucks using AHS can operate safely throughout a complicated load, haul and dump cycle and can be integrated with other components of an automated mining system, including dozers, loaders and shovels. But, they must always be supervised by humans.

AHS trials began on trucks through a Komatsu and Rio Tinto partnership in 2008. Within three years Rio Tinto had signed an MoU for 150 autonomous trucks. It has now hauled a billion tons of high-grade ore and other material in the Pilbara region of Western Australia and also at mines in Chile. Rio Tinto says it now owns and operates the largest fleet of AHS trucks in the world – 69 and counting. The company believes the fleet enables more material to be moved with greater efficiency and safety, resulting in improved productivity.

ABOVE: **An iron ore mine in Pilbara, Western Australia, which accounts for the bulk of the million tons of ore hauled by Komatsu using its autonomous vehicles**

One of the attractions is that driverless vehicles have the potential to operate 24/7 and stops are needed only for fuel and maintenance. They have teleoperational functionality, so they can be monitored and controlled from anywhere in the world. Around 70 such driverless trucks operate at the Pilbara mines of Nammuldi, Yandicoogina and Hope Downs 4. They work to transport millions of tons of iron ore and can be supervised by experts miles from the actual mines. The first batch of these vehicles has covered almost two million miles to date. They are capable of independently moving around

25 million tons of high-grade iron ore a month.

Full autonomy

Following the success of automated trucks, Rio Tinto has already embarked on a trial for robot drill mining. Unmanned trains are also being trialed, under the company's 'Mine of the Future' program. Yet the ultimate goal of fully autonomous trucks that don't require even remote manual supervision has not quite been achieved, despite companies such as Google showing how they are possible on the open road – an environment that is much less predictable than a mine or quarry. However, they may be on sites soon because Komatsu is already moving on from AHS, which is designed to be applied to regular ultra-class trucks. It has just launched a vehicle that has been designed for complete autonomy from the start (see *Komatsu Breakthrough*, p28).

But Komatsu now has plenty of competition in the race to achieve full autonomy. BHP Billiton has recently accomplished trials of fully automated, driverless lorries in a Mexican coal mine in collaboration with Caterpillar. Moreover, the company has plans to expand its existing fleet of driverless trucks and is currently testing unmanned lorries for underground tunnels. Caterpillar driverless trucks are currently under trial at BHP's Jimblebar mine and remotely operated dozers are tested at the company's proving ground near Tucson, Arizona.

Caterpillar is also working in collaboration with Fortescue Metals Group on automated robo-trucks at the Western Australia-based Solomon Hub mines. The company has achieved dramatically increased productivity levels following implementation of these autonomous haulage systems. Moreover, the Queensland mining industry awaits a fleet of driverless trucks for underground mining.

In Sweden, Volvo announced ambitious plans for a flagship automation project that could represent the highest possible level of mining vehicle automation – robot mining trucks or driverless trucks designed for operating in underground mines. Partnered with Swedish mining group Boliden, the company is currently testing driverless trucks in the country's Kristineberg mine.

Safely does it

Even more important than productivity, the greatest reason for vehicle automation in mining is safety. Nobody wants to see again the likes of the Chilean mining accident at Copiapó in 2010, in which 33 men were trapped 2,300ft (700m) underground, some for up to 69 days. By using more teleoperated or fully autonomous vehicles underground, the risk to human life will be reduced.

The functionality of automated vehicle technology continues to improve. Robotic components of fully automated mining vehicles can handle all functions, from ignition, acceleration, braking and transmission to accurate navigation. Today, obstacle detection and avoidance, once considered to be the most novel features for autonomous vehicles, are highly sophisticated and reliable.

Out of nearly 50,000 haul trucks operating in mines across the globe today, not even 1% are autonomous. The twin drivers of productivity and safety are going to boost that figure in the next five years. It'll happen almost automatically. **iVT**

Some of the information in this article is based on a report by market research and consulting firm Future Market Insights. You can browse the excerpts of the report at www.futuremarketinsights.com/reports/smart-mining-market

US$4.2bn

Value of the worldwide market for automated smart mining equipment in 2014

US$9.5bn

Predicted value of the worldwide market for automated smart mining equipment by 2020

BELOW: **Volvo's fully autonomous underground haul truck is being tested in Kristineberg mine in Sweden, in collaboration with mining group Boliden, in what is believed to be a world first**

On the Web

Watch a video of Volvo's truck being tested at **www.iVTinternational.com/volvo**

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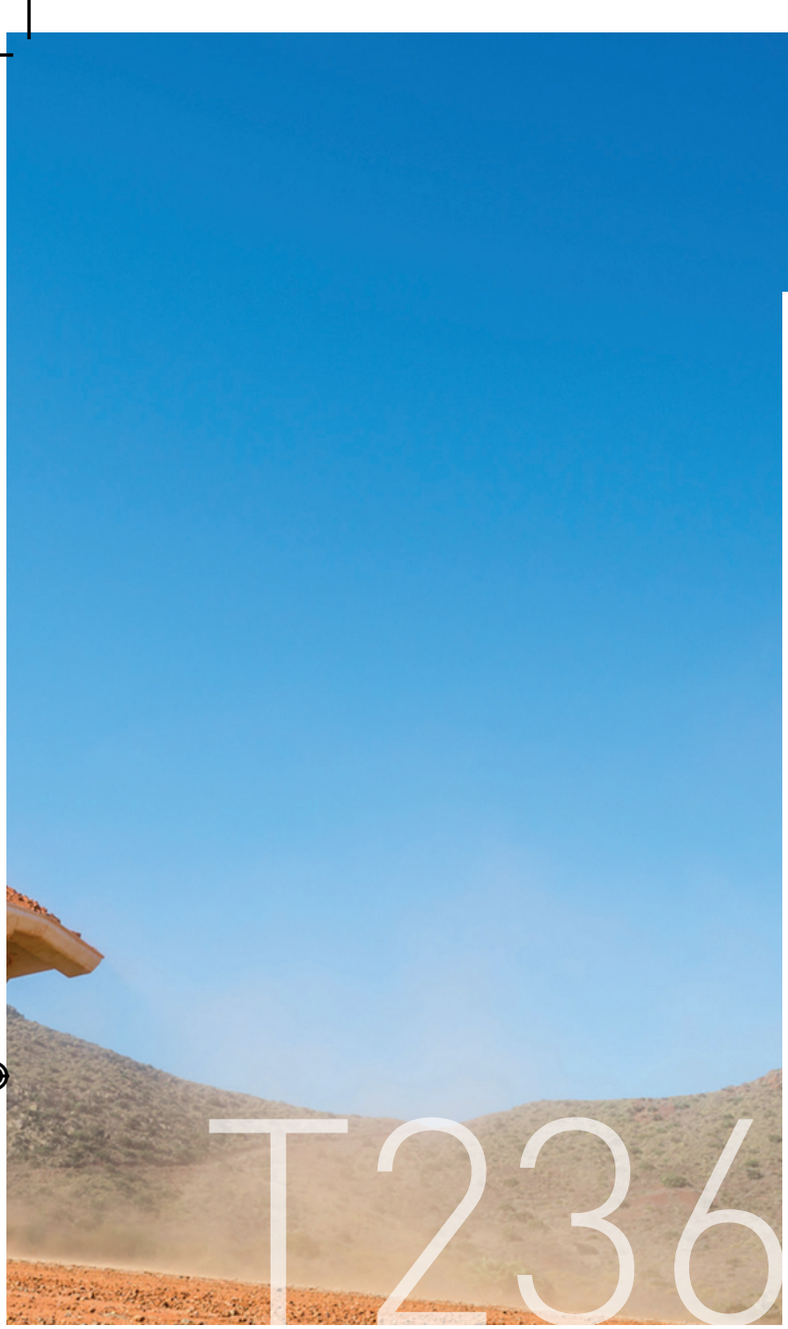
Quite a haul

LIEBHERR'S FORTHCOMING 100 METRIC TON HAULER BRINGS A NEW LEVEL OF SOPHISTICATION TO THE CLASS, WITH FOUR-CORNER OIL-IMMERSED BRAKES AND SAFE, EASILY SERVICED ELECTRICS



Liebherr has introduced its new 100 metric ton mining truck – the T236 – which incorporates the company's Litronic Plus Generation 2 technology, built on 10 years' application of vertically integrated electric drive technologies. The vehicle is the world's first diesel-electric truck with four-corner oil-immersed brakes.

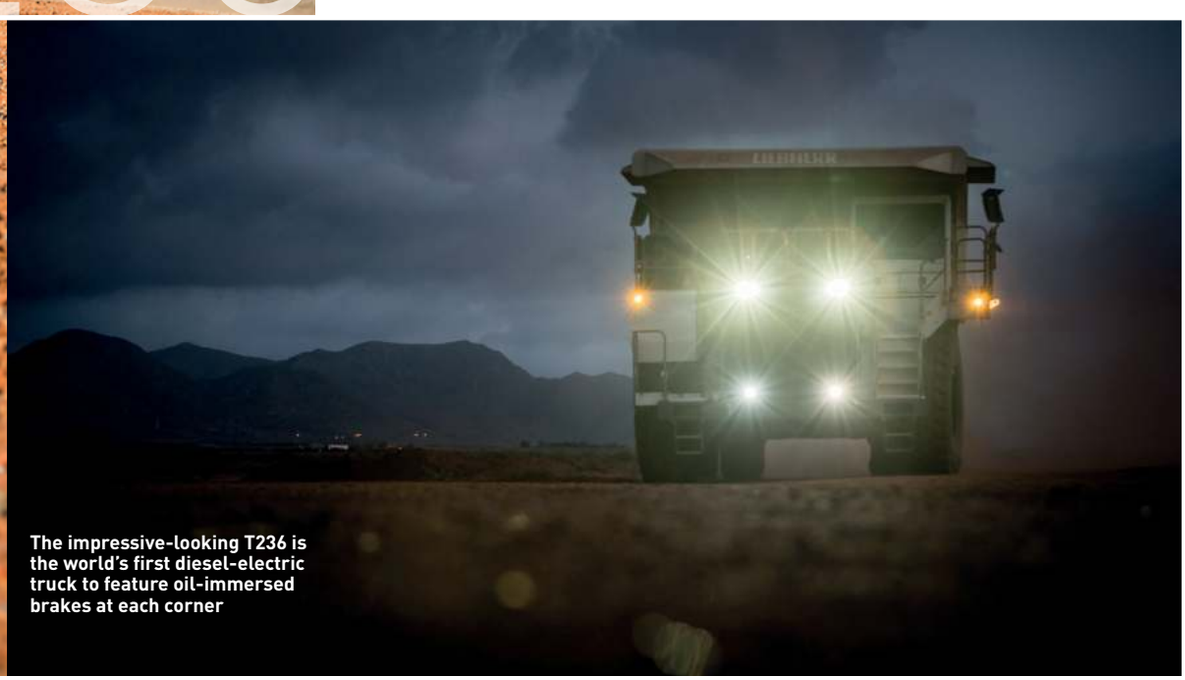
The new truck, says Liebherr, demonstrates the company's continued innovation in design, together with the evolution of its own high-quality components and class-leading technology. The combination results in increased productivity, more efficiency, and improved reliability and safety, while lowering the cost per ton.

Benefiting from Liebherr's decades of experience in off-highway truck technologies, the T236 features the company's electric drive system innovations with the vertically integrated Litronic Plus Generation 2 AC drive system.

Built to perform

"This revolutionary machine provides the industry with a new benchmark in the 100 metric ton class for off-highway haul trucks, focusing on top performance, maximum uptime and the lowest possible operating costs," says Dr Burkhard Richthammer, general manager for midsize trucks at Liebherr. "All components on our truck are designed and built to perform and last in the most extreme mining conditions. As a result, Liebherr trucks run much longer between component overhauls, saving time and money."

To help ensure the safety of technicians and bystanders, the T236 is equipped with a double pole battery, starter motor and hoist system isolators as standard. In addition it provides an innovative drive system inhibitor, where the electrical drive can be isolated completely from the machine during maintenance while operating the engine. Also, the machine features a world first – an electrically interlocking, grounding device for each plug-and-drive power module. This feature also helps ensure safe handling for electricians and mechanics when servicing the electrical drive. The drive operates at 690V AC and 900V DC – consequently in most countries regular site technicians can carry out the system maintenance. "An industry first, Liebherr's Litronic



The impressive-looking T236 is the world's first diesel-electric truck to feature oil-immersed brakes at each corner

"THE ERGONOMIC T236 CAB AND THE PROPERTIES OF THE FRONT-WHEEL SUSPENSION SYSTEM PROMOTE DRIVER EFFICIENCY WITH SUPERIOR COMFORT, SAFETY, ACCELERATION AND HANDLING FOR INCREASED PERFORMANCE"

Dr Burkhard Richthammer, general manager for midsize trucks, Liebherr

VITAL STATISTICS

Engine: Cummins QST 30 diesel	895kW
Payload class	100t
Gross vehicle weight (GVW)	180t
Empty vehicle weight (EVW)	80t
Gross HP (SAE J1995) at 1,900rpm	895kW
Emissions (USA/EPA)	Tier 2
Drive system:	Liebherr Litronic Plus Generation 2 high-efficiency drive system with integrated active front-end for engine retarding operation
Max. speed	55km/h (34mph)

ABOVE: **With its impressive performance and reliability and low operating costs, the T236 is intended to set a new benchmark in the 100 metric ton class**

Plus Isolation system ensures the safety of maintenance personnel through the elimination of hazards by design," says Scott Bellamy, senior product manager for Liebherr Mining Trucks.

The in-line electrical powertrain layout minimizes cable length, while the maintenance-free IP68-rated plug-and-drive power modules help provide reliable operation in all weathers. This is combined with extended-life service intervals and minimal maintenance time provided by ground-level service points.

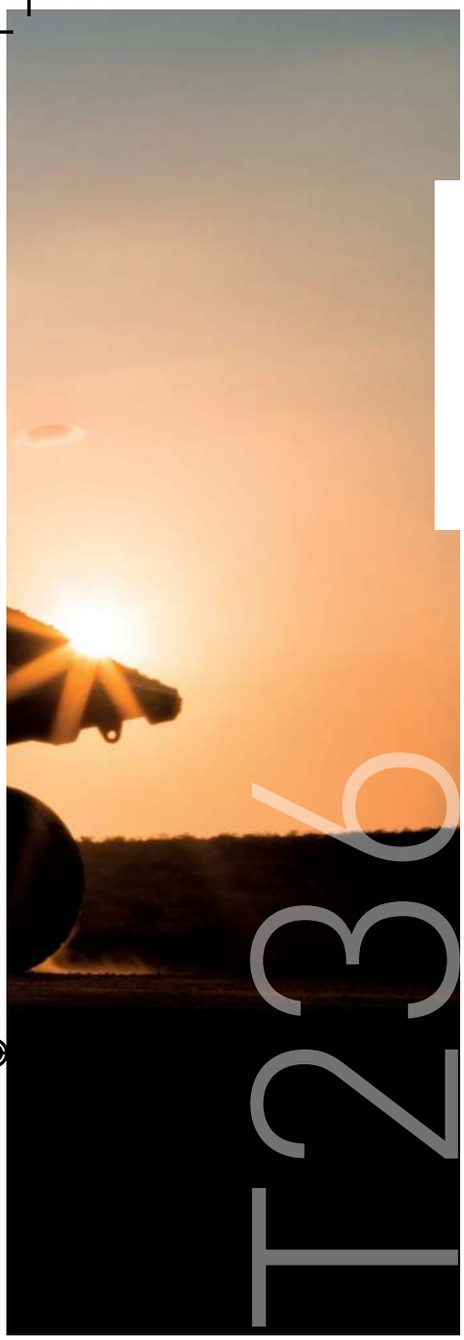
The hydraulics package covers the fan drives, blower and electrical traction motors. The powertrain comprises the diesel engine and remote-mounted alternator providing a 690V AC tension level – below the level that would require specifically certificated electricians for maintenance.

The three frequency converter modules installed in the rear of the machine are also rated to IP68 and can be easily removed and replaced.

Ergonomics inside

Richthammer says Liebherr is committed to designing mining trucks that operators want to drive: "The ergonomic T236 cab and the superior properties of the front-wheel suspension system fulfill this commitment and promote driver efficiency with superior comfort, safety, acceleration and handling for increased performance."

