SAE INTERNATIONAL

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November/December 2013

AIO'S JOE GREENWELL INTERVIEWED

"OUR JOB... IS TO HELP POTENTIAL INVESTORS"

GEARING UP TO THE FUTURE:

ADVANCED TRANSMISSIONS HELP TO SLASH EMISSIONS

HEADS UP ON 48 VOLTS

THREE TAKES ON HOW TO MAKE THIS A REALITY

Where All the Pieces Fall Into Place

Let's face it; driveline design can be a real brainteaser. Reduced emissions. Improved fuel economy. Enhanced vehicle performance. Getting all the pieces to fit is challenging—especially when you can't see the whole picture. That's why you need one more piece to solve the driveline puzzle.

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Lubrizol

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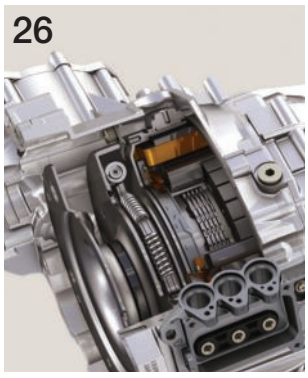

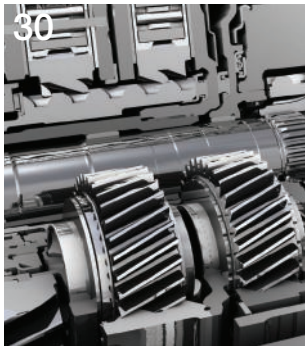

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Patient wait sees powerful revival

Cast your mind back to the mid 1990s and 'The English Patient' was sweeping all before it, winning nine Academy Oscars. So, it was with some irony that the British car industry – and Rover, in particular – was christened 'The English Patient' by its German owners. This was no romantic tale, but a struggle to get the UK car industry back on its feet.

It has taken a long time to achieve that recovery, but, as Joe Greenwell points out in the *Automotive Design* interview starting on page 14, the British car industry is in rude health, with £7.5bn investment pumped into it over the past two years alone.

It is also encouraging to see the likes of Mahindra & Mahindra joining Tata and Nissan to base advanced research and development centres in the UK.

The automotive industry is a vital part of the UK economy, accounting for £59 billion turnover and £12 billion value added. With more than 700,000 jobs dependent on the industry, it accounts for 10% of total UK exports and invests £1.7 billion each year in automotive R&D. The industry plays an important role in the UK's trade balance, with vehicle manufacturers exporting around 80% of production.

More than 30 manufacturers build in excess of 70 models of vehicle in the UK, supported by around 2,500 component providers and some of the world's most skilled engineers.

New car registrations are buoyant as well, with the SMMT trade body forecasting 2.25 million units for 2013.

Elsewhere in this issue, Tony Lewin turns his attention to transmission technologies that will play a key role in meeting emissions legislations, with some OEMs developing 10-speed systems to keep engines in their most frugal sweet spot. That's 18 years since ZF offered the first five-speed auto, so fast has been the rate of development and, given the exponential pace of development, who knows how many ratios there will be in five, never mind 18, years' time?

Ian Adcock, Editor in Chief

Delphi investment looks firmly to the future

Delphi has expanded its advanced diesel and combustion centre in Bascharage, Luxembourg, bringing together specialists in both diesel and petrol injection systems for the first time.

This new research centre is composed of 35 researchers and engineers, a new advanced hydraulic laboratory, optical and combustion single cylinder engines, multi-cylinder engines, a theoretical physics and numerical simulation group.

Noureddine Guerrassi: fresh approach

"Two years ago, Delphi decided to concentrate the diesel advanced teams in Luxembourg, in order to be close to our main customers and universities," said Noureddine Guerrassi, chief engineer, advanced injection and combustion engineering.

"The aim is to conduct interdisciplinary research to define future injection and combustion requirements to support future product development. This research centre will seek to collaborate extensively with customer advanced engineering and worldwide universities to integrate PhD and post-Doctorate research education."

Explained John Fuerst, Delphi's president powertrain systems: "Our total cumulative investment for advanced fuel injection development for gasoline and diesel is about €10 million. In the last two years, we have committed to building a world-class spray and combustion activity here in Luxembourg where we have spent half of that to get where we are now; previously to that, we had invested the other €5 million in the facility over the previous eight years."

Fuerst is confident that diesel has a continuing role to play in future powertrain strategy. "It's our job to see that we make the future legislation," he says, even predicting a growth in uptake in current markets, such as the USA, Brazil and even China where diesel sales are sluggish at best.

New to the Luxembourg facility are the upgraded Optical Morpehus and Hydra development engines

He also revealed that Delphi is working on petrol engine technologies that will provide lean cylinder mixture, still with homogeneous combustion at controlled temperatures, without the traditional NOx that occurs above the 2,500°C. "If we're successful with that technology development, we may be able to overcome the pumping loss disadvantage of petrol and simultaneously avoid the lean burn

New service supports use of advanced steel products

Tata Steel, Europe's second largest steel producer, launched its Total Cost of Ownership (TCO) Scan at this year's Blechexpo, which took place in early November.

In the past, Tata Steel supported OEMs and suppliers with TCO Concept Studies – virtual studies that evaluate how using certain product solutions can offer an optimum balance between performance, light weighting and cost. The new TCO Scans takes this a step further by assessing how a particular Tata Steel advanced product will function in the customer's own production process by using study methods tailored to the specific steel's characteristics.

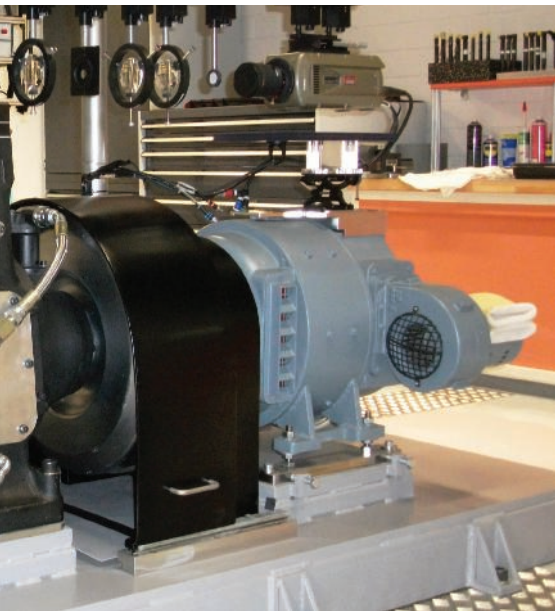
The first new service to be launched is TCO Scan MagiZinc, which targets press-shop efficiency by carrying out live trials on the customer's production lines to calculate the processing benefits of MagiZinc coating, compared to conventional zinc (GI) coating. MagiZinc, claims Tata Steel, can be used in thinner layers, due to its improved corrosion-protection properties, offering weight reduction benefits. It also causes less zinc abrasion, reducing tool pollution and maintenance downtime. The TCO Scan MagiZinc calculates how more efficient the customer's pressing process could be by its use.

Dr Dominik Schwarz, director sales automotive at Tata Steel, said: "With our new TCO Scans, we offer customers the opportunity to measure the individual benefits of our advanced products, in order to balance costs, performance and light weighting for their specific application and processes. We will introduce more TCO Scans shortly, including our DP800 HyperForm, with improved formability characteristics. Work we've done so far demonstrates the potential for vehicle manufacturers and component suppliers to increase competitiveness by meeting their light weighting challenge and, simultaneously, to reduce their processing costs."

Tata Steel's coating and lubricant experts have measured the effect of MagiZinc, compared to traditional galvanized steel, directly in customers' production lines by using the new TCO Scan. First, the surface roughness is measured, in order to indicate galling – the quantity of scraped-off metallic particles that cling to the tool following the pressing of sheet metal. After this, a thermal camera identifies critical tool positions by seeking out areas with high friction and thereby high tool pollution.

Tool pollution is measured at these points by assessing the quantity and size of metallic fragments present, with the levels and composition compared for galvanised steel and MagiZinc.

For a complex component like a tailgate, the TCO Scan has identified a 25 % reduction in tool pollution when MagiZinc is used, leading to a significant increase in up-time and reduced total costs of ownership.



NOx penalty. If we can do that, we can use three-way catalysts with a higher compression ratio and achieve improved fuel consumption that would be on a par with diesel."