Billed as an evolution in electric drive system design, the Litronic Plus Generation 2 features active front-end technology. The drive system is able to deliver controlled engine speed with almost no fuel consumption by making efficient use of electrical energy during retardation. Vertical integration of components ensures that the T236 powertrain achieves optimal system efficiency and performance throughout the full range of applications. The variable hydraulic system lowers machine parasitic losses (energy loss not contributing to power), maximizing the power available to the traction wheels, while lowering fuel consumption when power is not required.



LEFT: **The three frequency converter modules at the rear help reduce maintenance requirements as they can be easily removed and replaced**

There are two traction motors – one for each side – so that the speed of the wheel is controlled independently, which helps with efficient cornering.

With its high take-off torque and continuous power-to-ground capability, the T236 is not sensitive to grade and payload variations, while its oil-immersed braking system further improves safety.

The truck is designed to carry up to a 100 metric ton payload, when paired with the R9100, R9150, R9200, or R9250 mining excavators.

"The T236 provides a complete high-performance and scalable truck-shovel match, delivering the right combination for production requirements," says Richthammer.

Not yet commercially available, the first prototypes are undergoing intensive field functional and performance testing. The truck is expected to be available in selected markets in 2018. **iVT**

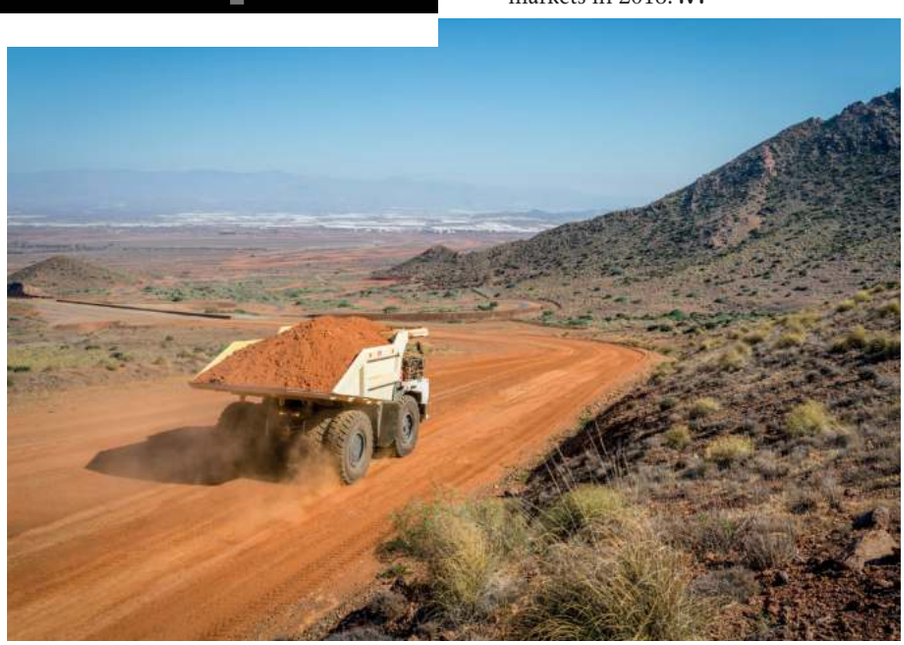
FAMILY HISTORY

The Liebherr Group is a diversified manufacturing and engineering group based in Bulle, Switzerland. Founded in 1949 by Hans Liebherr, the business is still wholly owned by the Liebherr family. The company started out by building tower cranes and later diversified into manufacturing aircraft parts, and commercial and domestic refrigerators.

The group is split into the following divisions: mining, concrete technology, maritime cranes, mobile cranes, tower cranes, earthmoving equipment, domestic appliances, aerospace and transportation systems, machine tools and automation systems, and components.

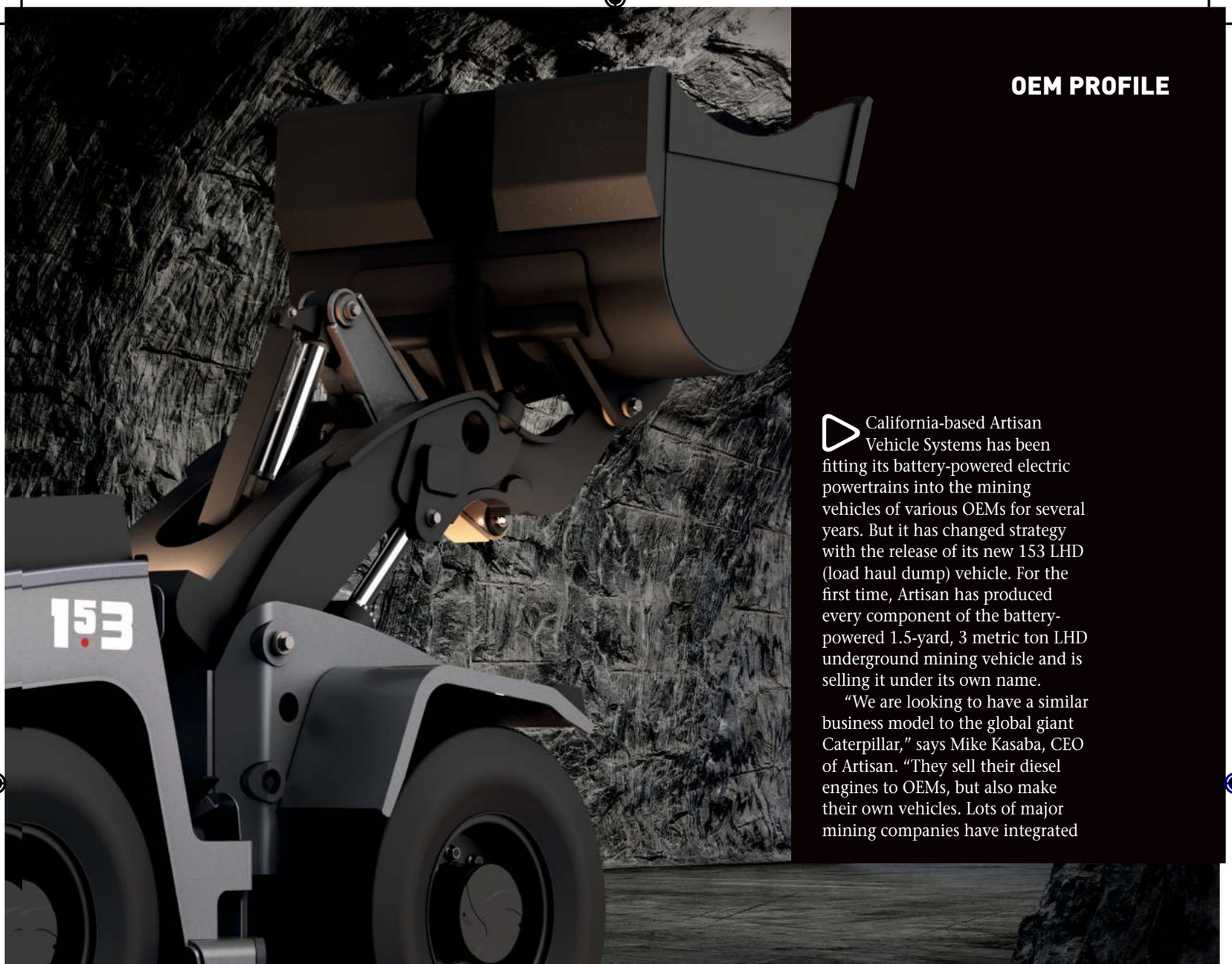
The mining division manufactures large machines for the extraction of raw materials in open-cast mining. These activities are coordinated by the division's parent company, Liebherr-Mining Equipment SAS, based in Colmar, France, where manufacturing takes place, together with a plant in Newport News, Virginia. The product range includes eight large hydraulic excavators with operating weights of 100 metric tons to 800 metric tons, and large dump trucks with payloads of between 220 metric tons and 360 metric tons.

The mining range includes excavators, trucks and crawler tractors. The main development objectives in all equipment classes include high machine availability, technical reliability and maximum energy efficiency in the entire drive system. The objective is to offer the most extensive range of products for excavators with an operating weight of more than 100 metric tons and dump trucks with a payload of 100 metric tons and over.



DAVID SMITH IVT INTERNATIONAL

MANY BELIEVE THE DAYS OF MINES HAVING TO CONTEND WITH NOISY, POLLUTING DIESEL ENGINES ARE NUMBERED – WHICH IS WHY ELECTRIC POWERTRAIN MANUFACTURER ARTISAN IS NOW BUILDING ITS OWN VEHICLES



The electric underground

California-based Artisan Vehicle Systems has been fitting its battery-powered electric powertrains into the mining vehicles of various OEMs for several years. But it has changed strategy with the release of its new 153 LHD (load haul dump) vehicle. For the first time, Artisan has produced every component of the battery-powered 1.5-yard, 3 metric ton LHD underground mining vehicle and is selling it under its own name.

"We are looking to have a similar business model to the global giant Caterpillar," says Mike Kasaba, CEO of Artisan. "They sell their diesel engines to OEMs, but also make their own vehicles. Lots of major mining companies have integrated

our powertrain into scoops and trucks that were originally made for diesel, but the new Artisan 1.5-yard LHD has been designed from the ground up uniquely for our battery system."

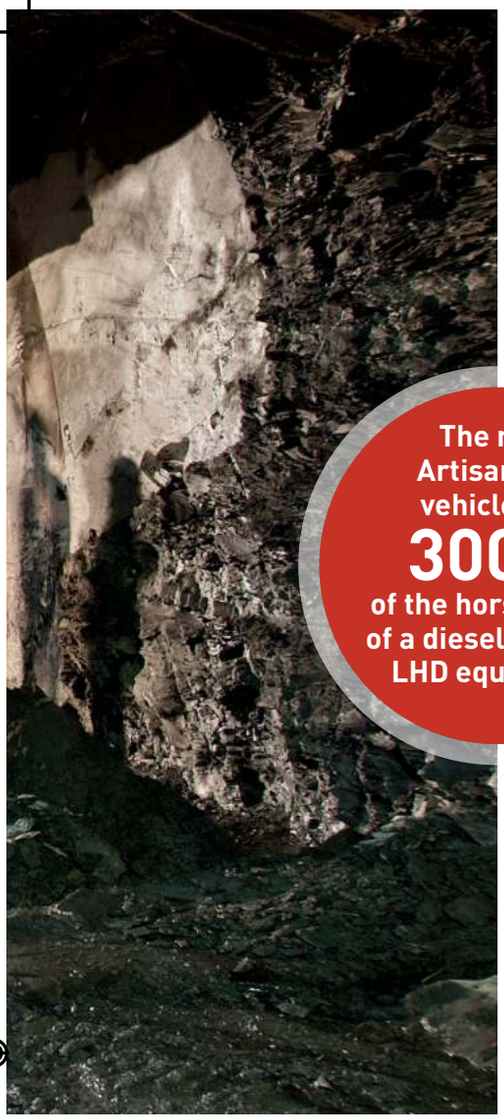
Artisan launched the LHD in September, and it is already proving popular in an industry slowly waking up to the benefits of battery technology. The company has sold out of the vehicle for the rest of 2016 and is taking orders for the second quarter of 2017. "The interest is part of the mining industry's move away from diesel technology," says Kasaba. "At MINExpo, executives from every major mining company told us they know battery power is the future and they have to plan now for the coming transformation from diesel to zero-emission vehicles."

Death of diesel

The tipping point, when battery-powered vehicles outnumber diesels, has not yet been reached; most underground mining vehicles are still powered by diesel. "We can make it happen quickly, but only if we get the message across about their superior performance and lower costs compared with diesel," Kasaba says. "If we can do that through publicizing the success stories, then by 2020 every request for proposal will be for a battery-powered vehicle and diesel will be a thing of the past."

Kasaba says the cost savings from using machines like the Artisan LHD vehicle in place of diesel are huge. A major factor is that using battery-powered equipment reduces the requirements for ventilation shafts to clear fumes. They can cost between US$50m and US$100m each. In most mines, 40% of energy costs go on ventilation and cooling. In ultra-deep mines the figure can reach as high as 90%. Diesel emissions are the major source of fumes and some mines have as many as 150 diesel machines working underground.

"A new mining project is an opportunity to save real money. A project using diesel could require four ventilation shafts, but with batteries, two shafts would be enough," says Kasaba. "Also, if



The new Artisan 153 vehicle has 300% of the horsepower of a diesel 1.5-yard LHD equivalent

LEFT: **The Artisan 153 reduces ventilation and cooling expenses for mining companies**

BELOW: **The Artisan 153 outperforms its diesel competition**

a company using diesel finds an adjacent ore body, it has to sink additional ventilation shafts. But that's not necessary with battery power. The company saves on capital expenditure and can reach the adjacent ore much more quickly."

Improved performance

Battery-powered machines are by no means an inferior alternative. On the contrary, their mechanical performance is far superior to diesel, according to Kasaba. The new Artisan 153 vehicle has 300% of the horsepower of a diesel 1.5-yard LHD equivalent. It loads more quickly, hauls up steep grades faster and is more precise, he says.

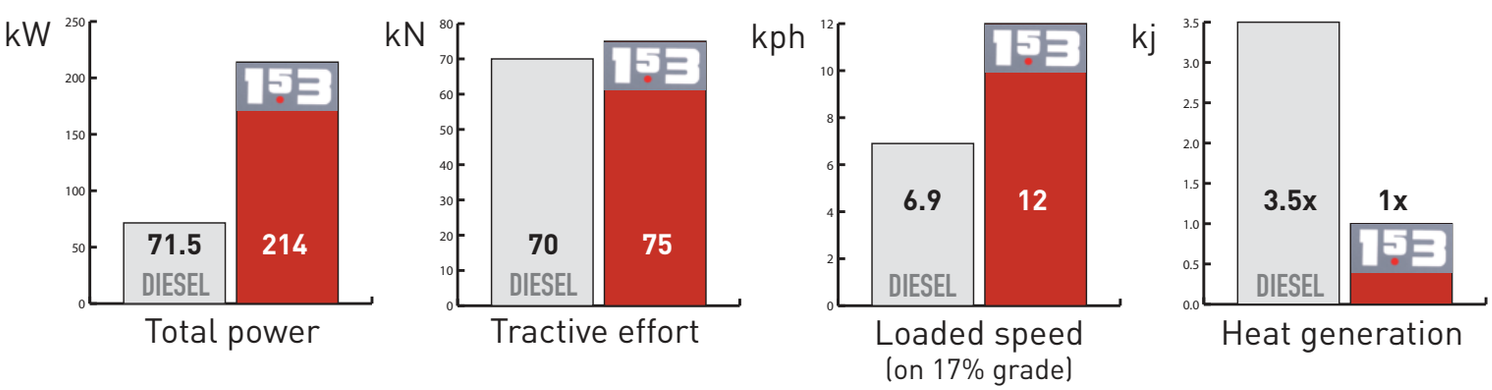
"Electric motors are very power dense with high torque and they fit into a very small space," says Kasaba. "For conventional diesel machines, the OEMs use the smallest engines possible that will get the job done. That's because the amount of ventilation required is determined by the horsepower. But we can put in a high horsepower and it has no effect on the ventilation. And because the battery-powered vehicles are smaller, they are more maneuverable. They can get in and out of stopes more easily and pull the ore out faster."

The experience for the underground workers, too, is far more agreeable. They don't have to put up with hot diesel equipment belching out fumes and their voices are not drowned out by noise. "Diesel machines can be so loud you have to scream to be heard, but all you can hear with battery machines is the hydraulic system running as the motors are essentially silent," he says.

The improvements in performance have been made possible by recent advances in lithium battery technology. Artisan tested all possible battery technologies over the years and, in the end, settled on lithium for hard-rock environments. In soft-rock environments, such as coal, salt and potash, lead-acid batteries work fine, but hard rock, including copper-, gold-, silver- and lead-bearing ores, demands smaller and more powerful machines that are best powered by lithium batteries. The vehicles can be charged in an hour for at least four hours' running time, or the batteries can be swapped over in around 10 minutes.

New factory

Artisan has built a 60,000ft² (5,574m²) battery development center and production facility in Camarillo, California, to carry out research into every aspect of the powertrain, including the battery, electric motor, vehicle controls, power electronics and high-powered chargers. The facility will also ramp up production tenfold to cope with anticipated demand. "California is the



"IF WE CAN PUBLICIZE SUCCESS STORIES, THEN BY 2020 EVERY REQUEST FOR PROPOSAL WILL BE FOR A BATTERY-POWERED VEHICLE AND DIESEL WILL BE A THING OF THE PAST"

MIKE KASABA, CEO, ARTISAN

"WE CAN TALK LIVE THROUGH OUR SYSTEM TO TECHNICIANS TO DIAGNOSE ANY PROBLEMS AND WE CAN REMOTELY UPGRADE OUR SOFTWARE"

MIKE KASABA, CEO, ARTISAN

ABOVE: **Users of the Artisan 153 can experience increased visibility and better maneuverability than they can with diesel mining vehicles**

home base for Tesla and other manufacturers of electric vehicles, so it's a huge intellectual center for what we're trying to achieve," says Kasaba.

Artisan offers remote technical assistance to any clients who own vehicles equipped with its powertrains, including those sold under the name of a different OEM. Artisan's California-based technicians are connected to the vehicles through web-based technologies. "They can communicate with local technicians in remote mining areas. It's as if we are sitting right beside them even though we could be thousands of miles away," says Kasaba.

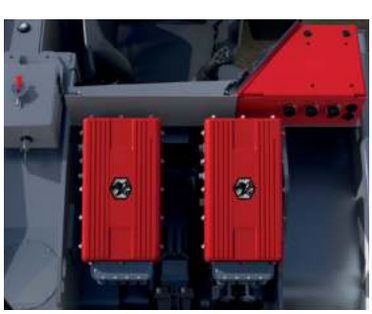
Whenever a vehicle is connected to a battery charger, Artisan's technicians receive information about every action it has performed. Faults show up on screen in California. "We can then talk live through our system to the technician and try to diagnose any problems. And we can remotely upgrade our software," says Kasaba.

Golden partnerships

Artisan has been working to develop its powertrain technologies in partnership with OEMs since 2010. One of the most productive partnerships has been with Kirkland Lake Gold (KLG), which relies heavily on Artisan's equipment for its gold mines in Ontario, Canada. At Kirkland Lake Gold's Macassa Mine, for example, Artisan's electric powertrains drive 14 underground machines, including 3.5-yard scoops and 20 metric ton haul trucks. The local company, RDH Mining Equipment, of Alban, in Ontario, supplied the vehicles, and incorporated the Artisan powertrain technology. Kasaba says that KLG's stock has quadrupled since 2013 and it has acquired two additional mining companies. He believes the cost savings and superior performance from battery power have contributed to that success.

"RDH Mining Equipment is a small company and, while we're very happy with the work we did with them, we also wanted to work with larger engineering companies, so we partnered with Atlas Copco, a giant with access to huge engineering departments. We knew we could rely on their integrations to produce superior performance," he says.

One of the fruits of the partnership with Atlas Copco is the Scooptran ST7 Battery vehicle, which was launched in May. Artisan provided the battery technology. Atlas Copco says it produced the vehicle to provide the market with alternatives to the more common tethered electric vehicles. Like Kasaba, Atlas Copco believes the trend for deeper mines will make electric vehicles necessary to reduce high ventilation costs.



LEFT: **The Artisan 153 emits zero poisonous diesel emissions**

Beating the battery lag

Considering the potential cost savings, superior performance, and environmental benefits, the mining industry's sluggish embrace of battery technology comes as a surprise to many people. But Kasaba says there are logical reasons for the industry's conservatism.

"To understand why, you have to look at the planning and execution process for major mining companies," he says. "They invest hundreds of millions of dollars and the payback is often not for several years, so they have to make their investors feel safe. How do they do that? By doing things they know will work for sure. Mining lags behind in accepting new technology because companies don't want investors to feel they are taking risks and, therefore, feel less safe."

But Kasaba says that if Artisan can demonstrate to nervous investors, that the up-front costs of battery-powered vehicles are roughly equivalent to diesel ones, the battle can be won. "If we look at the cost of the machine without the battery pack there's a slight premium for battery but it's not outrageous. If we look at the cost of a battery pack over its four-year life before it has to be remanufactured and compare that to the cost of diesel fuel, it's also comparable.

"The other benefits of batteries – lower emissions, lower ventilation costs, cooler and quieter motors, lower maintenance costs, and superior productivity – go direct to the bottom line," he says. **iVT**

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JON LAWSON, IVT INTERNATIONAL

NASA IS LOOKING FOR COMMERCIAL PARTNERS TO DEVELOP ITS OFF-WORLD MINING MACHINE, WHILE PRIVATE FIRMS HAVE SUCCEEDED IN 3D PRINTING A COMPLEX PART USING ONLY MATERIAL FROM AN ASTEROID. IS THE ERA OF EXTRATERRESTRIAL MINING CLOSER THAN WE THINK?

New worlds order

ABOVE: **An AC-3 truck that could be converted to use Hitachi's autonomous haulage system**

ABOVE RIGHT: **The stockyard at one of Rio Tinto's Pilbara iron ore mines in Western Australia, where increased automation has boosted production**

The prospect of extraterrestrial mining has been a staple of science fiction for decades, and now technology has progressed sufficiently for us to seriously examine how this could happen. Are the autonomous mining vehicles of today paving the way for extra-terrestrial mining in the future?

Certainly one of the great advances in the mining industry in recent years has been the rise of automation. For example, Rio Tinto has claimed that last year at its Pilbara mine 400 million tons of material were moved by autonomous trucks, resulting in a 12% productivity boost. There was also a 13% reduction in load and haulage costs due to truck efficiencies, and from a drilling perspective greater automation has cut costs by 8%. Even the mining cargo trains have benefited, with 250 journeys being automated.

The industry has not been slow to recognize this trend. Caterpillar recently launched an object detection system and an anti-collision proximity detection system that both operate without requiring a full area network.

Komatsu has developed what it calls "an innovative autonomous haulage vehicle" that doesn't even have a cab. At over 400 tons, and with a top speed of 64km/h it is a clear indication of the way the industry is going.

Hitachi is taking a slightly different view, building in the ability to upgrade at a later date if required.

Craig Lamarque, division manager, Hitachi Construction Machinery (Americas), commented recently, "As a fully integrated system, our autonomous haulage system results in a truck that can determine the most efficient paths without constant communication with traffic control. We've also included components that make it possible to convert any Hitachi AC-3 truck bought today to automated haulage in the future."

And there are even more ambitious plans afoot. Volvo is trialling an automated truck deep underground in the harsh conditions of the Kristineberg Mine in northern Sweden. Torbjörn Holmström, a member of the Volvo Group Executive Board and Volvo Group chief technology officer, observes, "This is the world's first fully self-driving truck to operate under such tough conditions. It is a true challenge to ensure that everything works with meticulous accuracy more than 1,300m (4,265ft) underground."

The machine features a battery of onboard sensors and is able to constantly work out the most economical routes.

With all this activity on automation research here on earth, could this be a template for mining on other planets?

The next thoughts to spring to mind must be: How would we know where to go? And how would we get our equipment up there?

Where do we go?

NASA's Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer (OSIRIS-REx) project may hold clues about answering the first

"OUR AUTONOMOUS HAULAGE SYSTEM RESULTS IN A TRUCK THAT CAN DETERMINE THE MOST EFFICIENT PATHS WITHOUT CONSTANT COMMUNICATION WITH TRAFFIC CONTROL"

Craig Lamarque, division manager, Hitachi Construction Machinery (Americas)

THEN... 1971

Of course NASA has been here before when it comes to the subtleties of designing off-planet off-roaders.

The Lunar Roving Vehicle (LRV) used on the Apollo 15, 16 and 17 missions is a fascinating little machine. On each mission it traveled a variety of distances over three traverses within its maximum safe range of 3 miles (5km) from the lander.

Starting at the bottom, the wheels consisted of a spun aluminum hub with tires made of zinc-coated steel strands. The tread is made up of titanium chevrons covering half the available surface area.

Each 0.25hp wheel motor is capable of 10,000rpm, reduced by an 80:1 harmonic drive. Power came from two 36V silver zinc potassium hydroxide non-rechargeable batteries. To steer, the driver used a T-shaped manual controller positioned between the seats. Pulling it back applied the brake, with a stick-mounted switch to select reverse.

Comfort was not neglected. There was an armrest between the seats, adjustable footrests and even Velcro seatbelts.

It did end up costing in the region of US$38m in 1971, though, which in today's money would be about US$226m.

Gene Cernan on Apollo 17 was the last person to drive an LRV on the moon. In a 2013 visit to the Science Museum in London he is reported as having said, "Flying Snoopy (the lunar module) was pretty exciting, but driving a car in one-sixth of Earth's gravity – if you get the chance, try it. It's a lot of fun. I truly believe we could go back and drive it again, but you might need to replace the batteries."

MAIN IMAGE: **OSIRIS-REx before sampling Bennu**

Image: NASA

ABOVE: **Commander Gene Cernan taking the LRV for a spin on the moon in 1972. He confirmed it was as much fun as it looks**

Photo: NASA

...AND NOW 2016

In September this year NASA demonstrated RASSOR 2.0, the Regolith Advanced Surface Systems Operations Robot, a machine with many novel features actually designed to go mining in space.

There are all sorts of challenges to be overcome for a lunar mining machine. For example, where gravity is low, a light machine would struggle to generate enough force to dig through what could be very dense material on the surface. To solve this problem, RASSOR features counter-rotating drums to give near-zero horizontal and minimal vertical net reaction force.

Loading is accomplished by scoops on the drums, spinning at around 20rpm. They can be raised to safely store the regolith while the vehicle drives to the dump site or processing plant. When there, the bucket drums reverse their direction of rotation, causing the regolith to be tipped out of each scoop.

This can all be done wirelessly, and cameras and telemetry enable situational awareness. Autonomy can be programmed if it is required.

The whole thing is scalable, meaning that its size can be easily altered to suit the space available on board the launcher – without a massive redesign.

Another area of the design that has received careful attention is overall mobility. Even if it overturns, its symmetry allows it to simply carry on reverse digging in the new orientation. It can even stand up to dump its cargo if there isn't a ramp handy.

In the images shown here RASSOR 2.0 is demonstrating an *in situ* resource utilization (ISRU) with a simulated propellant production exercise, exactly the type of task needed for a successful Mars mining mission.

NASA has said it is keen to explore whether there is any scope to use a large version of the machine on Earth in locations that are too difficult or dangerous to get to, and the Kennedy Space Center is looking for commercial partners to develop it further.

NASA/Dimitri Gerondidakis

ABOVE: **NASA's Kennedy Space Center in Florida hosts a demonstration of the RASSOR 2.0 mining vehicle prototype**

On the Web

Watch a video of NASA's RASSOR 2.0 in action at **http://www.iVTinternational.com/nasa**

"A SMALL, 10 METER S-TYPE ASTEROID CONTAINS ABOUT 650,000KG OF METAL, WITH ABOUT 50KG IN THE FORM OF RARE METALS LIKE PLATINUM AND GOLD"

Dante Lauretta, principal investigator, OSIRIS-REx mission, University of Arizona in Tucson

question. Launched in September 2016, its mission is to visit the near-earth asteroid Bennu, make a close-up study, break off a chunk and bring it home for detailed analysis.

In the close-up study, a device dubbed the OSIRIS-REx Visible and Infrared Spectrometer (OVIRS) will measure visible and near-infrared light reflected and emitted from the asteroid and split it into its component wavelengths. Dante Lauretta, principal investigator for the OSIRIS-REx mission at the University of Arizona in Tucson says, "In particular we will rely on it to find the areas of Bennu that are rich in organic molecules to identify possible sample sites of high scientific value, as well as the asteroid's general composition."

There are numerous types of asteroid, and with launch costs so high, knowing exactly where to get what you want is vital. The other key ingredient is water, as Lauretta explained when the OSIRIS-REx project was announced, "Water is a critical life-support item for a spacefaring civilization and it takes a lot of energy to launch it into space. With launch costs currently thousands of dollars per pound, you want to use water already available in space to reduce mission costs. The other thing you can do with water is break it apart into its constituents, hydrogen and oxygen, and that becomes rocket fuel. So you could have fuel depots out there where you're mining these asteroids. The other thing C-type asteroids have is organic material – a lot of organic carbon, phosphorous and other key elements for fertilizer to grow food."

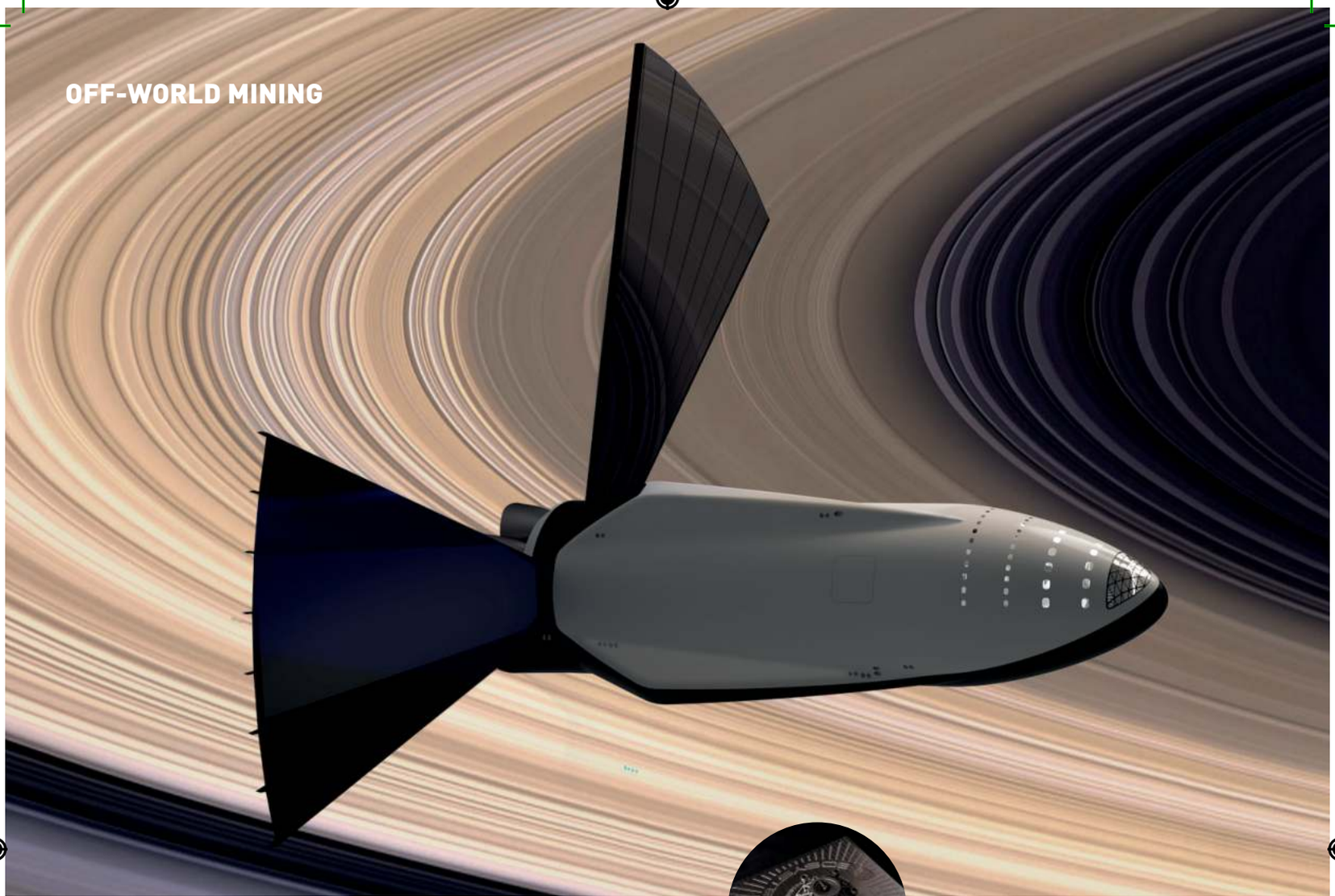
With stony S-type asteroids, Lauretta notes, "There is a fair amount of trace elements that are economically valuable, including gold, platinum and rhodium. A small, 10m S-type asteroid contains about 650,000kg of metal, with about 50kg in the form of rare metals like platinum and gold."

The rendezvous is expected in October 2018.

So if a trip like that could identify exactly where to go, now we need to consider how we'll get our heavy mining kit up there.

How do we get there?

One man spending time – and money – doing just that is SpaceX's Elon Musk. In a speech he gave in September he outlined his plan to colonize Mars. To get there he spoke of his dreams about a rocket with a potential payload of up to 450 tons of cargo, depending on how many fuel refills could be made available en route. While some of the presentation seemed fantastical, like bringing the cost of a trip there to under US$100,000 per person, and a colony of one million people living and working there, Musk is building and test firing engines and working on the huge carbon fiber structures such a project would need. It's not



"WE BELIEVE EARLY MARS WAS A LOT LIKE EARTH. IF WE COULD WARM MARS UP, IT WOULD ONCE AGAIN HAVE A THICK ATMOSPHERE AND LIQUID OCEANS"

Elon Musk, CEO and CTO, SpaceX

all been plain sailing, but he spoke with such confidence and enthusiasm that he does appear to genuinely believe he will see people on Mars in his lifetime.