New to the Luxembourg facility, having been transferred and upgraded from Delphi's Gillingham, UK, development site, is the Optical Morpheus and Hydra, with the former used primarily for spray characterisation, in terms of vapour, liquid, droplet size. The laboratory engine has a 1.6-litre displacement and, depending on which optical head is used, either 16:1 or 14:1 compression ratio. The lower compression head has a fixed swirl geometry, whereas the 16:1 optical head has a variable swirl geometry, allowing the engineers to look at any engine running speed conditions.

To track the spray characteristics, a high-speed pulse laser is coupled to a camera running at 50kHz, with an exposure time of between 4 to 20 nanoseconds.

Non-combustion work is a primary call on this engine, so, in order to suppress combustion, there's an exhaust gas recirculation (EGR) rig, consisting of an industrial diesel boiler, from which the exhaust gas is drawn. The system is capable of removing all the soot, particulates and moisture out from the gas, if necessary, which then passes through two series of superchargers, delivering 1 to 2 or 2 to 4 bar, to give a 4 bar boost pressure at the engine's intake, with the capability of heating the gas from ambient to 170°C to deliver a total TDC pressure of 120 bar and 900° Kelvin, allowing the engineers to simulate any engine running conditions at TDC.

The second engine is used primarily for combustion work; again, it's a 500cc single cylinder four-stroke, running at a 14:1 compression ratio. It has the capability of taking in burnt gases from 1% to 99%. At the opening, it was set up for two-colour technique to discriminate between the soot luminosity and flame luminosity by using filters that allowed only specific wavelengths to go through the camera. By coupling both engines to high-pressure fuel rigs, it eliminates any discrepancies between scenarios, so the engineers know if any pressure waves are created when looking at the spray formation.

The same pressure waves are created when analysing the combustion process, so the engineers know exactly what they are observing, like for like. The engines also allow Delphi to test injectors from rival suppliers.

Inherently, an optical engine can't be run for every single cycle, so what Delphi does is skip cycles, firing only every 4, 10 cycles, or whatever has been determined; otherwise, the optical system wouldn't last and, moreover, sooting would obscure the optics.

John Fuerst: €10 million investment

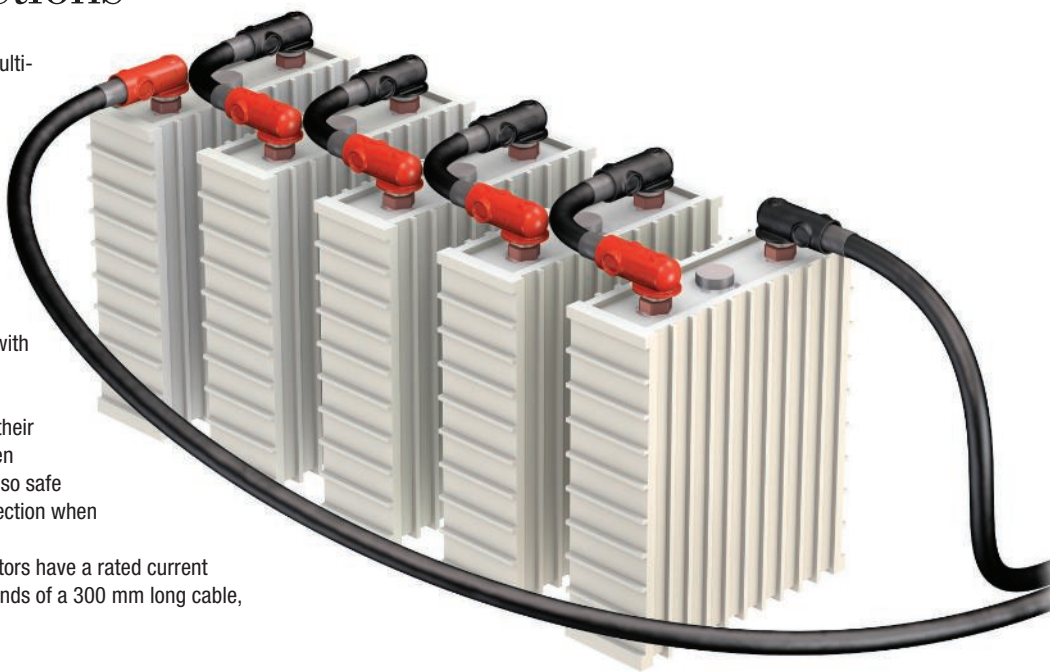
The right connections

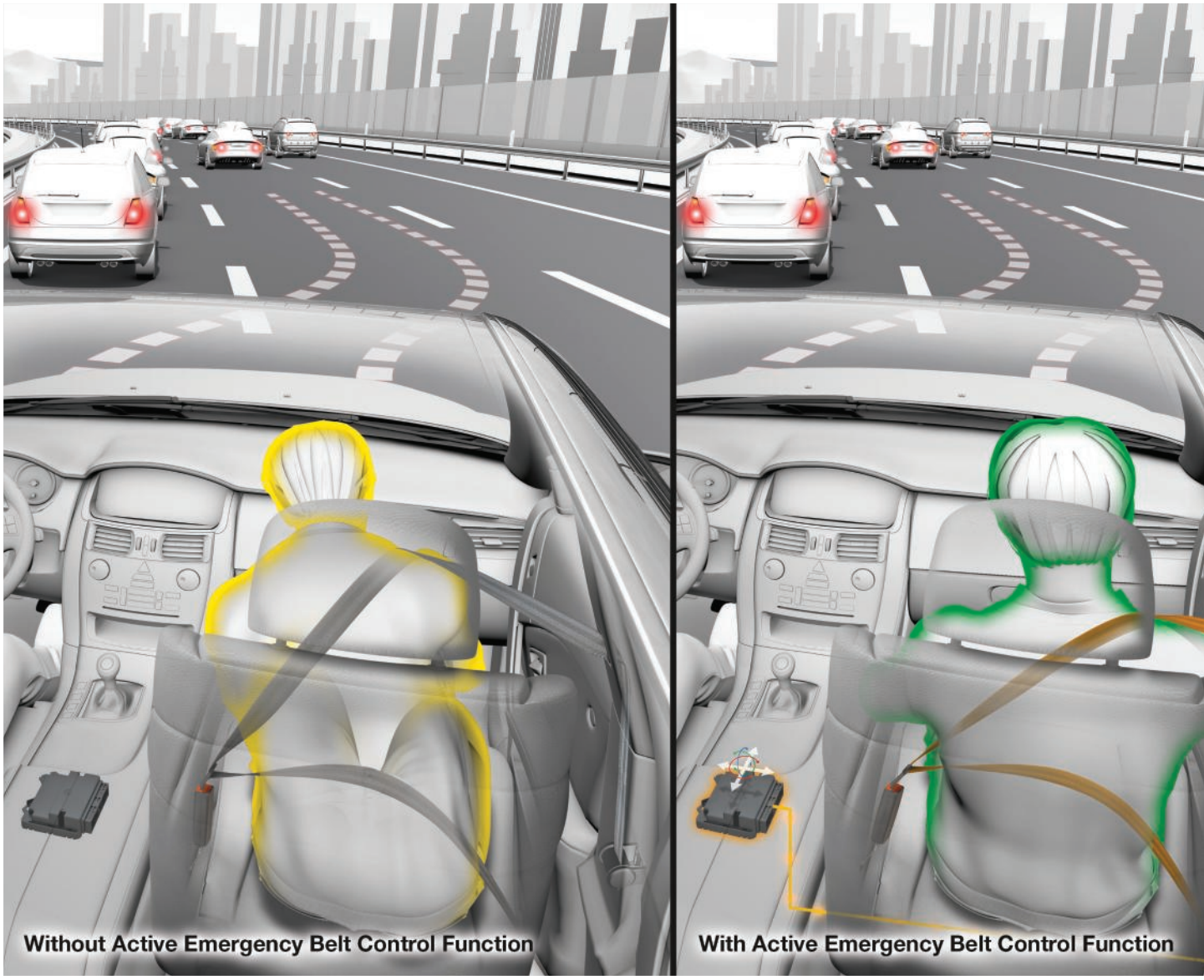
The new BCC battery cable connector from Multi-Contact is said to allow the fast and safe connection of batteries for stationary and mobile applications.