"We believe early Mars was a lot like earth," Musk said during his speech. "If we could warm Mars up, it would once again have a thick atmosphere and liquid oceans."

Even US president Barack Obama addressed the subject in October, telling CNN, "We have set a clear goal vital to the next chapter of America's story in space: sending humans to Mars by the 2030s and returning them safely to Earth, with the ultimate ambition to one day remain there for an extended time. Getting to Mars will require continued cooperation between government and private innovators, and we're already well on our way. I'm excited to announce that we are working with our commercial partners to build new habitats that can sustain and transport astronauts on long-duration missions in deep space. These missions will teach us how humans can live far from Earth – something we'll need for the long journey to Mars."

DIY at distance

As for moving our machines, there may be an alternative to the type of large payloads envisioned by Elon Musk. Back on the automation theme, rather than send up all the kit necessary in completed format, why not send up a machine that builds it all up there, from materials harvested from the asteroid or planet itself? That would save a fortune on launch costs.

TOP: **The SpaceX Interplanetary Transport System, once in space, would run using power from vast solar panels. It would be capable of carrying 450 tons of cargo and passengers**

ABOVE AND BELOW: **Planetary Resources and 3D Systems' prototype object, made from a piece of an asteroid composed of iron, nickel and cobalt, using 3D printing**

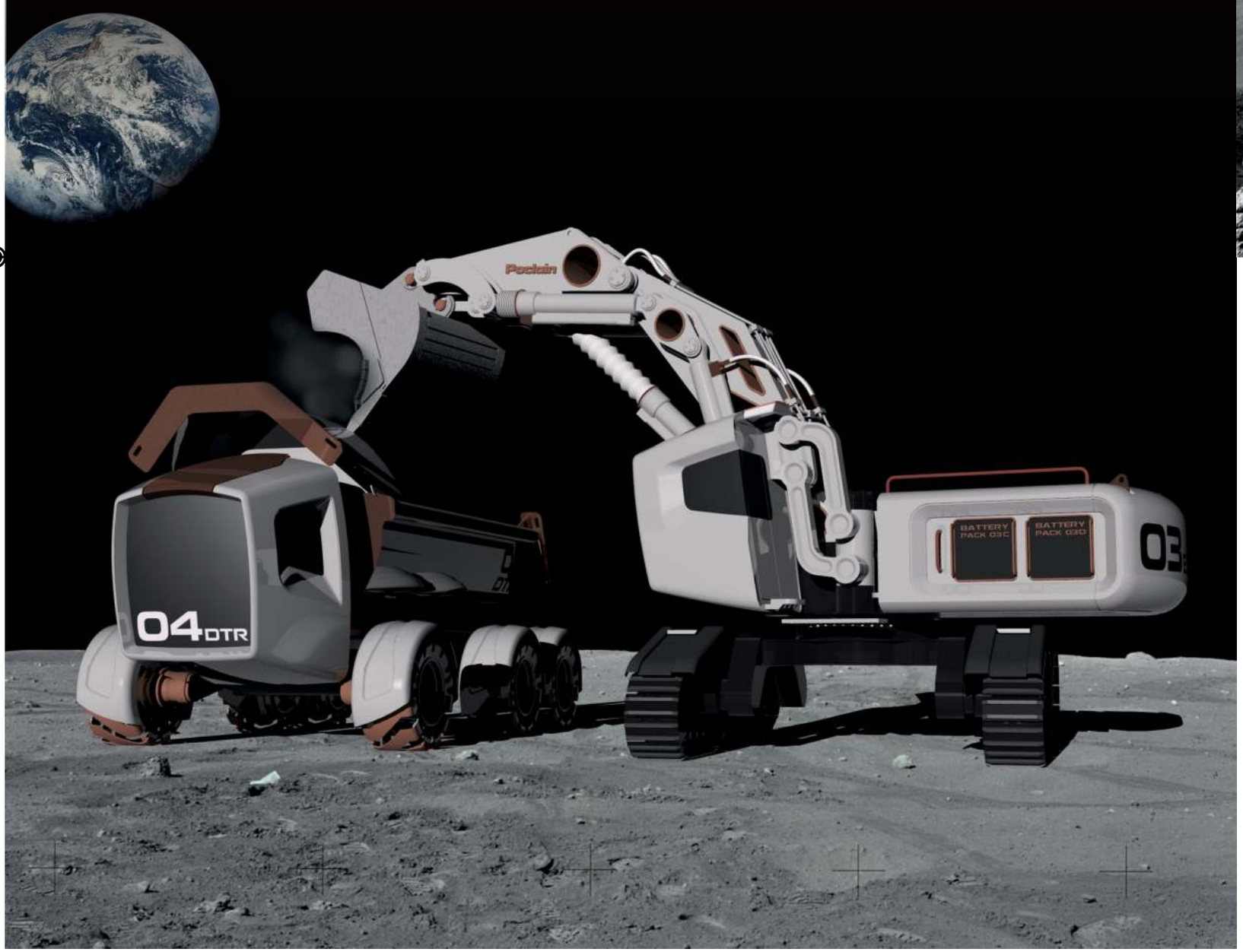
This notion was tested this year by a joint project between the firms Planetary Resources and 3D Systems. At the Consumer Electronics Show in Las Vegas they unveiled what they claimed was the first-ever object constructed using an additive process from a real piece of asteroid, which was found at the Campo Del Cielo impact site northwest of Buenos Aires, Argentina.

Consisting of iron, nickel and cobalt, it was melted under vacuum then gas atomized into powder, before being printed into a complex shape.

Clearly there are options available as to how best to take advantage of the opportunities that exist in space. It does take some imagination, but it really could be possible that one day a man-made machine will alight on a celestial body, unpack itself, assemble robotic mining machines and dig. **iVT**

DC DESIGN

DESIGN A VEHICLE SUITABLE FOR EXTRATERRESTRIAL MINING ACTIVITIES



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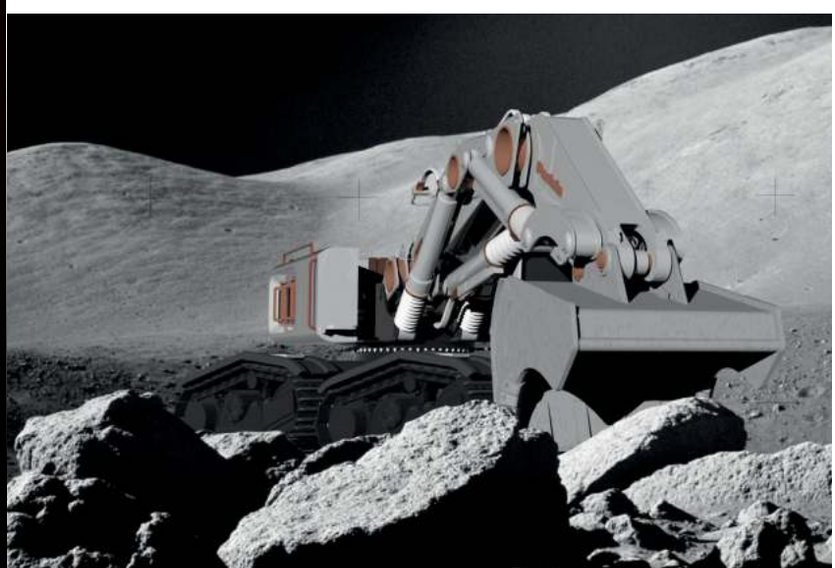

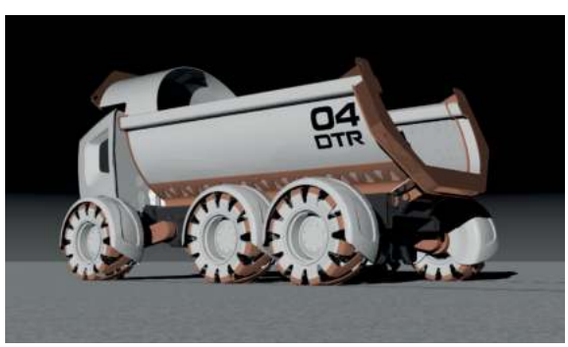

SHOOT FOR THE MOON

ALBERTO SECO

Alberto has been involved in design projects from cell phones to heavy equipment. After a spell at an Italian design consultancy and as an industrial designer, he now works in the automotive sector

This concept excavator and dump truck can work together and they are suitable for moon mining activities.

The materials would need to be of the highest quality aerospace grade so that they will cope with temperatures that can range from around -200°C out of sight of the sun, up to nearly 200°C in full sunlight (-328°F to +392°F). This temperature range requires robust materials whose dimensions have minimal thermal expansion and contraction properties. The boom and stick on the excavator have been built by using transversal tubes and structural elements that would offer both stiffness and flexibility. These cross-elements would create windows on the boom that will improve right-hand-side visibility for the operator.

To minimize their need for external energy delivery, energy recovery systems would be fundamental for the operation of both vehicles; electricity would have to be the base of the drivetrain and the batteries would need to be easily accessible. For the dump truck, the energy recovery would come from regenerative braking systems, while in the excavator the energy-storage cylinders would benefit from the boom and stick being operated by electric motors.

There is no wind or rain on the moon, so every kind of impression left behind on the surface would last for many thousands of years. Such a fragile environment calls for the most effective form of compaction reduction. Thus, instead of a four-wheel driveline, the 40-ton lunar dump truck has been designed with six wide wheels that will distribute the burden. In order to minimize the dust thrown up, the wheels are to be made of metal strips, creating a sort of perforated tire. These flexible wheels, combined with variable suspension, would provide self-leveling transportation suitable for the moon's topography.

In the case of the 55-ton lunar front-shovel excavator, four independent tracks covered with mudguards reduce compaction while controlling dust. Dividing two conventional tracks would allow a better adaptation to ground conditions. The width of the lunar dump truck has been enlarged for added stability. The same principle is adopted for the lunar-shovel undercarriage.

Although both vehicles would be autonomous, big windshield would add visibility and therefore vehicle control in case of occasional operation by astronauts. To minimize accidents caused by any clumsy movements of humans, access to machines and cabs has been eased by means of parallelogram systems that would place the cabs on the ground. The wide windshield would act as convenient front doors.

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The concept excavator and dump truck have modular design approaches that will making it easier to transport them. For instance, the circular section of the dump truck body would allow it to be transported inside a shuttle-type lander as a complete unit. Rounded surfaces also help to enhance safety as they are more resistant to fracture.

JON LAWSON, IVT INTERNATIONAL

The battery takes charge

VOLVO'S NEW WORKING CONCEPT HYBRID HAS A DIESEL ENGINE ONLY FOR CHARGING THE BATTERY, NOT DIRECTLY DRIVING THE VEHICLE, PLUS AN AUTONOMOUS 'HELPER' TO SHARE THE LOADS

Volvo has created a prototype hybrid wheel loader with the aim of cutting fuel consumption in half. Shown to the public for the first time at the Xploration Forum in Eskilstuna, Sweden, in September, the LX1 has many novel features, and Volvo says it is "98% new".

The machine is the latest in a line of experimental vehicles. Volvo has been interested in hybrids since 1998 and the company sees a bright future for the technology.

As it is so different from conventional designs, and the fuel systems are completely decoupled, the entire machine architecture is radically different too. Andreas Hjertström, chief project manager for the LX1, says, "As it is all electrified, we don't have the traditional collection of connected mechanical parts. Instead we have new parts that to some extent we can choose where to place."

The 600V system features a small 3.6-liter 90kW Deutz engine that runs at its optimum at all times. Due to its reduced size, the rump of the LX1 slopes steeply, a useful feature, as Hjertström explains: "Normally we would have a 13-liter engine to do this much work, but by downsizing we can greatly improve visibility for the driver."

The layout is as follows. The genset, which consists of the diesel engine and a 600V generator, is the main power source of the machine and is used to keep the energy in the batteries at a certain level. Energy is

"AS IT IS ALL ELECTRIFIED, WE DON'T HAVE THE TRADITIONAL COLLECTION OF CONNECTED MECHANICAL PARTS. INSTEAD WE HAVE NEW PARTS THAT TO SOME EXTENT WE CAN CHOOSE WHERE TO PLACE"

Andreas Hjertström, chief project manager, LX1

50%
The increase in fuel efficiency due to the machine's innovative design

In the LX1, full power to both the hydraulics and the driveline is always available

used mainly for propulsion and lifting the hydraulics. It is regenerated back into the battery during braking and lowering of the bucket, as the electric motors become generators.

By having a decoupled system with energy storage, there is no connection between power available for the machine and the rpm of the diesel engine, as is the case in a traditional machine. In the LX1, full power to both the hydraulics and the driveline is always available, even if the diesel engine is shut off.

"Some of the technologies in this concept machine may not be new, but there are considerable challenges to overcome to make them work together smoothly," says Hjertström. "Designing and building the machine is one thing; getting the driveability is something else. This is the part of the design we have worked the most with. We have come very far, but there is still work to be done when compared with the smoothness of a traditional, mechanically coupled machine that has been developed over many years. Electronically controlling the four individual hub motors is a very complex task." Hjertström is happy that progress is being made and he confirms that getting it perfect is "definitely not decades away".

Due to the machine's innovative design, the larger L150 is used as a benchmark, particularly for productivity and fuel economy. Hjertström confirms that a 50% fuel efficiency improvement is a reality, and now something longer term will be carried out to further evolve the technology and durability.

Starting in November, the machine will be field tested in California by Volvo CE's customer Waste Management.

Boom time

One of the results of ditching the traditional axle design for hub motors means there can be improvements elsewhere in the design. For example at the front, the bucket is a standard L150-size, which looks slightly unusual on an

ELECTRIC DREAMS

Both these vehicles form part of a wider vision Volvo has for the future: the fully electrified site. The targets are ambitious, with a 25% reduction in the total cost of ownership and a whopping 95% cut in carbon emissions.

To achieve this, Volvo has partnered with Skanska Sweden, the Swedish Energy Agency, Linköping University and Mälardalen University in a Skr203m (US$22.6m) project that they all hope will culminate with a full-scale 10-week demonstration in a quarry at the end of 2018. Although Volvo stresses that at this stage it is more a technology trial than an attempt to create something that can be commercialized, it will inevitably have useful spin-offs – in particular for advances in automation and hybrid design.

Martin Weissburg, president of Volvo CE, comments, "We are developing technologies connected to electromobility, intelligent machines and total site solutions that will benefit our customers and the environment by contributing to increased machine performance, productivity, efficiency, safety and sustainability. Our future products and services will play an important part in building a sustainable society."

"AT VOLVO CE WE ARE DEVELOPING TECHNOLOGIES CONNECTED TO ELECTROMOBILITY, INTELLIGENT MACHINES AND TOTAL SITE SOLUTIONS THAT WILL BENEFIT OUR CUSTOMERS AND THE ENVIRONMENT"

Martin Weissburg, president, Volvo CE

95%
The cut in carbon emissions expected across one work site if Volvo achieves its vision of full vehicle electrification

SELF STARTER

This is not the only novel vehicle Volvo is working on. The LX1 has a little helper – the HX1. This 6-ton electric machine is fully autonomous and Volvo believes this is the way of the future. Johan Sjöberg, technical specialist in site automation, says, "By using electricity instead of diesel to power construction equipment in a quarry we have the potential to deliver major reductions in fuel consumption, carbon dioxide emissions, the environmental impact and cost-per-ton. The electrification of construction equipment will produce cleaner, quieter and more efficient machines."

Volvo envisages a fleet of these small haulers following a pre-determined path around a quarry. Currently this example has no machine vision of its own, meaning it follows a programmed GPS path without actively detecting or seeing obstacles along the way, but in 2018 the next iteration of the project will see vision sensors/obstacle detection systems installed. Another idea is that they will eventually be able to give each other instructions on where and when to tip.

As with the LX1, energy recovery is vital to the success of this machine. Volvo says that in a typical application transporting material uphill, an HX1 has more than five times the energy of a conventional rigid dump truck. In a downhill application the machine could even be energy neutral (no need for charging at all) over the complete work cycle, due to electric energy recovery when going downhill.

ABOVE: **Volvo's LX1 hybrid wheel loader fills the battery-electric autonomous HX1 load carrier prototype**

L140 machine, and behind that is a new, unique single boom. Hjertström explains, "Due to the use of hub units we are able to pull the loading nearer to the center of the machine, enabling us to lift more than if we had a front axle."

Hjertström sees increasing interest in hybrid technology across the industrial spectrum. "Of course it depends a lot on the application," he observes. "One of the keys to success is with regeneration from, for instance, braking or lowering a bucket. An agricultural vehicle, such as a tractor doing lots of towing on flat ground, may not benefit as much as one that spends all day shoveling. Looking further, I predict further electrification in all areas."

The business case for automation is compelling, especially when considering the labor costs in the developed world. As our natural resources become increasingly scarce, automation could one day open up quarries that had previously been seen as uneconomical. **iVT**

Clean up your act

HOW THE MOVE FROM STAGE IV TO STAGE V EMISSIONS STANDARDS, TABLED FOR 2019-2020, WILL POSE FURTHER CHALLENGES FOR VEHICLE MANUFACTURERS

Starting in 2019, Stage V legislation will begin coming into force in the European Union (EU). Some manufacturers are already embracing the new rules, which will pit the competing requirements of cutting particulates and NO_X against each other to arrive at the best compromise solution, ideally without too much fuel-sapping backpressure being created.

The changes will for the first time affect the sub-19kW and the 560kW and above power brackets. Bob Laing, from emission control systems manufacturer Eminox explains, "As the new rules apply to more engines there will be more types of machine that need new aftertreatment. This could include small scissor lifts and tillers at one end of the scale right up to large excavators and dump trucks. Even train and inland boat engines are covered."

Focusing on the technology, Laing continues, "Prior to Stage V there were different ways of approaching the problem. Some reduced particulates by concentrating on the cylinder design and controlling NO_X with SCR [selective catalytic reduction], others used a DPF [diesel particulate filter] to cut the NO_X. The introduction of Stage V essentially mandates the use of a DPF as well as some degree of SCR."

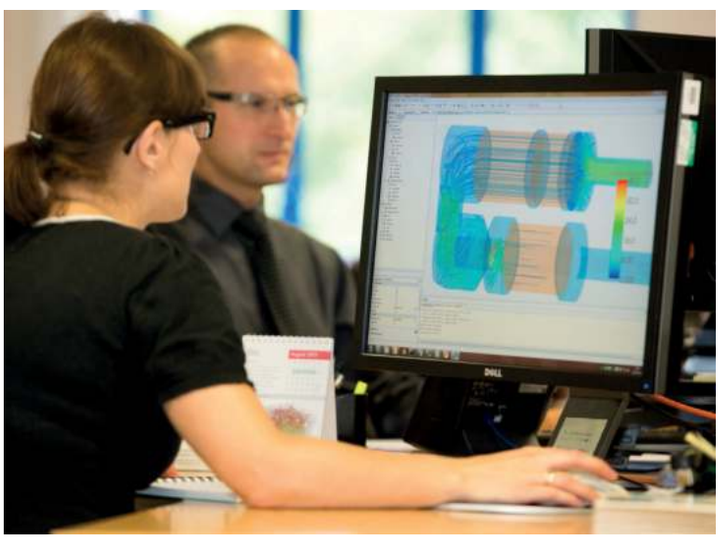
So for those just starting out on the design process, what issues lie ahead? "It's about the trade-off between the particulates and the NO_X," Laing confirms. "Starting with the smaller engines, the first issue might be one of packaging. It's best practice to design the new system with the same footprint and profile as the old one where possible. Then we have to consider the thermal management."

Laing cites various possibilities. "The first thing to look at is the machine itself. Are there any areas where we would wish to avoid

routing hot pipe work? What's the best option for layout? Should we place a small SCR-coated DPF close to the engine, or would we be better off having a high-efficiency, lower-temperature SCR elsewhere on the chassis? And what about that DPF? We need it large enough that it won't clog too quickly, but on a smaller machine such as a gardening tractor, space constraints may be an issue. Plus, we need to have room for enough insulation to keep the system at an ideal temperature."

"COULD THE IMPACT OF EXHAUST GAS RECIRCULATION FORCE THE DIESEL PARTICULATE FILTER TO A BIGGER SIZE? IF SO, SPACE MAY BE AN ISSUE, PARTICULARLY IN SMALLER ENGINES"

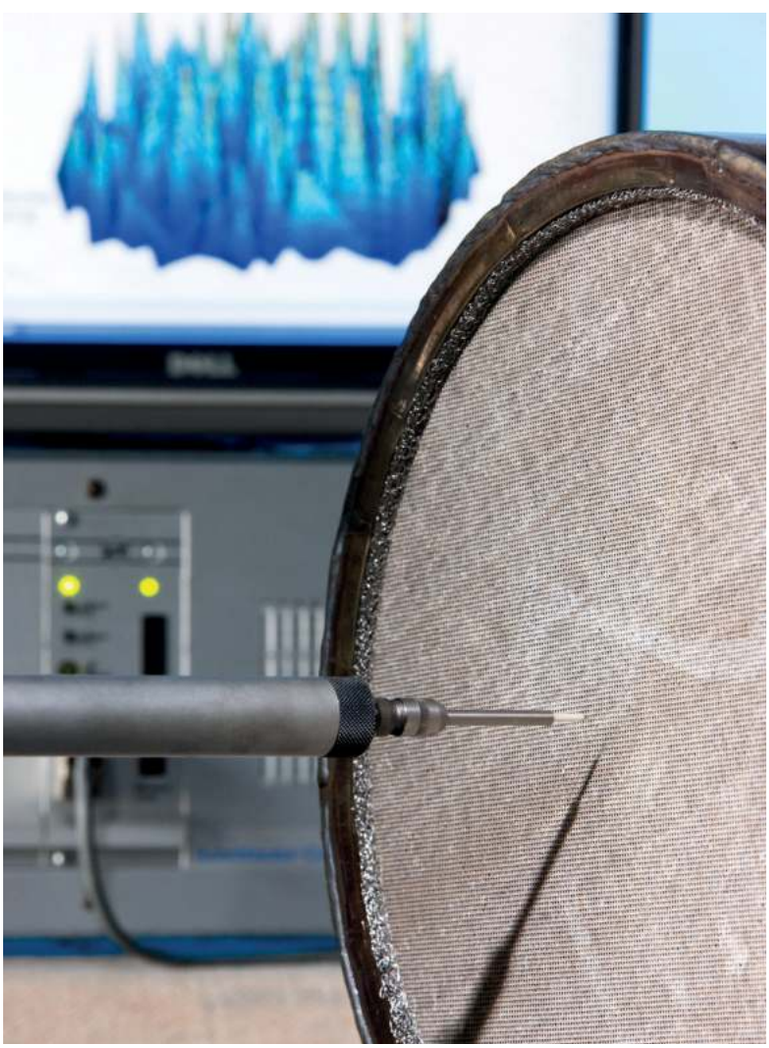
RIGHT: **Computer modeling systems help to judge potential emissions**



Feeling the heat

On top of the new requirements, OEMs are seeking further economy improvements, which will ultimately drive down exhaust temperatures, resulting in an increase in thermal management strategies to accelerate temperature increase after startup. Some will have exhaust gas recirculation (EGR), which will complicate the picture still further.

"Again this is more of an issue for smaller engines. Could the impact of EGR force the DPF to a bigger size? If so, space may be an issue," he says.



LEFT: **Fuel injector durability test. Operators do not want high running costs to be the trade-off for Stage V compliance**

Go large

For bigger engines the challenges are slightly different. Although packaging always remains an issue, fuel consumption and the question of how it is best to administer AdBlue to cut the NO_x become more important factors.

This is one area where there is little technology transfer from on-road applications, as Laing notes, "Typically the larger engines we work on are either medium speed (300-1,000rpm) or slow speed (less than 300rpm), and the slow speed engines are typically two stroke. Drive cycles for these engines are very different from those observed

with on-road vehicles. Here the use of high-flow injectors is necessary to spray the AdBlue into the SCR system. Specific attention needs to be given to tuning the spray pattern, ensuring fine atomization for better mixing, minimizing wall wetting and eliminating crystallization of urea on the injector nozzle."

Where space is an issue, Eminox combines SCR and DPF technology into a single filter substrate. Laing feels fortunate to have all the tools necessary to do this complex kind of design work: "Our ongoing investment in 3D scanning and modeling tools to design compact systems that use high-performance catalysts helps here. Furthermore, our computational fluid dynamics enables us to fine-tune close proximity mixing solutions. Having this level of in-house capability is still unusual in the industry."

Cost considerations

If designing an aftertreatment system, there is a need to balance the many technical demands against the need to provide a value-for-money exhaust aftertreatment system. This is brought into perspective when considering the potential cost of developing a Stage V compliant solution for a 19kW engine from scratch, which OEMs in the new engine size bandings are potentially facing.

"Our advice to the OEM is that there are obvious timescale and value engineering advantages to evolving a solution from technology and components that already exist," says Laing. "Creating it from a blank sheet of paper and apportioning these development and tooling costs to the finished product would potentially price the engine – and product – out of the market."

For those who have no choice but to start from scratch, Laing offers two pieces of advice. "First, engine-out emissions. What changes are required to achieve the next level of emissions legislation? All the trade-offs will need to be considered, including the impact on engine subsystems such as the fuel and air intake system with changes potentially extending as far as inlet manifold, piston bowl and exhaust manifold redesign.

"Second, much depends on the space constraints of the particular installation. If the OEM had to redesign a machine for Stage IV, then repeating the exercise at Stage V may not be an option."

Technological evolution

Observing the evolution of the technology, from Stage 3b onward a diesel oxidation catalyst (DOC) with a platinum-group metal (PGM) washcoat to supply NO_2 for either passive DPF regeneration or to support SCR was in vogue. Stage IV bought further application of SCR whether a DPF was used or not.

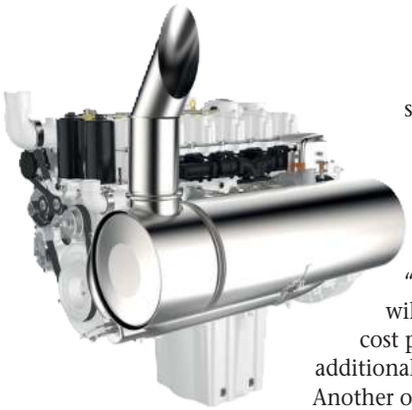
With Stage V, Laing notes, "In all likelihood the proven DOC/DPF recipe, applied by many OEMs on

MAIN IMAGE: **A technician works on an emission control system**

INSET: **Eminox Stage V 1958. Stage V effectively mandates the use of a DPF in the aftertreatment system**

"OUR ADVICE TO OEMs IS THAT THERE ARE OBVIOUS ADVANTAGES TO EVOLVING A SOLUTION FROM TECHNOLOGY AND COMPONENTS THAT ALREADY EXIST"

engines over 56kW at Stage 3b, will be the technology of choice for manufacturers of 19-56kW engines. The main questions remaining surround the strategy for DPF regeneration. The trade-off between population risk and system cost is important to understand in this power range."



ABOVE: **Engine with Eminox SRC1. Stage V will be influenced by the technology used on Stage IV – an evolution of existing technology, not a revolution**

BELOW: **Buses are tested at Millbrook Proving Ground in Bedfordshire, UK**

Regeneration conversation

The most common aftertreatment arrangement for Stage V, 56-560kW, is likely to be a DOC upstream of a DPF followed by an SCR and ammonia slip catalyst (ASC). Even after the system layout has been confirmed there are still a number of questions to be answered, such as what is the regeneration strategy? How should the platinum-group metal be distributed?

"In order to facilitate package constraints, some OEMs may consider implementing a three-can solution with the diesel oxidation catalyst canned independently and close coupled to the turbo to use all the space available," says Laing. "However, this solution will likely carry a significant cost penalty due to the additional canning requirements. Another option available is to downsize the DPF and mandate a filter service interval, usually half way through the emissions life of the system."

A step forward

A final note of caution. When designing a system where the DPF and SCR functions are combined into one substrate, the additional chemistry created, as soot and ammonia fight for the NO_2, may need a control system so complicated as to send the whole thing back to the drawing board. Also optimization of filter porosity and washcoat application to balance the backpressure, soot filtration efficiency and SCR could result in a lengthy development process.

But for Eminox, Stage V is just another step forward. Laing concludes, "The journey to Stage V compliance should be an evolution of existing technology, not a revolution. Many OEMs exploit recent experience and, where possible, leverage knowledge from other divisions in their organization. On the other hand, some manufacturers of smaller engines without much previous experience of aftertreatment will rely more on specialist exhaust system integrators." **iVT**

98.8%

The reduction in particulate matter (PM) recorded at Millbrook Proving Ground when buses were fitted with SCR and CRT technology on a simulated urban cycle

LOW EMISSIONS ON BUSES

Starting in September 2020, vehicles entering the London Ultra Low Emission Zone (ULEZ) will be fined if they exceed the Euro VI emissions standards. Routes controlled by Transport for London (TfL) will need to meet the new standards a year earlier.

The financial penalties will be considerable, with a £100 (US$123) per day levy on non-compliant vehicles and a fine of £1,000 (US£1,230) for those trying to dodge the charge.

Preparations are already being made for the new zone. For London buses a combination of SCR and CRT (continuously regenerating technology), retrofitted by Eminox, has been tested at the Millbrook Proving Ground on a simulated urban cycle with impressive results: NO_x was down by 95%, PM by 98.8%, HC by 98.1% and CO by 96.5%.

This type of installation is likely to be a growth area, especially as Clean Air Zones (CAZ) are expected in five other UK cities by 2020: Birmingham, Leeds, Nottingham, Derby and Southampton.

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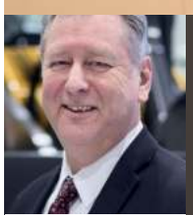
iVT ELECTRIC & HYBRID SYMPOSIUM REVIEW

FOLLOWING THE FIRST-EVER ELECTRIC & HYBRID INDUSTRIAL VEHICLE TECHNOLOGY SYMPOSIUM, WHICH TOOK PLACE IN COLOGNE, GERMANY, NOVEMBER 9-10, WE HAVE RECEIVED DOZENS OF MESSAGES OF THANKS FROM GRATEFUL ATTENDEES. HERE, WE SHARE JUST A FEW OF THEM. SEE YOU AT NEXT YEAR'S EVENT!

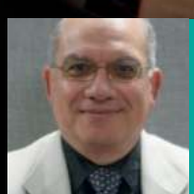


Dave Ross, VP Advanced Technology & Verification, Volvo Construction Equipment

"This conference was a very interesting mix of speakers, all touching on the important disruptive technology of electric vehicles. There were tons of good questions and positive energy."

Vern Caron, Electric Vehicle Engineering, Oerlikon Fairfield

"I was very impressed with the iVT Symposium and hope that Oerlikon will continue to be involved with the conference in the future. Our CTO, Gunnar Stein, who also attended, felt that this was very worthwhile."



Ashraf Zeid, VSS technical leader, Volvo Construction Equipment

"Not only did the speakers present motivation for electrification, but I was thrilled to hear the opposing point of view so eloquently articulated by distinguished researchers and leaders. Overall, the symposium brought together a diverse and influential group of speakers in one location over two days."

Dr Niall Caldwell, managing director, Artemis Intelligent Power

"The symposium was certainly a successful event, which more than reached critical mass in terms of most of the large OEMs in attendance (either presenting or listening) and a good selection of up-and-coming technology companies and research groups seeking their attention with new ideas."

Bill Van Amburg, senior vice president, Calstart

"Calstart was proud and pleased to be involved – I heard some very good comments from attendees – and a strong sense they want to take part next year."

Dr Joachim Sobotzik, Enterprise Electric Drives Services Group, John Deere

"The symposium was well-sized, with a nice setup and location, and the right balance between presentations and networking breaks. The speakers were well prepared, with a good mix of research organizations, OEMs and industry."