Its high quality design, using silver-plated Multilam technology, ensures low contact resistance throughout the long service life required for low maintenance or maintenance-free battery systems, such as Li-ion battery packs.

A novel rapid locking system, combined with low insertion and removal forces, makes the connectors fast to use, saving time and maintenance costs, says the company, while their compact design saves space, particularly when interconnecting multiple batteries. They are also safe to use, providing IP2X 'finger safe' touch protection when connected.

With a rated voltage of 300 V, the connectors have a rated current 165 A. They are supplied terminated to both ends of a 300 mm long cable, with a 50 mm2 cross-section.





Power MOSFETs – space savings without compromise

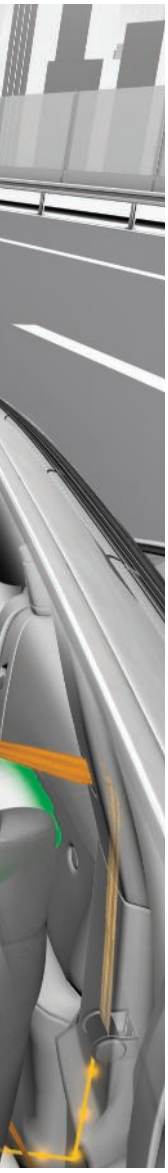
Toshiba Electronics Europe (TEE) has expanded its family of power MOSFETs for automotive applications with three new miniature package formats that will help designers make significant PCB space savings, without compromising performance.

The TPCA8xxx, TPCC8xxx and TPCP8xxx series of MOSFETs offer N-channel and P-channel variants and are provided in SOP Advance, TSON Advance and PS-8 package formats respectively. Respective dimensions are 5mm x 6mm x 0.95mm; 3.3mm x 3.3mm x 0.85mm and 2.8mm x 2.9mm x 0.8mm. All of the new devices are 175°C rated, and feature low on resistance and low input capacitance, leading to low conduction and switching power loss. SOP Advance and TSON Advance packages, according to the company, have bottom-side metal heat slugs to conduct heat better than conventional miniature packages, such as SOP-8, .

Toshiba's SOP-Advance devices are described as ideal for mid-power applications where DPAK devices are conventionally used. TSON advance and PS-8 devices can replace SOP-8 devices and save board space.

The new TPCA8xxx SOP-Advance MOSFETs offer voltage and current ratings up to +60V and 40A for N-channel devices and -60V and -35A for P-channel devices. The TPCC8xxx TSON Advance series features voltages and currents to +60V/-60V and +30/-30A. TPCP8xxx N-channel PS-8 MOSFETs can be supplied as single-channel devices, with ratings to +60V and 10A, or in a dual-channel version, rated to 40V and 5A. P-channel TPCP8xxx MOSFETs are available for voltages and currents up to -60V and -8A.

In addition, Toshiba can supply a PS-8 packaged device that combines a 40V, 5A N-channel MOSFET and a -40V, -4A P-channel MOSFET in the same ultra-miniature package.



Seatbelt to reduce severity of injuries by up to 15%

Continental has developed a new seatbelt that tightens immediately prior to an accident and can reduce the severity of possible injuries by up to 15%.

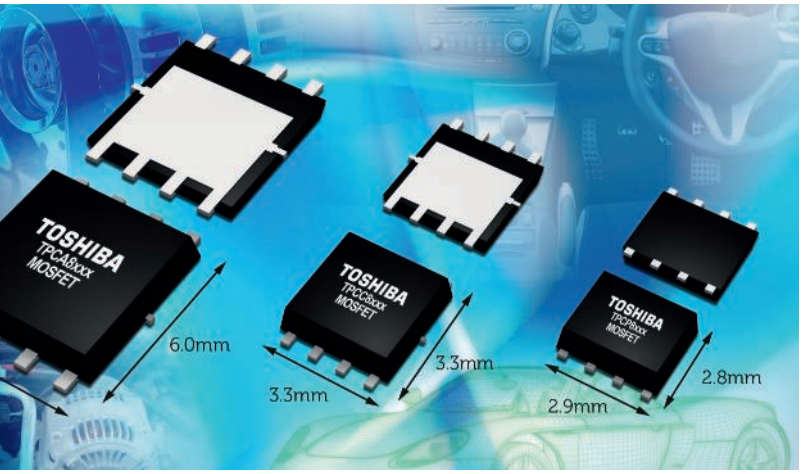
The new ContiGuard function – Active Emergency Belt Control – received the Euro NCAP Advanced Award last year and is already available in two compact cars produced by major German automobile manufacturers.

"Safety systems, like seatbelts and airbags, are fully effective, if occupants happen to be in the optimal seating position before the impact," said Dr Ralf Schnupp, head of the occupant safety and inertial sensors (OSIS) segment of the passive safety and sensorics business unit. "Our new Active Emergency Belt Control function can make this possible by tightening the seatbelts and holding the occupants in that optimal position."

Seatbelt tightening occurs by means of a reversible electro-mechanical belt tensioner. The driving status of the vehicle is analysed in the safety control unit (SCU), with the help of vehicle dynamics sensors and signals from surrounding sensors. As soon as the system detects that the driver is braking heavily; that the car is skidding; that a low-speed accident is about to occur; or that a front-end or rear-end collision is imminent, the Active Emergency Belt Control activates the integrated safety functions prior to impact.

Dynamic road tests demonstrated to what extent early activation of the seatbelt was able to hold an occupant in the optimised position, with the vehicle executing a borderline manoeuvre. Parallel tests were conducted without belt activation as a control. In these cases, the occupant was jolted out of the ideal position. Crash scenarios using an acceleration sled simulated the position of occupants obtained through the driving tests.

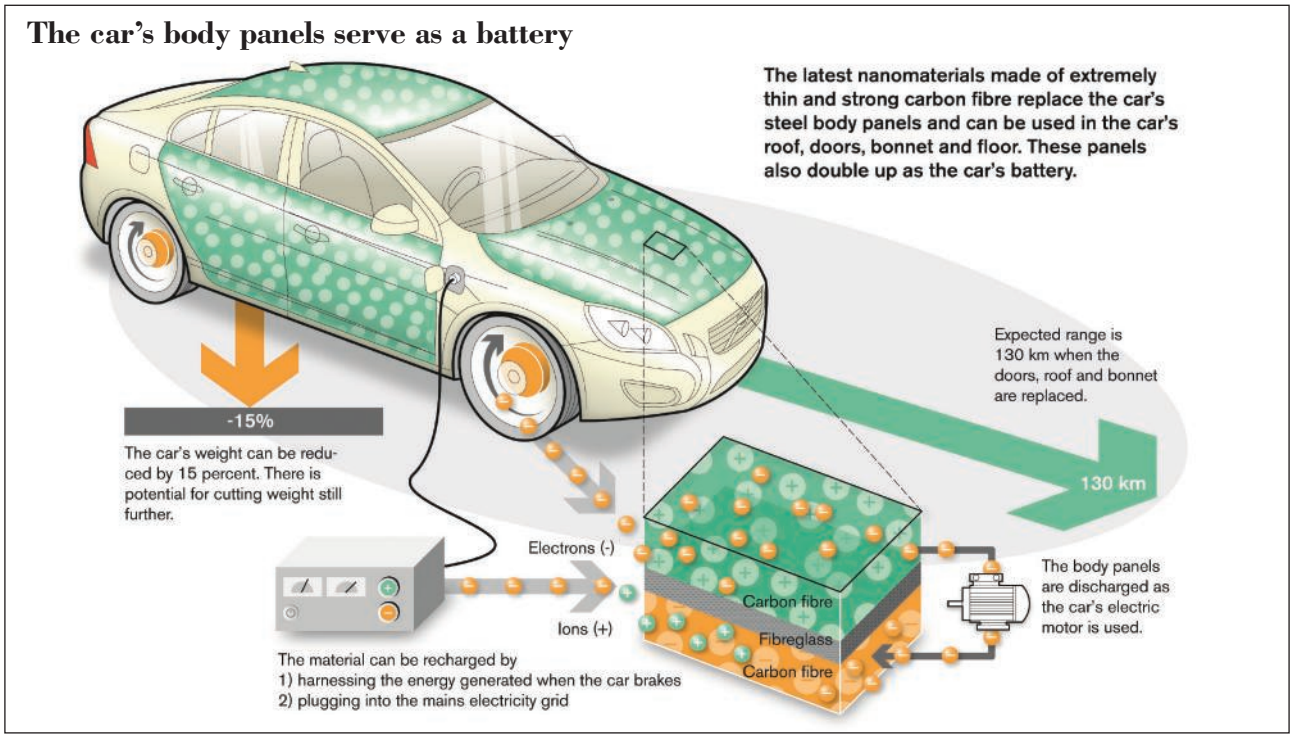
"We were able to observe much less severe injuries, which proved the effectiveness of the Active Emergency Belt Control function," said Dr Gunnar Jürgens, managing director of Continental Safety Engineering.