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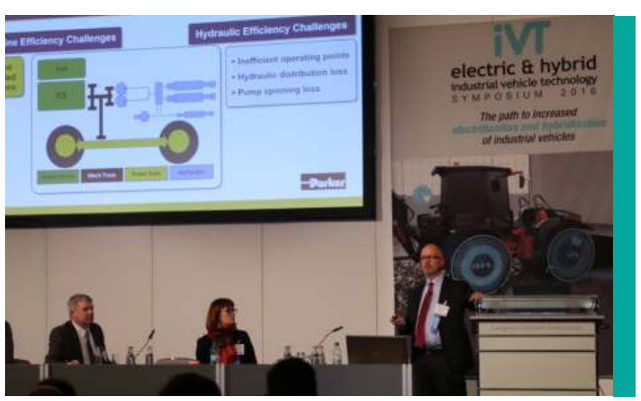

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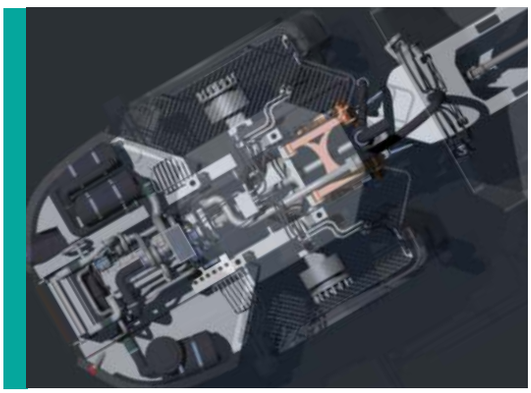

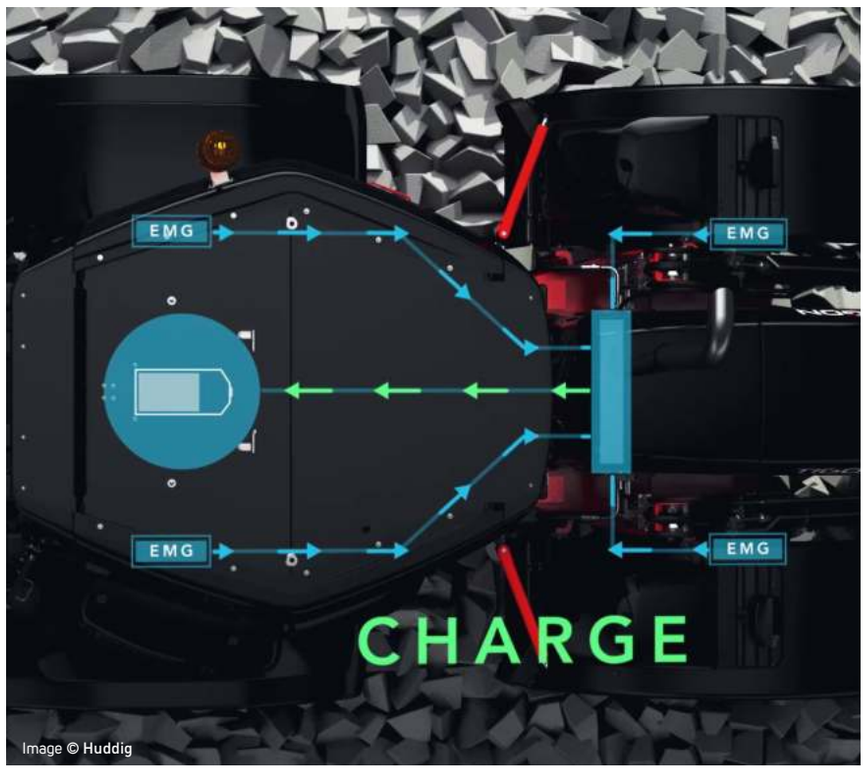

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Plant transplant

WHAT'S THE BEST WAY TO INCREASE THE CAPACITY OF A HIGH-QUALITY ENGINE FACTORY? THE SIMPLE, STRAIGHTFORWARD SOLUTION IS TO DUPLICATE IT

Sensing the growing demand for high-quality, reliable industrial diesel engines in China, in 2013 Yanmar decided to invest heavily in the local market by creating a new factory in Qingdao in the Shandong province. The new plant produces the vertical, water-cooled TNV diesel engine range.

The template for the new venture is the company's mother plant at Biwa in Japan, which produces 440,000 units per year (2,000 models). All the cutting-edge automation technology has been transplanted to the Qingdao factory. In addition, Qingdao features the same computerized production control network as Biwa, with all the details of every engine stored on a central server. This approach has proven itself by keeping the engine's quality and performance high.

Many of the core components, such as injection pumps, injectors, cylinder heads, cylinder blocks, gears and con-rods, are manufactured and supplied within Yanmar Group facilities. To ensure there are no issues on arrival, the parts are scrutinized in the Precision Inspection Room before getting crated up.

Sample inspection

Furthermore, Qingdao uses the latest measuring instruments to inspect specific samples. Only the highest-quality parts that meet Yanmar's strict standards are used.

All engines go through the dyno testing cell to guarantee the prescribed performance. The Qingdao plant also has an emissions measuring room to ensure that each country's emissions regulations are met.

Yanmar's approach to its staff is the secret of the rapid success in Qingdao. There is a two-year training program, with time spent at both plants. In the first year, health and safety, engine knowledge and the production system are covered, while year two features more direct on-the-job training. The teachers are all long-time Yanmar employees who, of course, were also taught in this way in the past.

Quality improvements and work efficiency are regularly discussed in small groups. This can increase motivation and encourage more rapid personal growth. It's a lot of effort and attention to detail, but that's what customers need. When they take the engine out of the box they need to know it's already been passed fit by being emissions tested and checked on a dyno.

TOP: **In 2013, Yanmar duplicated its Biwa diesel engine factory in Qingdao to meet sales demands**
ABOVE: **Qingdao, China**

Production capacity in Qingdao is 60,000 units per year. From agriculture to zoology, these engines are working in a huge variety of industries. Some are stationary, such as generators and pumps, and many are mobile such as mini-excavators, wheeled loaders, small tractors and forklifts. All are made to the same exacting quality as at the Biwa plant. **iVT**

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Five steps ahead

THE INDUSTRY IS ADJUSTING ITS ENGINE PRODUCTION ACCORDINGLY AS THE STAGE V EMISSIONS REGULATIONS FOR EUROPEAN COUNTRIES APPROACH

Stage V emissions regulations will come into force in European countries from January 2019 on all power ranges, except for applications between 56kW (76hp) and 129kW (175hp), which will be implemented one year later (January 2020). The new regulations will introduce stricter limits on particulate matter emissions (PM), asking for a 40% reduction compared with current Stage IV limits, and add a new limit on particle number (PN), thus requiring a control over the quantity of generated PM particles – and not only on their weight. Such regulations will require the adoption of a particulate filtration system, while limits on nitrogen oxides (NOx) will be unchanged compared with the current norm. Moreover, Stage V will cover power ranges currently with low or no regulation in Europe, such as below 37kW (50hp) and above 560kW (760hp).

With more than 25 years' experience in SCR solutions development and its exclusive HI-eSCR2 technology, with its active regeneration-free particulate filter, an aftertreatment system 'for life' and best-in-class engine efficiency, FPT Industrial can justify saying, "We are five steps ahead." The company is ready for the challenge of new Stage V technologies, too.

To comply with Stage V, all engines above 4 liters will use HI-eSCR2, the second generation of FPT Industrial's renowned and patented High-efficiency Selective Catalytic Reduction (HI-eSCR) aftertreatment technology. With this, FPT confirms its long-term SCR-only strategy to achieve uprated standards retaining an active regeneration-free solution and avoiding an exhaust gas recirculation (EGR) on engines above 4 liters. This maintains the competitive advantages achieved in Stage IV/Tier 4B, in terms of fuel economy, and power and torque density.

ABOVE: **HI-eSCR2, the Stage V solution for off-road applications**

New and improved

To meet both Stage V's particle mass and particle count requirements, the second-generation HI-eSCR system has an integrated particle filter on the SCR, which makes it an extremely compact solution with no dimension increase compared with current Stage IV. When considering the engine, its cooling and aftertreatment system, FPT's solution is 10% smaller than the competitor average (considering 6 liter, six cylinder engine competitors). On top of this, FPT's flexible solution, with up to 20 different layouts available for each power node, saves vehicle manufacturers from carrying out additional redesign work. The newly integrated particle filter does not require active regeneration and the engine is highly efficient in terms of fluid consumption, with 3% lower fluid consumption versus the market average using EGR and with active regeneration.

Always at the forefront of innovation and with a strong focus on research and development, FPT Industrial has confirmed itself as a game-changer in the powertrain sector. This is thanks to a network of seven R&D centers worldwide – Turin and Foggia in Italy, Arbon in Switzerland, Fécamp in France, Burr Ridge in the USA, Betim in Brazil and Chongqing in China. In its 10 plants around the world in 2015, 508,000 engines (more than one engine every minute, when including joint ventures and licenses), 68,000 transmissions and 182,000 axles were produced for on-road (75% of the total FPT's production in 2015), off-road (20%), power generation (4%) and marine (1%). A wide product offering includes six engine ranges from 31kW up to 740kW, transmissions with maximum torque of 200Nm up to 500Nm, and front and rear axles from 2-ton to 32-ton gross axle weight. Furthermore, FPT's sales network consists of 93 dealers and more than 900 service centers in almost 100 countries. **iVT**

NEW G3 DROP-IN CARTRIDGE VALVES:

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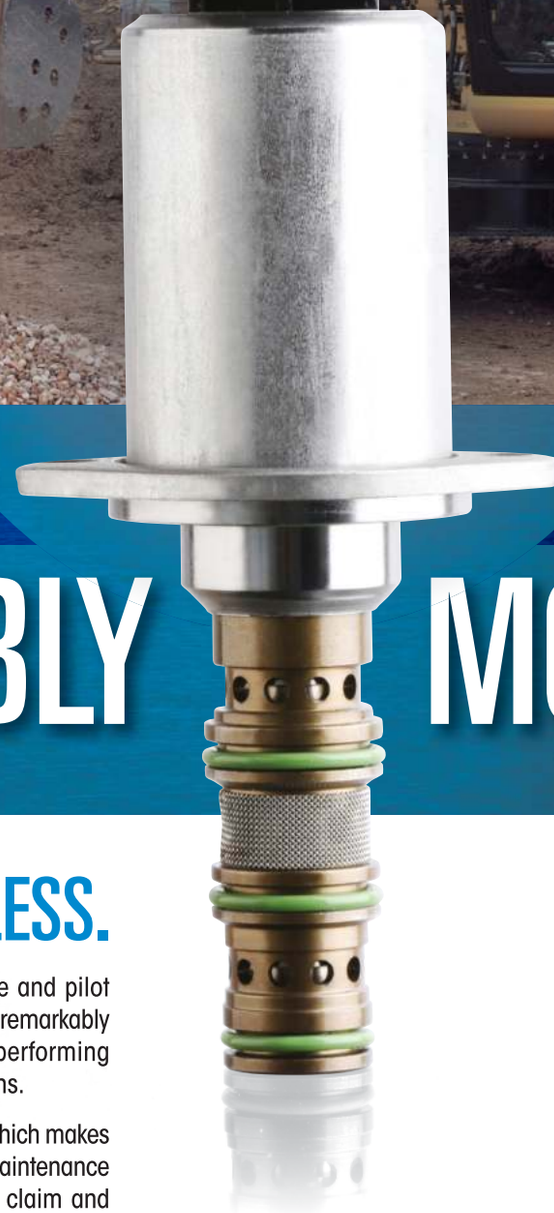

AND SIGNIFICANTLY LESS.

Engineered specifically for powertrain, diesel engine and pilot control applications, our new G3 drop-in valves deliver remarkably more flexibility, reliability and efficiency — outperforming conventional designs, even in the harshest conditions.

G3 valves operate with higher electro-magnetic force, which makes them less susceptible to contamination and reduces maintenance downtime. The improved design also reduces space claim and delivers reliable and precise linear control — with low hysteresis and even lower leakage.

For powertrain engineering assistance, visit **hydraforce.com**

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CYNTHIA MACKIN FAWCETT

Quick and easy custom control

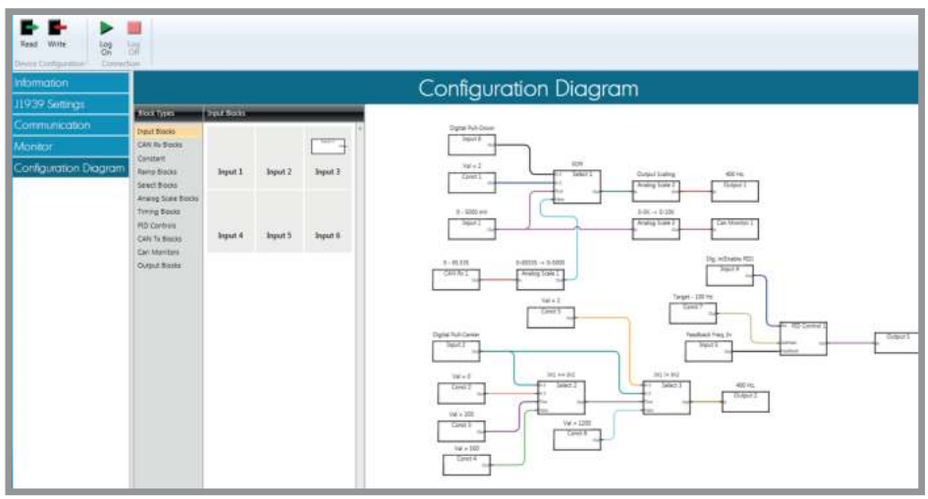
AN ELECTRONIC VALVE DRIVER FAMILY IS EXPANDED TO INCLUDE A CONFIGURABLE ECDR CONTROLLER

Adding electronic control to hydraulic functions on mobile equipment has become a little easier with the latest addition to the HydraForce family of electronic valve drivers. The ECDR valve family can be configured using HydraForce HF-Impulse configuration software, which was developed specifically by HydraForce to make its proportional valve drivers easy to configure. The software is free and is available to download from the HydraForce website.

ECDR valve drivers are an evolution from the EVDR plug-in style valve drivers developed by HydraForce several years ago. The EVDR valve drivers were pre-configured to handle specific control functions – such as timed transmission control and reversing fan control.

"We called this valve driver an ECDR instead of an EVDR because it has an additional level of configuration capability," says Chris Shader, electronics product manager at HydraForce. "Surveying the market, we saw a huge gap in the capabilities of driver programming versus typical programmable controllers. The ECDR can bridge the gap between higher priced programmable controllers and more affordable drivers. Its flexibility means the device can be easily configured for use in specialized applications – not just fan drives and transmissions, but also in more complex control schemes," he added.

"We created an entirely new HF-Impulse configuration environment for the valve drivers," said Chris James, electronics engineering group leader at HydraForce. "The ease and intuitiveness of the output and input configuration blocks, coupled with their ability to create and replicate macros and create libraries, are definitely going to be appreciated by our customers."



ABOVE: **All ECDR valve drivers can be configured easily with HF-Impulse configuration software**

There are several ECDR models available. The ECDR-0201A has one input and two outputs that can drive one or two proportional valves; the ECDR-0203A has three inputs and two outputs; and the ECDR-0506A has six inputs and five outputs. All of these valve drivers have CANbus capability, allowing CANopen and SAE J1939 communication protocols. Input signals drive the output current. ECDR valve drivers can enhance the control of hydraulic proportional valves used for transmission control, vehicle traction control, joystick control, and mobile equipment work functions, such as lifting, lowering and rotating. They can also be used in combination – for example, a larger ECDR-0506A can be used to drive an ECDR-0201A mounted onto a proportional valve.

LEFT: **The six-input, five-output HydraForce ECDR-0506A shown side-by-side with the single-input, dual output ECDR-0201A**

Durable and robust

The ECDR-0506A has a 32-bit processor and six inputs that are capable of various signal types – four analog and two digital. It has five outputs: four are closed-loop and one is open-loop.

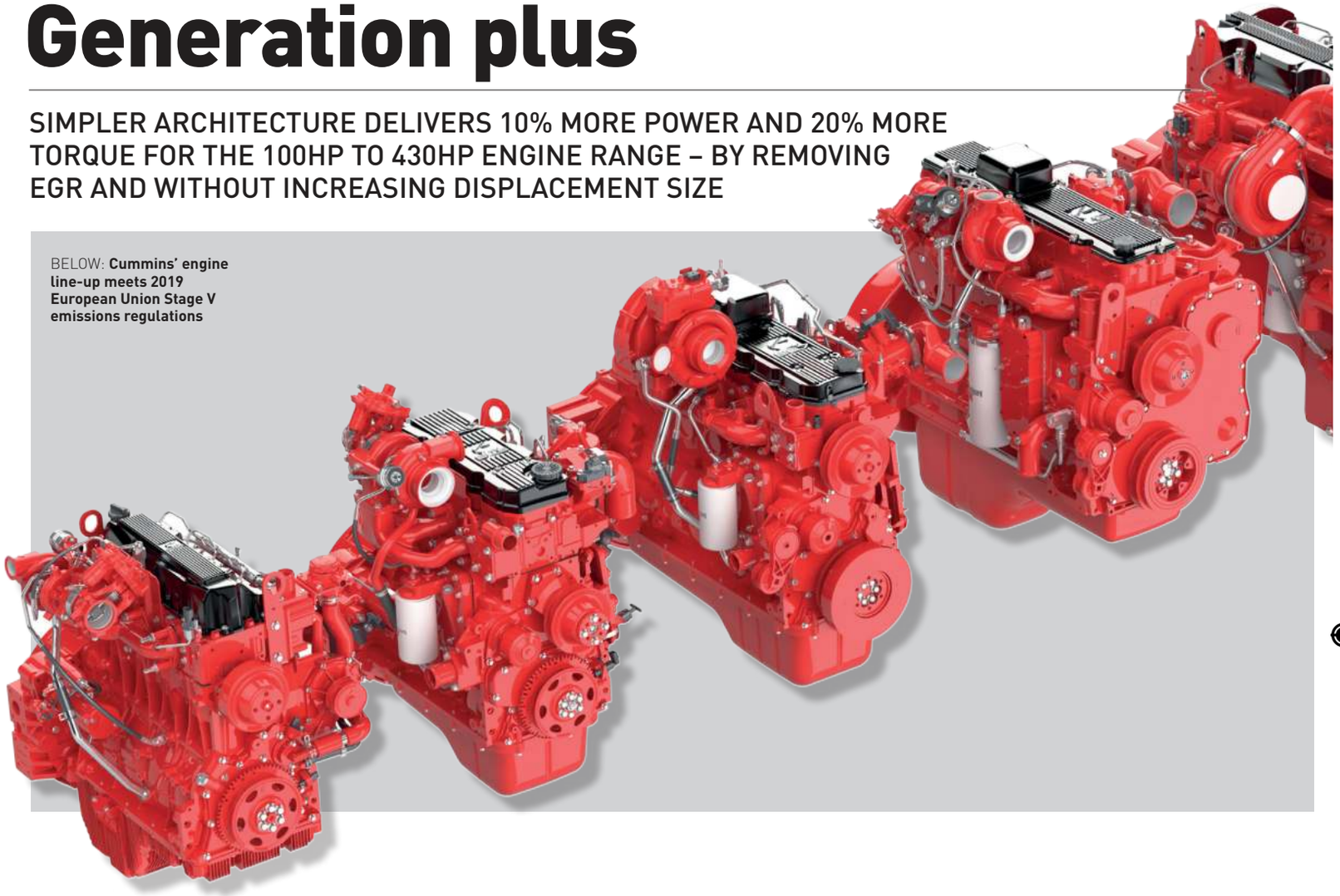
The ECDR-0203A has three inputs that are configurable to multiple settings ranging from digital to analog. Two of the outputs, including one pulse width modulation (PWM) closed-loop output and one PWM open-loop output, have configurable frequency.

The ECDR-0201A proportionally controls one or two coils to a user-defined metering profile. All ECDR valve drivers have an 8-32V DC rating that enables them to handle a range of power, from battery to full voltage. ECDR valve drivers are designed for use in extreme environments and they have an operating temperature range from -40°C to 85°C (-40°F to 185°F). They also have a robust, compact and fully sealed housing that provides protection from moisture and contamination in the environment in which they're used, and Deutsch connectors that qualify for the IP67 environmental rating. **iVT**

Cynthia Mackin Fawcett is a senior technical publications specialist at HydraForce

Generation plus

SIMPLER ARCHITECTURE DELIVERS 10% MORE POWER AND 20% MORE TORQUE FOR THE 100HP TO 430HP ENGINE RANGE – BY REMOVING EGR AND WITHOUT INCREASING DISPLACEMENT SIZE



BELOW: **Cummins' engine line-up meets 2019 European Union Stage V emissions regulations**

Cummins has a new generation of ultra-low-emissions engines spanning from 100 horsepower to 430hp (75-321kW). The EGR-free engine line-up is designed to meet 2019 European Union (EU) Stage V emissions regulations with simpler, EGR-free architecture and single-module aftertreatment technology.

The newly named F3.8, B4.5, B6.7 and L9 engines leap ahead of their Stage IV/Tier 4 Final equivalent engines with over 10% more power and almost 20% more torque averaged across the range.

"Removing exhaust gas recirculation [EGR] allowed us to realize the full potential of the engine for Stage V without increasing displacement size. Our 12-liter engine already pointed the way forward for a successful EGR-free design at Stage IV, so we were able to cascade this simpler approach down through the power range. No EGR also means there is less to cool, which will help lower the cost of OEM integration," says Jim Fier, Cummins' vice president – engineering.

Improvements to fuel efficiency will result in the overall fluid cost of the new Stage V engines reducing by 3% on average, depending on application, compared with those of Stage IV. The engine operating costs will be further reduced with an achievable 1,000-hour oil change interval, twice as long as the current 500 hours.

Stop/start technology

Smarter electronics will bring stop/start technology embedded in the engine management system, offering the potential to realize fuel savings of between 5% and 15%, corresponding to the amount of equipment idle time. Cummins Stage V engines are enabled for wireless connectivity, ready to deliver instant engine diagnostics over the air so that operators can maximize the uptime availability of their equipment.

"Each one of these new engines is intended to set a new benchmark in its class by providing unprecedented levels of performance and will come with the ability to transform the productivity of equipment for Stage V applications," says Fier.

Enhanced performance combined with simplicity is further reflected in the use of a single Cummins turbocharger on the Stage V engine range. The latest high-efficiency wastegate turbocharging is used for the F3.8, B4.5 and L9 engines. The B6.7 retains proven variable-geometry technology, with the Holset VGT achieving exceptional power density with fuel-efficient performance.

Single-module advantage

The Cummins Single Module for Stage V combines DPF, SCR and urea-dosing technologies in one module, providing an up to 50% reduction in envelope size and a 30% reduction in weight

NAOMI BUCKLAND

ABOVE: **Cummins' Single Module is a highly efficient aftertreatment system**

compared with those of Stage IV exhaust aftertreatment.

The Single Module is essentially a fit-and-forget system, capable of removing emissions almost entirely by passive regeneration, with no impact on equipment operation and requiring no operator intervention. The service cleaning interval is expected to extend well beyond the 5,000 hours of today's systems. The modular design of the Single Module allows for varying diameters and lengths, to efficiently match catalyst capacity to the power output of the engine.

The Cummins heavy-duty duo, renamed the X12 and X15 for Stage V applications, will retain the same DPF-SCR aftertreatment system in order to provide ongoing installation continuity for OEMs in higher-output, more specialized machines. With an impressive 512hp (382kW) top rating for the 12-liter and 675hp (503kW) for the 15-liter, the two engines will continue to bring proven, premium performance ideally suited for the toughest duty cycles. The EGR-free X12 lowers heat rejection by over 40% compared with that of engines using cooled EGR.

No torque loss

At the other end of the Stage V engine range, the four-cylinder F3.8 will be available at a 74hp (55kW) rating, allowing the opportunity for machines to downsize their engine installation without any loss of torque performance. The F3.8 will offer the benefit of a highly compact, engine-mounted Cummins DPF without the need for SCR, making that rating particularly suitable for rental equipment.

Cummins Stage V engines come with an inherently high degree of tolerance to sulfur in fuel – up to 5,000 parts per million – removing a major barrier in reaching the goal of a universal engine platform. That offers OEMs the prospect of using the same Cummins Stage V engine in their equipment worldwide, overcoming the complexity of multiple emissions regulations in effect. For each machine, that will bring a common engine installation, with the same electronic integration and mechanical hookups, with or without exhaust aftertreatment, depending on the emissions levels.

While meeting the more stringent Stage V regulations in 2019, the new engines will also be co-certified to meet US Environmental Protection Agency Tier 4 Final and equivalent emissions regulations in Japan and South Korea. That will make the benefits of the EGR-free engines available to OEMs for reducing the complexity involved with powering their global equipment platforms. **iVT**

Naomi Buckland is senior off-highway communications specialist at Cummins

ETIENNE HUSSENOT

Coordinated power

A FULLY INTEGRATED ELECTRIC HYBRID DRIVETRAIN SYSTEM FOR DEMANDING OFF-HIGHWAY APPLICATIONS CUTS EMISSIONS AND OFFERS OEMS A NEW ALTERNATIVE

OEMs looking for low-emissions solutions are starting to turn to a familiar name in off-highway powertrain technology for electric drive components. John Deere – a well-known manufacturer of industrial, marine and generator drive diesel engines, as well as drivetrain and electric components – has designed and implemented a fully integrated electric hybrid drivetrain system for demanding off-highway applications.

The right part

The John Deere electric drive systems portfolio is the result of cooperation between John Deere Electronic Solutions (JDES) and John Deere Power Systems (JDPS). JDES developed a series of rugged inverters using a simple, modular design for flexibility that can be readily integrated in a variety of applications. The inverter's continuous power goes up to 300kVA and nominal voltage to 750V. Also, multiple functions are combined into a single or dual configuration, which saves costs by reducing the number of interfaces, cables and connections. The generator pump drives from JDPS that come in two power ranges, 200kW (268hp) and 400kW (536hp), and the Series Three Speed Electric (STSE) transmission, have accumulated over 250,000 hours in John Deere construction equipment applications. When combined, the product offerings from JDES and JDPS work in conjunction to deliver a complete electric drive system for OEMs exploring new ways to utilize electric power.

"The modular nature of the components in our electric drive product portfolio allows them to be considered for a variety of vehicle forms, including construction, mining and even marine applications," says Darren Almond, global drivetrain business manager at John Deere Power Systems. "This technology opens the door and creates the possibility for many innovative solutions."

Hybrid benefits

Since 2013, John Deere has applied diesel-electric hybrid systems on two of its wheel loaders – the 644K Hybrid and 944K. While the two machines use electric power in different ways, both improve machine performance, thanks to their designs. The conventional drivelines and axles in the 644K Hybrid are powered by an electrically driven 3-speed transmission. An alternate series electric architecture was utilized with the 944K, which uses individual wheel motors and gear boxes at each wheel. This example illustrates how similar applications with comparable functions can use a John Deere electric drivetrain system in varying capacities. Rather than offering a one-size-fits-all solution, the John Deere components can be configured specifically for different applications depending on the needs of the OEM using them.

ABOVE: **The 644K hybrid loader and the new PD400 dual inverter by JDES**

The diesel-electric hybrid systems have revealed numerous benefits, including the ability to easily control the machines, because the constant engine speed ensures full hydraulic power at any operating condition while the demand for traction is independently supported by the electric system. This makes it easy for operators at all skill levels to be more productive. In addition, data collection capabilities enable users to capture important details, such as energy and load usage history, that can be used in the future to improve predictive maintenance programs. The hybrid system is also more fuel efficient than a traditional mechanical and hydraulic drivetrain system in applications that change directions frequently, such as loaders.

More importantly, OEMs are benefiting from the knowledge and extensive experience John Deere has developed in designing efficient, reliable drivetrain systems. John Deere has the ability to provide OEM customers with an integrated electric drive system that can work with their unique machine design in a wide array of applications. The outcome for the OEM is reduced product development time and expense, resulting in a reliable vehicle solution. **iVT**

Etienne Hussenot is a European business development manager at John Deere Electronic Solutions

ANDERS NORDNER

It's a gas (engine)

SCANIA HAS ADDED A GAS-FUELED V8 ENGINE TO ITS RANGE OF POWER GENERATION SOLUTIONS. THE ENGINE FEATURES LOWER CARBON EMISSIONS THAN THE DIESEL VERSION

The latest addition to Scania's wide range of engines for industrial applications is a gas-fueled version of its well-proven 16.4-liter V8 engine. The solution is specifically adapted for single-speed power generation.

Its introduction follows growing global interest in replacing diesel with natural gas and biogas, reducing both carbon dioxide emissions and noise. With natural gas, CO_2 emissions are reduced by as much as 20%; with biogas, reductions can be up to 90%.

"The offering is a part of Scania Engines' sustainability goals," says Andreas Stenemyr, director, product support at Scania Engines. "We see an increased interest in gas engines across the world, specifically in Brazil and Russia. "In São Paulo, for example, the power generators that are used in power plants to handle energy supply shortages must be fueled by gas.

In addition, Stenemyr points out, the engines are a perfect fit for remotely located oil fields where gas is readily available and power is needed. Thanks to Scania's modular system, the gas-fueled engine shares many components with the diesel V8 engine. This gives customers global access to parts, as well as fast, reliable service.

"If trained service technicians are used to Scania engines in general, and V8 engines in particular, they can also work on the gas version," he says. Some components of Scania's basic diesel engine need to be adapted for use with biogas or natural gas. For example, with the combustion chamber, the piston head is shaped differently to reduce the compression ratio to 12.2:1, compared with a compression ratio of between 16:1 and 20:1 for diesel engines. As for the cylinder heads, the diesel injection technology is replaced with spark plugs. There are also modifications to the air inlet system and the fuel injection system.

ABOVE: **Scania's 16.4.litre V8 gas engine**

Field proven

Stenemyr adds that the new engine has also performed well in recent field tests. "It has been running for 500 hours and we haven't experienced any problems," he says.

The engine platform is single-speed, PRP (prime power) with a maximum power output of 364-477 kVA at 1,500-1,800rpm and a displacement of 16.4 liters in the V8 configuration. It is four-stroke, spark ignited, and fueled by natural gas or biogas. Including the cooling package, it measures 2,021 x 1,316 x 1,754mm (L x W x H).

Scania's modular system allows the company's diesel engine to be adapted to a wide range of fuels.

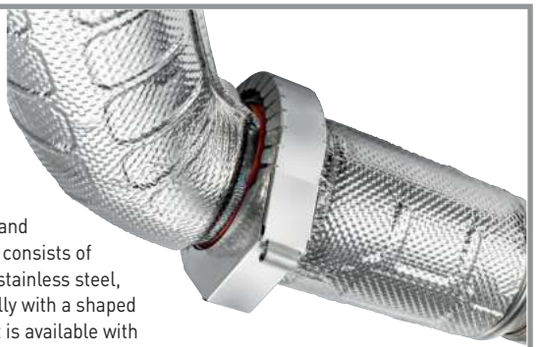
Compression and spark ignition are the two basic principles by which combustion engines operate. In compression engines, the fuel mixture is ignited when extreme compression raises its temperature. Scania's diesel and ethanol engines both work according to this principle.

In contrast, Scania's gas engines rely on spark ignition technology, with a spark plug igniting the fuel mixture and starting the combustion process. Scania offers gas engines for both biogas and natural gas. **iVT**

Anders Nordner is a writer at Scania

BULLETIN BOARD

Thermal protection



Thermamax has developed a new type of insulation system for connection points in engine compartments and exhaust lines.

Many components are normally interconnected to make up a complete system, generally by using metallic V-Band Clamps, but even an otherwise perfectly insulated system can have small gaps at these interfaces, allowing for unwanted and uncontrolled heat loss into the engine compartment. Apart from the temperature loss, there is also a risk that heat-sensitive components in the surrounding space may be damaged by the radiated heat.

Thanks to the newly developed TMax-V-Band Clamp Insulation, Thermamax is able to solve these problems in a safe and highly efficient manner: the complete system can be insulated, without compromise, resulting in increased safety and improved overall efficiency.

The TMax-V-Band Clamp Insulation consists of an outer shell in stainless steel, insulated internally with a shaped insulating liner. It is available with different TMax-insulation-inlays and two different types of fixing systems. In addition to a conventional screwed connection, Thermamax can also provide a new fixing system, TMax-TwistTec, which uses a specially provided ring that is positioned onto the TMax-V-Band Clamp Insulation and winds out to ensure effective insulation at the connection point.

Exhaust aftertreatment is improved using TMax-V-Band Clamp Insulation due to the reduced heat loss providing better operating parameters for the exhaust system.

The robust, stainless steel construction protects the insulation from water spray, radiated heat, and stone impact, and ensures total protection from any leaks in the exhaust system.

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Keep cool and carry on

Kalori's Stop&Kool provides air-conditioning in cabs when the engine is shut down.

One of the aims of the technology is to save engine operating time by reducing the vehicle's depreciation, since it is based on its engine operating hours.

Stop&Kool is suitable for vehicles that experience downtime, where the engine is left on and the driver is in the cab, but the machinery is not being properly used (loaders, for instance). During this time, he can leave the engine on to keep the passenger compartment cool.

When the vehicle engine is turned off, Stop&Kool replaces the engine's compressor with an entirely electric system that is connected to the vehicle's original evaporator.