Revolutionary concept could transform future electrified vehicles

Volvo Car Group has developed a revolutionary concept for lightweight structural energy storage components that could improve the energy usage of future electrified vehicles. As revealed exclusively by Automotive Design in October 2012, the material, consisting of carbon fibres, nano-structured batteries and super capacitors, offers lighter energy storage that requires less space in the car, more cost-effective structure options and is eco-friendly.

As part of an EU-funded research project, including nine other major participants, Volvo Car Group was the only car manufacturer in the project. The project identified a feasible solution to the heavy weight, large size and high costs associated with the batteries seen in hybrids and electric vehicles (EVs), while maintaining the efficient capacity of power and performance. The



TRW appoints new chief operating officer

The current president of Volvo Construction Equipment, Patrick Olney, will assume the role of TRW Automotive chief operating officer from 1 January next year. He will report to John Plant, chairman and chief executive officer, TRW, based in Livonia, Michigan. Olney replaces Steve Lunn, TRW's current chief operating officer, who previously announced his intention to retire at the end of next February.

"Pat Olney is a well-rounded, hands-on, financially astute and globally experienced senior executive, with 18 years' experience in roles of increasing responsibility at Volvo Construction Equipment," commented Plant.

"I am pleased to have an executive with Pat's global experience and successful track record joining our team at TRW. His operating style and laser focus will complement our existing team of talented executives. The overlap between Pat and Steve will ensure a smooth transition and operational continuity."

Freescale selects RealVNC as partner

RealVNC, the global provider of VNC, has been selected by Freescale Semiconductor as a partner for MirrorLink certified in-car connectivity. It is available on Freescale i.MX 5 and i.MX 6 automotive platforms, running on a wide selection of operating systems, including QNX, Windows CE, Android and Linux.

The collaboration helps partners to bring products to market quickly, minimising the development and test time, and ensuring the latest MirrorLink-compliant products are readily available. VNC Automotive is said to allow safe access and control of a mobile device from a vehicle head unit or infotainment system, giving drivers all of their Smartphone content, such as navigation applications, music libraries and internet radio stations, while on the move, and without distraction.

research project, which took place over 3.5 years, is now realised in the form of car panels within a Volvo S80 experimental car.

The answer was found in a combination of carbon fibres and polymer resin, creating a very advanced nanomaterial and structural super capacitors. The reinforced carbon fibres sandwich the new battery, and are moulded and formed to fit around the car's frame, such as the door panels, the boot lid and wheel arch, saving substantial space. The carbon fibre laminate is first layered, shaped and then cured in an oven to set and harden. The super capacitors are integrated within the component skin. This material can then be used around the vehicle, replacing existing components, to store and charge energy.

The material is recharged and energised by the use of brake regeneration or by plugging into a mains electrical grid. It then transfers the energy to the electric motor, which is discharged as it is used around the car.

To date, Volvo has evaluated the technology by creating two components for testing and development: a boot lid and a plenum cover, tested on a Volvo S80. The boot lid is a functioning electrically-powered storage component and has the potential to replace the standard batteries seen in today's cars. Moreover, it is lighter than a standard boot lid.

The new plenum is a strong structural piece that stabilises the car at the front and the start-stop battery. This saves more than 50% in weight and is powerful enough to supply energy to the car's 12v system.

It is believed that the complete substitution of an electric car's existing components with the new material could cut the overall weight by more than 15%.

Johnson Matthey opens new €60m plant expansion

Johnson Matthey has opened a new extension to its European emission control catalyst manufacturing facility in Macedonia. The €60 million plant will provide additional capacity for catalysts to meet the increase in demand from the introduction of tighter emissions legislation coming into effect from January 2014 in the EU. The facility produces catalysts for both light duty and heavy duty diesel applications.

The extended facility in Macedonia will have an additional two manufacturing lines and brings the site's total capacity to around 10 million catalysts. The new plant will predominantly produce SCR (selective catalyst reduction) catalysts used to reduce emissions of oxides of nitrogen (NOx) from diesel engines.

Spread carbon fabrics target high-end market

Chomarat is extending its line of carbon reinforcements with C-Weave SP, a new line of spread carbon fabrics for composite parts with high aesthetic performance requirements, especially for the high-end automotive markets.

C-Weave SP spread carbon fabric is made with 200 g/m² 3K fibres and is available in plain or twill weave. C-Weave SP achieves a 99% spreading rate. At this rate, it is possible to obtain carbon composite parts with a surface layer that is 20% lighter (compared to 245 g/m² 3K fibres), with, it is claimed, impeccable surface quality, and optimised aesthetics, performance and cost. "The spreading technology has been developed internally by Chomarat, who worked on the choice of production processes and quality control, all of which are crucial selection criteria for this type of technically demanding product." said Michel Cognet, Chomarat's group managing director.

News in brief

Chinese JV

Getrag and joint venture partner Jiangling Motors Company Group celebrated the start of dual clutch transmission production in China together with customer Qoros. With the first 6DCT250 off the production line, Getrag (Jiangxi) Transmission successfully completed the last milestone before start of serial production in November. The dual clutch transmission will be applied first in the upcoming Qoros 3.

FRP centre opens

ZF has opened its composites technical centre in Schweinfurt, where it will develop manufacturing processes for the volume production of fibre-reinforced plastics (FRP) products. All group divisions will be able to use this facility, which is also a prerequisite for developing lightweight design concepts for passenger cars and commercial vehicles.

Sensor freedom

Bosch has announced a new sensor that offers six degrees of freedom (6DoF) by measuring acceleration in all three spatial dimensions and yaw rates around all axes. The SMI130 is designed for non-safety-critical applications in vehicles, including in-dash navigation and telematics systems, such as toll, eCall and alarm systems.

Creative thinking

Kevin Rice has rejoined Mazda's European operation as its creative director. The 49-year-old returns to Mazda after a 13-year spell with BMW, where he was responsible for the new 3- and 4-series.

Treading new paths

Researchers from the Fraunhofer Institute for Molecular Biology and Applied Ecology IME are collaborating with Continental researchers in building the first ever pilot system to extract dandelion rubber for making tyres: an important milestone on the path to rubber procurement in Europe.

Dynamic technology

The latest Chevrolet Camaro Z/28 has become the first production car to feature Multimatic's Dynamic Suspensions Spool Valve technology, following its road car debut in the limited edition Aston Martin One-77.Multimatic's spool valve technology has come to dominate Formula One and Le Mans prototypes.

Multiple cameras tackle driver distraction

Visteon is addressing the challenge of driver distraction through a new cockpit concept that uses multiple cameras in the vehicle, in order to keep a constant eye on both the driver and the road ahead.

The new camera-enhanced cockpit concept from Visteon Electronics – designed with input from consumers – uses cameras to automatically enlarge certain driver controls, thus limiting the time needed to operate them and helping prevent potential collisions. The system also recognises the driver, in order to adjust settings, while helping prevent theft.

Visteon's system offers potential improvements over other camera-based systems by providing a simple user interface and through the efficient way in which it could be integrated into the vehicle.

"Auto manufacturers are constantly looking for ways to reduce driver distraction, while enhancing user experiences, and this new cockpit concept addresses both issues," said Anthony Ciatti, electronics innovator. "This solution offers advantages related to user interface, anti-theft and safety to keep the driver focused on road and potential obstacles ahead."