When the driver is taking a break or waiting, he can initiate the Stop&Kool air-conditioning, which is linked to the air-conditioning circuit with solenoid valves.

The system carries out safety monitoring of the vehicle's battery tension, providing assurance for the driver that his vehicle will restart.

As far as the driver is concerned, the air-conditioning feels the same: the air comes from the original louvers, with a power sufficient to maintain the cab temperature.

Stop&Kool doesn't just save energy; the quiet transition from where the air-conditioning power is generated when the engine is switched off enables the driver to remain comfortable, too.

Stop&Kool installations can be carried out by a dealer or by an air-conditioning specialist.

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Heat up productivity

Dana has announced that its new series of Spicer axles for rough-terrain cranes is nearing production. The new Spicer 245, 246 and 247 heavy-duty steer drive axles cover vehicles with lift capacities ranging from 30-110 metric tons (33-120 tons). This series of axles is part of Dana's complete drivetrain system for rough-terrain cranes.

Dana has supplied transmissions and driveshafts to the crane market by offering axles with superior pick-and-carry, over-end, and over-corner load lift performance. In addition to rough-terrain cranes, these axles can also accommodate aircraft ground-support pushback tractors.

Dana's engineers have decades of experience developing successful rough-terrain crane applications, delivering solutions to keep machines running in demanding environments. On jobs where site preparation is minimal, Dana's drivetrain solutions help to deliver reliable vehicle operation.

Manufactured at the Dana China Technical Center in Wuxi, China, the axles are designed to accommodate Dana's optional Spicer smart suite technology, a platform of fully integrated, connected-vehicle features that converts operating data from the drivetrain into actionable insights. This platform features machine-learning algorithms built into the software to optimize productivity by measuring performance, forecasting maintenance issues, and enabling capabilities such as load monitoring.

Dana will have more information on these new axles, along with a variety of other drivetrain offerings, at Bauma China in Hall N5, Stand 210.

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Total accuracy

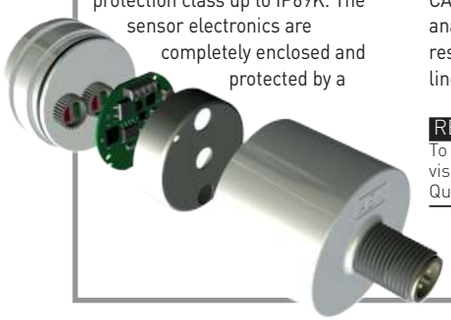
ASM Sensors has launched Posihall, its magnetic multi-turn encoder technology and product line. Posihall technology measures the absolute angular position of a shaft over multiple revolutions by utilizing a gear-coupled multi-hall sensor system that uses a magnetic scale nonius (vernier) principle. In contrast to current encoder technologies, Posihall technology guarantees a reliable measurement – with high levels of shock and vibration and in a temperature range of -40°C to +85°C – by ensuring correct positioning, even in areas where high electromagnetic influences are present.

Posihall sensors can be mounted directly onto the machine's rotation axis and they are available in protection class up to IP69K. The sensor electronics are completely enclosed and protected by a rugged housing. The non-contact magnetic multi-hall technology is able to reliably detect measuring data even if the machine housing is filled with water or oil. The sensor body has an integral shielding against magnetic fields, which works in environments with magnetic field strengths up to 0.5 tesla. Posihall sensors are also available with redundant outputs.

The sensor line is suited for machine applications such as packaging, food processing and mobile working, offshore, or wind and solar energy plants.

The measurement range for the PH36 is up to 31 x 360° revolutions and for the PH58/PH68, up to 255 x 360° revolutions.

Posihall sensors are available with digital (sensor system interface, CANopen and CAN SAE J1939) and analog outputs and they can reach a resolution of 14 bit. The single turn linearity is 0.3%.



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Quote Ref: **510**

Display solutions

Thanks to a rugged design, displays from **Bauser** can withstand environments with high levels of shock and vibration over a wide ambient range.

Bauser offers displays, from 3.5in (320x240) to 7in (1024x600) color transmissive TFT (thin film transistor), with LED backlights between 350cd/m² (3.5in) and 1,000cd/m² (7in) over a lifetime of up to 50,000 hours.

The displays can be incorporated into onto a surface by using a jointed arm. The displays are compatible with CAN J1939 engine data. The optional rotary encoder enables easy setting of a wide variety of machine and accessory equipment parameters.

Standard displays include up to 21 LED warning lamps and up to 26 pins for inputs and outputs, such as analog, digital or frequency inputs, as well as field-effect transistor outputs (switching capacity 24V, 500mA).

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Quote Ref: **511**

Get a grip on the latest innovations

Curtiss-Wright's Industrial Group is a leader in the research, design and manufacture of critical controls and assemblies for specialty on-/off-highway vehicles.

The latest single- or dual-axis JC4000 joystick controller from **Penny & Giles**, a subsidiary company of Curtiss-Wright, has been designed specifically for use in the diverse environments of the aerial work platform (AWP) market, with the company ensuring it achieves an optimal combination of performance and price for both scissor lifts and boom applications.

Three dual-axis gates are available – round, square or plus – while ergonomically designed grips offer users the choice of one or two top switches, as well as a 'person present' lever, meaning that the unit can be operated across a wide variety of machines.

Another innovation is the VPT351, Curtiss-Wright's first ever commercial off-the-shelf valve-position sensor, which offers an optimal combination of performance, safety and cost for OEMs of vehicle hydraulic valves and systems intended for safety-critical applications. It features a measurement range of 0-10mm (±5mm) to 0-25mm (±12.5mm) in 1mm increments and is ideal for off-highway, specialty-vehicle applications including mobile cranes and construction vehicles, which require a feedback system for hydraulically driven mechanisms. Its features also allow system designers to comply with the regulations established in the EN 13849 machinery directive.

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Quote Ref: **512**

World's first 3D-printed excavator debut

A highlight of the new tech experience at ConExpo-Con/Agg 2017 will be the world's first fully functional 3D printed steel excavator. ConExpo-Con/Agg and the co-located IFPE exhibitions have teamed up to bring the excavator, which features fluid power innovations, to the shows.

The 75,000ft² (6,900m²) immersive tech experience is designed as a future-forward showcase of the evolution in materials, machines, systems and software that will spark a revolution in how we build, where we work, and the jobs that we will be working in, in the years to come.

The excavator initiative, known as Project AME (Additive Manufactured Excavator), is a collaboration of trade associations, industry, government and academia working for the past two years: Association of Equipment Manufacturers; National Fluid Power Association; Center for Compact and Efficient Fluid Power; Oak Ridge National Laboratory; and National Science Foundation. The project was supported by DOE's Office of Energy Efficiency and Renewable Energy – Advanced Manufacturing Office.

The joint trade shows are on March 7-11, 2017, in Las Vegas, USA, and considered the global gathering place for the construction, construction materials and fluid power/power transmission/motion control sectors.

Find out more by using the reader inquiry service below, and register early to save time and money, and to get the best hotel rates and availability. Save 40% by registering for the event before January 13.

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Quote Ref: **513**

Heavy-duty Hall effect joysticks

Tecnord's range of JHM joystick controllers has been designed for use in mobile and industrial field applications. The use of Hall effect sensors, which eliminates any contact between moving electrical parts, improves the overall resolution, precision and service life.

The use of a supervised microcontroller implements a Hardware Category 2 according to EN 13849 safety standard.

A complete line of built-in electronic drivers, generating on-off, proportional and CANbus control signals, guarantees the highest controllability of any type of electrohydraulic system.

When coupled with an ergonomic multifunction handle of the 'M' range, up to five proportional axes and nine on-off push buttons can be integrated in the same joystick.

Tecnord's comprehensive portfolio of standard push-button switches, thumbwheels and switches, enables a quick and cost-effective customization to suit any individual applications or request.

As optional features, the joystick can include:

- Integrated PWM driver with electronic directional switches on axes, fully programmable via PC by means of a user-friendly calibration software;
- CANbus interface (CANopen or SAE J1939 protocols available);
- Ratiometric voltage output;
- Capacitive dead man switch;
- Magnetic position detent on the y- or x-axis.

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Quote Ref: **514**

Connector block

Faster continues to offer both quality and reliability in its new block, the 5-Lines, which unifies two hydraulic lines of different dimensions in a single casting, allowing it to decompress both lines while collecting drained oil.

Standard (½in lines) or high-flow attachments (¾in lines) can be connected to the block, and thanks to two adaptors, it also connects to the hydraulic circuit and divides the oil flow between above line, where there are ¾in couplers, and below line, where the ½in couplers are to be found.

Users can connect up to four hydraulic lines to the new 5-Lines block. The positions of the couplers inside the block are not fixed, meaning that a ½in or ¾in cartridge can be placed within the same housing.

The pressure relief system is inside the casting and by simply pushing on one of the two cartridges, the corresponding line is decompressed – therefore making it possible to connect the lines with corresponding quick-release couplings on the attachment. The drained oil can then be collected by the drain line below the main lines, and directed to the oil tank.

The position and the shape of the casting can be customized according to the space available on the skid-steer or compact track loader.

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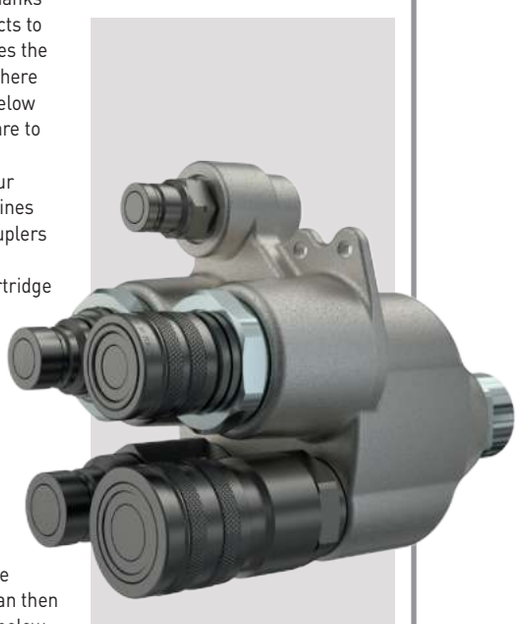

High-performance plating

FOR's portfolio covers a wide range of standard connections that comply with JIC, ORFS, DIN, BSP, NPT and JIS standards. The company provides catalog parts and tailored-made solutions made according to customer demand.

The off-highway market is increasingly demanding clean, reliable products that offer high resistance to corrosion at a very competitive price. FOR achieves this with state-of-the-art machining, high automation, robots, and keeping its facilities immaculately clean.

FOR's production flow, from machining right through to assembly, is performed in-house, including zinc plating. Carrying out this treatment in-house has enabled FOR to be flexible in the process, as well as taking full control of the quality. For instance, the company's zinc-plating plants include a variety of steps in which the components are flushed to remove any contaminant particles.

FOR recently improved the performance of its ISO 9227 salt spray test. The company now uses FeZn 12 IV S plating, with 12µ thickness, chrome passivation, and the latest generation of top sealer, to achieve the highest standard of plating.

FOR has also released a new grease check valve – a niche product that can be used in a range of applications. The valve ensures the idler is greased and can withstand pressure up to 1,000 bar.

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INDEX TO ADVERTISERS

WITH UNDERGROUND EXPLOSIONS STILL ONE OF THE BIGGEST RISKS IN MINING, ELECTRIC VEHICLES ARE ABOUT TO USHER IN A NEW ERA OF SAFETY THAT CANNOT BE IGNORED

There are people in this world who are predisposed to a subterranean lifestyle but, dear reader, your hero is not one of them. Some time back I was invited to see a vehicle working in a mineral mine in the north of England. What I saw was a seemingly sensible human being mounting a machine and reversing it into dark and dangerous tunnel cut into a hillside (I swear not 10cm wider than the truck).

"Do you want to go to the face?" my companion inquired. "It's only a mile or so." I stared at the guy. He was serious; I was claustrophobic. "No, I've seen enough," I said as nonchalantly as I could, and made my way nervously back to my car. As I reached it the machine (now traveling forward) burst from the tunnel laden with some sort of ore. "Yes," said my companion on noticing my interest, "there's not room to swing a cat at the face." Not sure why anyone would want to take a cat into a mine or indeed to try to swing it, I took it that things were tight down there. Miners are, it seems, a little different from many folk.

GASES LIKE HYDROGEN AND METHANE DON'T NEED MUCH EXCUSE TO EXPLODE AND RIP THE MINE AND EVERYONE IN IT TO SHREDS

This encounter set me up well for a further experience some years later that saw me decked out in white overalls and safety gear descending hundreds of meters in a cage to the first level of a gold mine. My apprehension and claustrophobia had not diminished, but my salary had increased, so I got on with it.

Anyone who has been underground will know that emerging from the cage in a modern mine is a bizarre experience. The shafts still run off to the face, but the support facilities, offices, canteens even workshops are all there underground just as they are at the surface. Constant reminders of safety measures and good practice blaze at you from signs. There is a constant clatter of machinery, while the hum from the ventilation shafts reminds you that air must constantly be pumped down here as well as extracted.

Many of the vehicles though, are pretty standard. In the coal mines I have visited, many are still based on an agricultural tractor chassis; fewer are purpose configured from individual components. All, however, have diesel engines, which of course poses problems simply because of emissions. Even so, many mines are in countries where emission controls are in their infancy, and when you consider the amount of dust in the atmosphere at these depths, the particulate counts from diesels is probably the lesser of two evils.

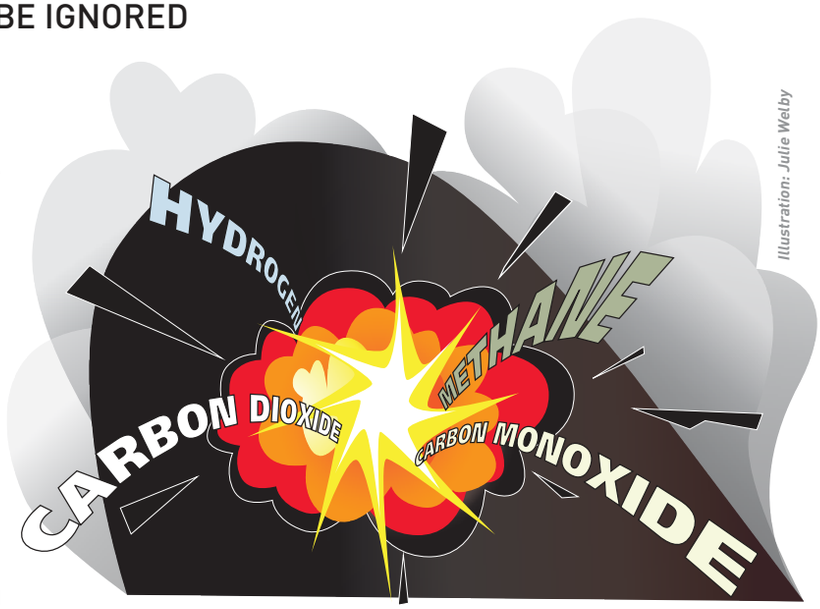

Illustration: Julie Welby

However, these risks pale into insignificance when there is material with any explosive potential. Even dust in suspension can ignite, but by far the most dangerous are the gaseous by-products that coal produces. Pockets of gas are released as the coal is extracted. There are some carbon gases (monoxide and dioxide) but also gases like hydrogen and methane that don't need much excuse to explode and rip the mine and everyone in it to shreds. It happened frequently in the past and it is this factor that spawned the development of the 'flameproof' engines essential to ensure safe diesel operation in underground coal mines. The big engine manufacturers don't produce them. They are modified from standard engines by a handful of OEMs around the world who have made it their mission to provide the specialized equipment that stops miners from blowing themselves to smithereens. Modifications include electrics that are encapsulated, exhausts that run through wet scrubbers and sensors that monitor surface temperatures, ensuring shutdown should anything go awry.

The thing is, flameproofing technology, although sound in principle, has really not moved on for the best part of 60 years. It was developed before there were emission controls and before the quantum leaps that took place in battery technology in the last decade or so. Flameproofers have been dealing with generators, switches and electric motors for years, so now that we have lithium iron phosphate ($LiFePO_4$) batteries, why not ditch the diesel completely? Generators could be on the surface, charging could be spark-free, there would be no fuel at the face level and no harmful particulates to pump to the surface.

I am sure as I write this that many will scoff at the concept. Why bother with the investment? But to make the best of the future, as engineers we have a duty to at least ask these sorts of questions and formulate some practical answers to them, before circumstances force us to do so. **iVT**

Comments: theinsider@ukipme.com

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