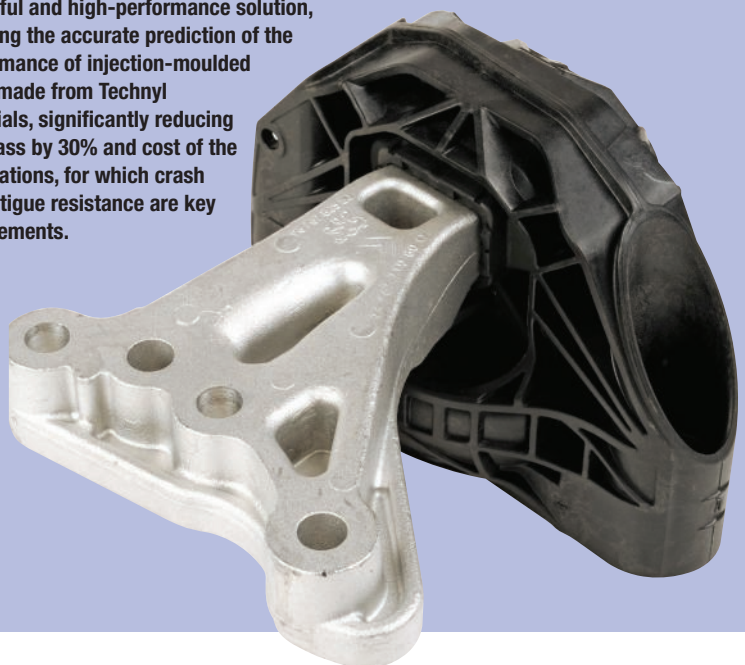
During a recent Visteon consumer research study, 80% of those surveyed reacted positively to Visteon's camera-enhanced cockpit concept, which allows cameras to be integrated into various locations to provide optimal viewing angles. The cameras determine where the driver is looking and – paired with a microprocessor that calculates data from the cameras – can ascertain which centre display panel controls the driver is looking at. Based on this data, the system can automatically and instantly enhance these controls, making them easier to view.

This recognition capability can also be used to automatically adjust controls, such as seat

Smarter approach to thermoplastic engine mounts

Trelleborg's Vibracoustic engine mounts, manufactured using Solvay's MMI Technyl Design, first featured on Peugeot's and Citroen's three-cylinder engines, are now also to be found on a variety of Renault, Nissan and Dacia products.

MMI Technyl Design is an advanced service that Solvay Engineering Plastics offers customers to meet the light-weight challenge. This technological solution is allied with an extremely comprehensive materials database and allows for a wide range of calculations when integrated with injection process modelling. This is described as a powerful and high-performance solution, enabling the accurate prediction of the performance of injection-moulded parts made from Technyl materials, significantly reducing the mass by 30% and cost of the applications, for which crash and fatigue resistance are key requirements.



position and side mirrors. Also, it can help guard against theft by ensuring the vehicle's engine won't start in the event of a break-in – even recording images of the intruder.

The front-facing camera captures obstacles ahead of the vehicle, such as pedestrians and road signs. A microprocessor calculates data from the front-facing camera and the driver cameras to determine the direction in which the driver is looking when pedestrians or important road signs appear – and whether they have been seen. This information can then be relayed to the driver through an audible alert and a visual cue on the instrument cluster.

Visteon Electronics is showing the cockpit concept to various vehicle manufacturers, with the goal of incorporating the technology into future vehicle programmes. "This camera-enhanced cockpit concept is a logical extension of Visteon's expertise in cockpit electronics," Ciatti continued, "and reflects our commitment to help vehicle manufacturers improve the overall driving experience."

The fast route to greater protection

Federal-Mogul has developed a new harness protection sleeve that, it claims, delivers multiple benefits, including abrasion resistance, flexibility and ease of application. Called FastWrap 2305, it features integral adhesive strips for quick installation, and ships in flat packaging to reduce logistics complexity and storage costs.

FastWrap's patent-pending high density weave construction is said to deliver mechanical abrasion protection, while maintaining exceptional flexibility for ease of installation and routing in even the most crowded engine compartment. The fabric, a combination of polyester monofilament and multifilament yarns, is rated up to 150°C and is resistant to all normal engine fluids.

"FastWrap's flat profile provides a significant advantage to customers," explained Cassie Malloy, product development team leader, Federal-Mogul Systems Protection.

FastWrap features two adhesive strips integral to installation, each covered during shipping and storage. The first strip assists the operator by adhering to the wire harness for accurate location of the product.

The operator's hands are then free to wrap the harness and secure the closure with the second adhesive strip, ensuring full protection of the harness, without the need for additional tape or ties.

PREMO has expanded its TP0702CAP family of transponder coils with an improved version, with higher Q and sensitivity specially designed for Tyre Pressure Monitoring Systems (TPMS) applications.

The TP0702UCAP series is offered in five standard values – 2.38mH, 4.91mH, 7.2mH, 9mH and 18.52mH – at a working frequency of 125 kHz, and can be customised with values from 0.34mH-18mH. These antennas offer up to 90mV/A/m sensitivity to give the best sensitivity in this transponder size (8.50mmx2.90mmx2.70mm).

Its NiZn ferrite core offers high surface resistivity (> 10Mohm/mm) and enables highly stable behaviour (better than / +/- 3%) from -40°C to 125°C.

This rugged antenna provides an upper and lateral side protection, with co-polyamide polyhexamethylene polymer walls, gamma radiated with high thermal stability and mechanical resistance. Its surface mount (SMT) allows easy use in manufacturing automated processes.

The new TP0702UCAP is particularly suitable for rugged applications, such as TPMS, which require an excellent performance under extreme conditions, according to AEC-Q200 and additional requirements for EU regulations.

Household electricity demand linked to energy management

Denso and Nagoya University have developed an in-vehicle, battery-based energy management system (EMS) that uses forecasting models of household electricity demand and vehicle use to reduce electricity costs. They started to evaluate the system's performance of the system in October this year under the Toyota city low-carbon society verification project.

The EMS coordinates with batteries used in electric and plug-in hybrid vehicles to use their stored electricity to help reduce electricity bills. The system measures power consumption, the amount of power generated by solar panels, vehicle use, and other household characteristics to construct models for forecasting household electricity demand and vehicle use. Based on these estimates, the system controls the charging and discharging of the in-vehicle battery in real time, reducing the amount of power purchased when the rates are high, while increasing it when the rates are low to save money on electricity.

Batteries used in electric and plug-in hybrid vehicles are frequently connected (when the vehicle is parked) and disconnected (when the vehicle is used) from the EMS. To use these batteries effectively, there are issues to be resolved, including accurately predicting the times of the day when the vehicle is parked, and optimally controlling battery charging and discharging, depending on the household electric power demand.

UK plc? It's the

Ask Joe Greenwell where is the best location for global car makers and suppliers to be based to grow their businesses, research and development, and he has no hesitation in responding: the UK. Now he is out to persuade the rest of the world, writes Ian Adcock. Photographs: Donald Maclellan

Joe Greenwell is a man on a mission. As chief executive officer of the Automotive Investment Organisation (AIO) – former chairman of Ford of Britain and, previously, the chairman and CEO of Jaguar Land Rover – he is out to persuade global car makers and suppliers that UK plc is the place to be when they want to expand their manufacturing facilities and, especially, grow research and development capabilities.

The day before this interview, Indian car maker Mahindra & Mahindra announced plans to build a high-end engineering and design centre in the UK to fast track development not only of new vehicles, but also more efficient engines and advanced power train technologies that will be vital, if the Indian OEM is to achieve its ambitions to become a global automotive player.

Clearly, Greenwell knew more about the deal than a gagging non-disclosure agreement (NDA) would allow him to say. However, he stressed: "Mahindra & Mahindra is really important, because it advertises the UK as a real global centre of excellence in design, engineering,

only place to be!

advanced technology and R&D investment. It suggests that there's a gathering global recognition of a business environment that's stable, favourable, positive, and with the expertise, capability and a desire to be world leading. R&D centres grow in job numbers and facilities, and it sends a strong signal to the Indian industry and others, so I can get my foot in the door."

This is just the latest in a stream of investments that has seen £6bn of private investment pumped into new facilities by OEMs in the past two years and a further £1.5bn from the supply chain. No doubt, Mahindra & Mahindra was encouraged by the joint industry-government initiative to fund a £1bn Advanced Propulsion Centre (APC) over the next decade, with backing from 27 businesses, including from the supply chain. "It will be a world-leading centre of excellence," says Greenwell, "that will attract those from the supply chain who are interested in advanced powertrain and low carbon emissions."

Although its location has yet to be decided, Greenwell explains: "There will be bricks and mortar, virtual links; there will be a hub and spoke, acting as a magnet for technological developments from wherever in the global automotive industry."

Greenwell is the first to admit that, while OEMs such as Honda, Toyota, Nissan, BMW, Jaguar Land Rover, Bentley and Rolls-Royce have been heavily investing in vehicle manufacturing, not forgetting Ford with its engine production plants, the same cannot be said of the supply chain. "Given that UK vehicles have only 30-35% local content, versus 65% in Germany, there is the opportunity to close that gap.

"We have identified that UK OEMs are interested in £3 billion worth of commodities they want to source locally," he points out.

It's no small task: the target that has been set is 15,000 jobs in three years – many of which Greenwell classifies as "high value" – and to increase the 149 project wins since 2010 to 182 in the same time frame.

Joe Greenwell

CV

Joe Greenwell has had an extensive career in the automotive industry and previously held the position of chairman, Ford of Britain. He was formerly the chairman and CEO of Jaguar and Land Rover, where he was responsible for overseeing sales and production expansion at Land Rover and setting in train necessary structural changes at Jaguar. He has also held a number of global marketing and operations positions at Ford's world headquarters in the USA.
Greenwell is a member of the UK's Automotive Council and was president of the UK automotive industry's trade organisation, the Society of Motor Manufacturers and Traders (SMMT). He was awarded the CBE for services to the automotive industry in the Queen's Birthday Honours list in 2011.
He is the chief executive of the Automotive Investment Organisation (AIO) and chairman of the RAC Foundation.

Having recently visited Delphi's expanded diesel technology centre in Luxembourg (see pages 6 and 7) that has relocated some expertise from its Gillingham facility, I put it to Greenwell that this is an uphill battle he is waging. "I am not going to suggest there isn't two-way traffic here. That's exactly the challenge we're facing and the point where this strategy comes in. Within that, there's a frank recognition of what's important to us, so we can keep as much as we can and add even more."

So, what is the compelling narrative that, as the AIO's chief sales man, Greenwell can deliver to persuade suppliers to choose the UK over alternatives, such as the mid-European nations, the Far East, India and China? "There's government policy and a political consensus across the parties around the significance of engineering and manufacturing that puts it at the core of the economy, which is in complete contrast to 10 years ago when there was a real policy divide and you couldn't mention industrial policy in some polite company.

"I think we [the UK] punch above our weight. It's a very heterogeneous industry, in terms of mass market and premium, powertrain, and a unique skill set in Formula One and motorsport in general."

Greenwell explains that it's not "illogical" to assume the supply chain will follow the OEMs, but warns: "There's so much competition for inward investment from the USA, Germany, France, Italy etc that we need to be proactive." To this end, his team organises what he describes as "speed dating" events for the industry at the Oval and Goodwood, in which a 100 or so interested parties get to know each other,

"From those meetings have come some serious discussions. NDAs prevent me saying more, but there is a market," he insists, "and it boils down to explaining what's going on in the UK at national and local levels, and then looking in detail at the competitiveness issues that relate to that supplier, commodity and customer, and trying to help achieve a successful outcome. At the same time, following a presentation at the last IAA in Frankfurt, we have had 26 conversations we are pursuing right now about potential investment."

Greenwell and his team are also targeting Detroit, from where he had just returned; Japan; Automechanika in China; and, next year, Korea and elsewhere. This is a worldwide sales pitch he is undertaking, but can the UK compete with the financial incentives being offered by rivals? Greenwell is confident that it can not only match, but exceed them in some instances, as he explains: "Our job at the AIO is to help potential investors make sense of all the national, regional and city grants that are available – from reduced business rates relief right through to seed funding and grants.

"In addition to that, when finance directors are calculating the costs, they can take into consideration R&D credits, the patent box where you get an effective 10% tax rate for an invention, rather than corporation tax. In addition, the UK has, at 18.4%, the most competitive tax regime amongst the larger European economies.

"Major announcements from OEMs make people sit up and think: 'There's something happening in the UK automotive sector; their market is quite buoyant, compared to Europe, and they don't' seem to be distracted as an economy by the same challenges the Eurozone has.'

"I can add other factors to the equation: 2% wage inflation, lower labour costs than Germany, France or Italy. The English language is a great asset, and the commercial and legal system is both stable and used by many companies around the world as it is," he states.

And despite the best recent efforts of Unite to disrupt the Grangemouth refinery, returning British labour relations to the bad, dark days of the 1970s and '80s, sense prevailed, underscoring the industrial harmony that exists in UK manufacturing.

If there is one area where the UK might lag behind, it's in developing the necessary skills base, but that, says Greenwell, is being tackled aggressively at all stages – from schools right through to postgraduate level: "At level 2 or 3, there has been a fantastic amount of work done on apprenticeships, for example. But, if you talk to any of the OEMs, one of their primary concerns is skills, and the ready availability of technically qualified individuals and technically experienced leaders and managers.

"There is a sector-wide strategy, starting with internships, traineeships, apprenticeships, higher apprenticeships, undergraduates, graduates, post-doctoral and continuous professional development. There is a skills deficit, and we have work to do in some areas and in automotive. That does apply in any science, technology, engineering and mathematics (STEM) related area where we have to uprate the overall skills capability of our sector. This is going to take time and a connection with the education system.

"At a national policy level, there is a strong refocus on maths and science, in terms of future economy and growth, and a recognition that we're competing with other countries.

"There's a consistent effort in education to improve performance in STEM related areas, a greater take-up in engineering apprenticeships and a realisation that we need more girls in engineering.

"Again, it's work in progress; 30 years ago, manufacturing was more than 30% of GDP. Today, it's 12%. You don't turn that round overnight.

"I am committed to trying to encourage young people that there's a basic level of competence in literacy and maths you need to reach. There's an acceptance that we have not marketed the reality of careers in engineering in our sector. It will take time to flow through and we need to accelerate the process to maintain our competitiveness. Don't forget that, at the highest level, we have four of the top 10 academic institutions in the world in the UK, and our engineering capability, at Warwick, Imperial, Cranfield, Loughborough et al, is respected globally.

"We do need to go out and strut our stuff; we have rather hid our light under a bushel," he concludes. "Shame on us, if we don't get out there and talk ourselves up a bit."

"I think we [the UK] punch above our weight. It's a very heterogeneous industry, in terms of mass market and premium, powertrain, and a unique skill set in Formula One and motorsport in general."
— *Joe Greenwell*

TIME FOR A RETHINK

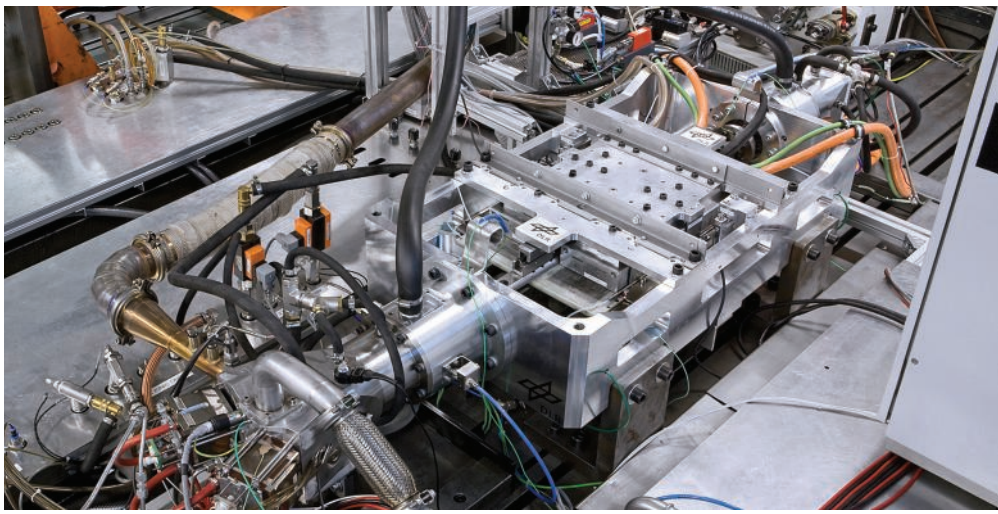
A free-piston IC generator has been developed for range-extended hybrids. Steven Ashley looks at the implications

Despite the best efforts of industry, the market for electric vehicles (EV) is still hampered by inadequate battery range and a dearth of recharging services. To get around 'range anxiety' and infrastructure issues, automakers resorted to adding a petrol engine range-assist, first building parallel hybrids, such as the Toyota Prius, which drive the wheels with both power plants.

Increasingly, however, series hybrids, such as the Chevrolet Volt, Cadillac ELR and BMW i3, are hitting the road. These range extender-type hybrids power an electric tractor motor solely with a petrol-fuelled generator set.

A research team working at the German Aerospace Center (DLR, or Deutsches Zentrum für Luft- und Raumfahrt) in Stuttgart has developed a new kind of EV range-extender concept that could be efficient, quiet and compatible with many fuels. If successful, the device could also be used as an auxiliary power unit in aircraft or in decentralised combined heat and power plants (CHP).

The DLR's 8kW prototype is a free-piston linear (or 'crankless') generator. It comprises three main components: an internal combustion chamber, a linear alternator and an adjustable gas spring. After a fuel-air mixture is ignited in the combustion chamber, the expansion pushes a piston-driven magnet through linear-generator coils, inducing electricity. Then a spring decelerates and rebounds the piston for the compression stroke, which generates more electricity, explains Florian Kock, research associate at the DLR's Institute of Vehicle Concepts. (www.youtube.com/watch?v=sDqmXgIFIkg)

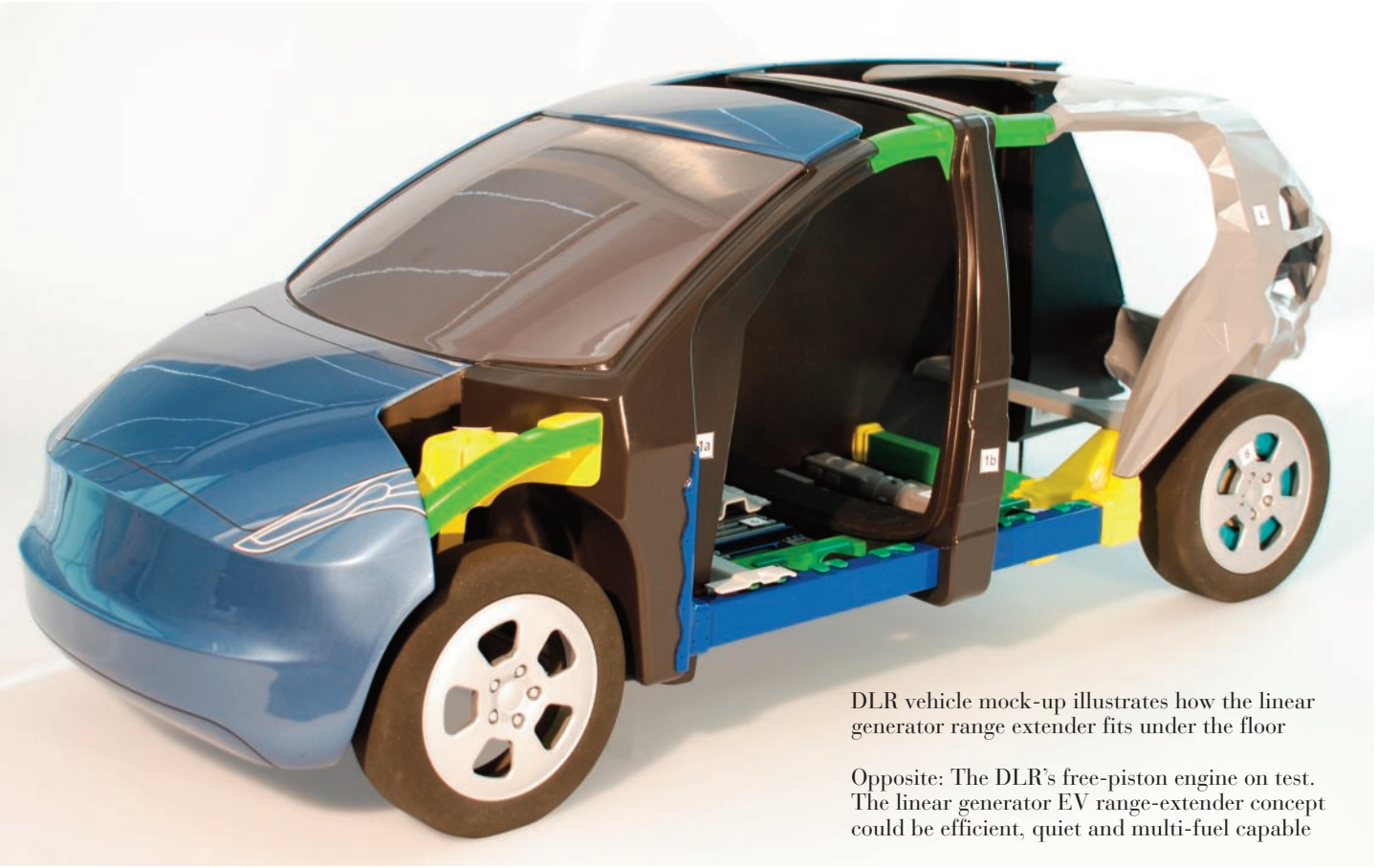


SHUTTLECOCK GENERATOR

Free-piston engines have variable compression ratios, which enable optimised operations under all conditions, as well as multi-fuel capability—from gasoline, diesel and natural gas, through to ethanol or hydrogen, he adds. The DLR engine's simple design has few moving parts, providing for a compact unit, with low maintenance costs and reduced frictional losses. In particular, the free-piston design avoids the extra complexity of the traditional rotating crankshaft, which, Kock says, provides additional operational flexibility, such as the ability to adjust stroke length and compression ratio.

"Engineers have been aware of the principle of this drive unit for some time," notes Ulrich Wagner, DLR director of energy and transport. The concept of combining the free-piston engine and the linear generator, which dates back to the late 1950s, has been revived by several research groups in recent years for use in hybrids.

"Through the installation of a gas spring," states Wagner, "DLR researchers have now succeeded, for the first time, in operating this system in a stable manner. The challenge here



DLR vehicle mock-up illustrates how the linear generator range extender fits under the floor

Opposite: The DLR's free-piston engine on test. The linear generator EV range-extender concept could be efficient, quiet and multi-fuel capable

was to develop a particularly powerful mechanism with a highly dynamic control unit that regulates the complex interactions between the individual components."

Although linear motors aren't new, "the technology has never been a great success", Kock explains, one reason being "that control is very difficult, because one combustion event is not as good as the next one; there are always fluctuations in the process".

When a combustion event does not burn to full completion, it cannot provide sufficient compression for the next burn. This cycle-to-cycle variation propagates through the system and is difficult to maintain in a steady and stable condition.

SINGLE CHAMBER APPROACH

Work on the linear generator concept at DLR started in 2002 with simulation studies. "Our team brought two new things to the problem. Much more computing power – 10,000 calculations per second – and a different design. Instead of two combustion chambers, we use one, which simplifies matters," explains Koch.

The explosion of a fuel-air mix in a centre combustion chamber drives the pistons on either side towards gas springs, which decelerate the pistons and push them back. The opposing synchronised pistons minimise noise and vibration.

In the single-piston laboratory bench unit, adaptive control is provided by a powerful software algorithm that does an energy calculation for each combustion cycle – from beginning of cycle to the end of combustion – in real time.

"Its goal is to extract the same amount of energy from every cycle," Kock points out.

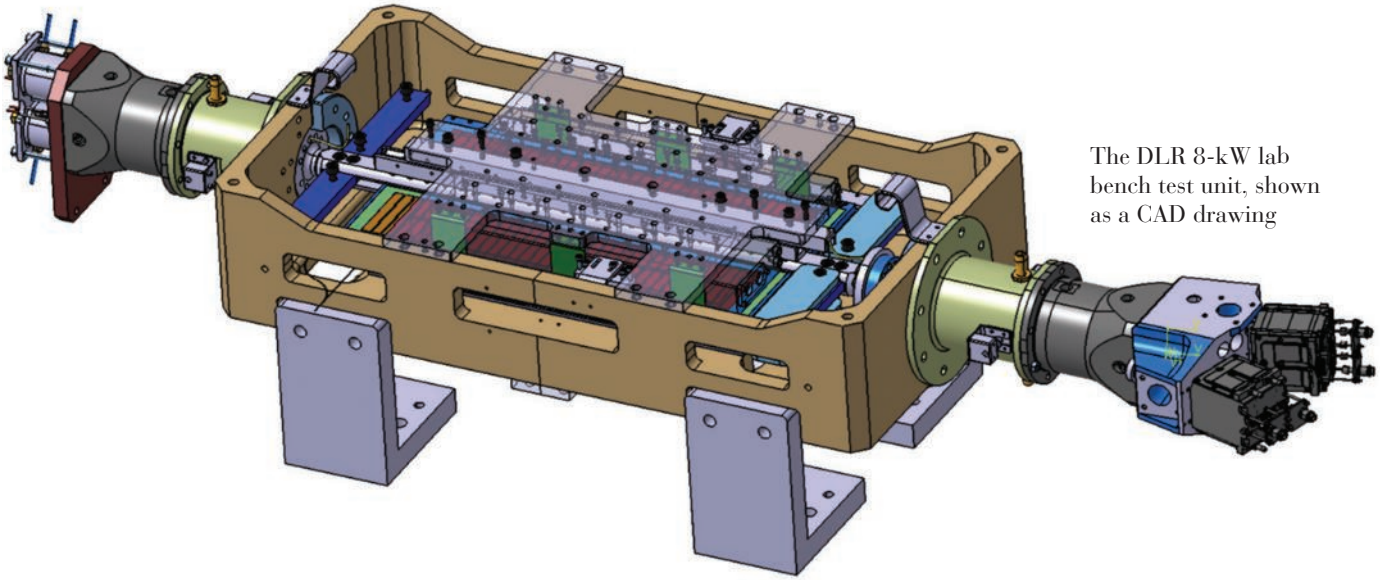
Sensors monitor piston travel, pressure and temperature, which enables the controller to control and balance the chemical energy stored in the fuel, the kinetic energy of the piston, the induction energy of the coils and the potential energy in the springs to provide steady operation. Managing the three interdependent subsystems provides the biggest challenge.

CONTROL FLEXIBILITY

The system created can accurately control the piston movement to within a tenth of a millimetre, while recognising fluctuations in the combustion process and compensating for them. It also allows flexible adjustment of the compression ratio, piston speed and cubic capacity. The engine is thought to be highly suitable for HCCI (homogeneous charge combustion ignition) operation as well.

"We adjust the physics of the combustion event for dynamic downsizing," Kock continues. To operate at part load, for instance, the controls alter the compression ratio or shorten the piston stroke.

"If you need to reduce power rapidly, you increase the force in the linear generator. If you want a slower



The DLR 8-kW lab bench test unit, shown as a CAD drawing

adjustment, you increase the pressure in the gas spring." The current demonstrator is rated at 8kW, but "we're now working to get it to 12 kW," he says. It currently operates at about 20 Hz. The DLR group believes that a 35kW unit would make sense for a car. The device would run at a frequency of 40 to 50 Hz. Its flat, low-profile design could allow one or more units to be installed in the underbody area of a vehicle, potentially providing an additional range of as much as 600Kms, without raising the vehicle weight. One 26kW design, for example, has nominal dimensions of 97 x 23 x 14cms.

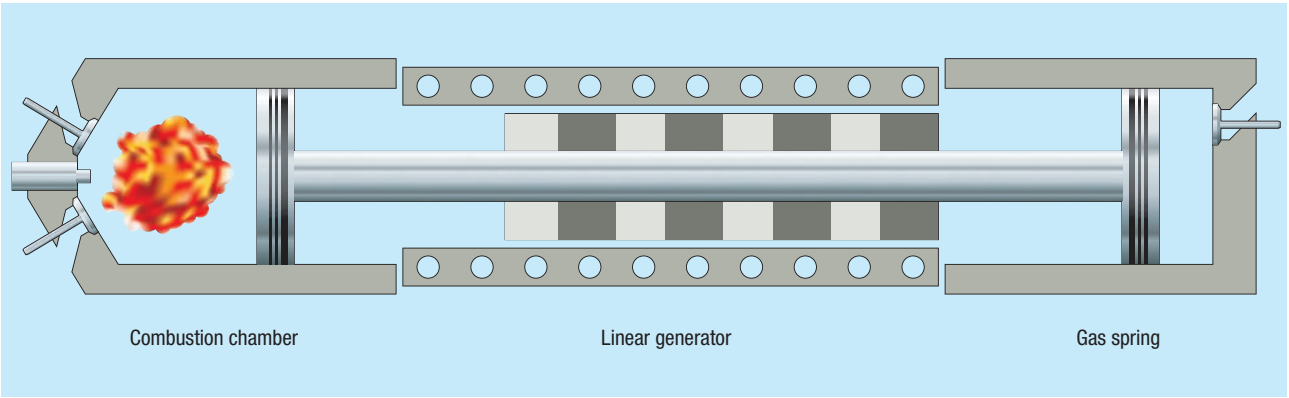
REMAINING HURDLES

Kock concedes that a list of unresolved issues remains to be addressed. "First, it's too large, and needs redesign and downsizing." Also, with the single chamber, "there is no space for a cylinder head with valves, so we're using scavenger ports—small holes in cylinder like a cheap two-stroke engine which have poor emissions".

The team, he reveals, is working on alternative delivery systems and zero lubrication operation: "Maybe a carbon piston and piston rings, or some other approach." They expect that the additional degrees of freedom with compression ratio and stroke will allow them to compensate for the scavenging process.

Besides developing the general design of the system, the team aims to increase the operating frequency from 20 to 50 Hz on the production version, because power density goes up with frequency. "But gas exchange is easy at 20 Hz and a lot tougher at 50 Hz. Plus, we'll need the controls to be able to act faster," Kock observes.

The DLR researchers are partnering with the lab's first commercial spin-off firm, Universal Motor Corp GmbH, to develop the technology and build a prototype vehicle unit. To accomplish this, DLR has concluded a technology transfer contract with Universal Motor and will provide scientific support during further work. Ultimately, they hope that the free-piston linear range extender will be a bridging technology for car buyers who are now ready to buy an EV, but thus far have been hesitant to plug in all the way.



Kevin Jost, The Columnist
SAE International Editorial Director

Efficiency innovations

In the past four decades or so, since emissions and fuel-economy regulations were first enacted, automakers have made huge strides in slashing emissions and fuel consumption, even as they were faced with the mass-adding demands of more stringent safety regulations and increasing consumer expectations for improved comfort and convenience features.

The challenge is now more formidable, as European CO2, US CAFE and California ZEV regulations will call for even further fleet reductions in emissions and fuel economy simultaneously. Since governments are mandating the improvements, it is only reasonable that they are helping advance the necessary technologies. There are many government-funded R&D efforts around the world to progress this.

One example was an October announcement that the US Department of Energy's (DOE's) Pacific Northwest National Laboratory (PNNL) has received $1.1 million (€800,000), aimed at reducing vehicle fuel consumption and emissions through three new efforts, part of a suite of 38 new projects around the US.

George Muntean, director of transportation programs, is heading the PNNL team doing the research. He discusses this and related transportation issues in a recent video at https://www.youtube.com/watch?v=0qwA4_mq-8Y#t=36. In one of the projects, PNNL scientists are looking to make lightweight magnesium parts more easily for use in cars and trucks. They are analysing alloys, so that manufacturing processes can be controlled more precisely for widespread use.

Another PNNL team is aiming to develop a new type of lubricant that reduces wear and boosts fuel efficiency beyond conventional lubricants. "The great news here is that a new lubricant could be used in older vehicles," says Muntean. "Even if we can save just a little bit of fuel for each vehicle, there are a whole lot of vehicles out there already that could be equipped with a new lubricant relatively easily."

In the third project, led by Ford Motor Co, PNNL scientists will perform computer modelling to help engineers better understand how to weld different materials together. This is becoming more important as automakers pursue more multi-material lightweighting strategies, involving steel, aluminium, magnesium and other materials.

In October, Volkswagen began selling an EV (electric vehicle) called the e-Up, with a consumption of 11.7 kW·h/100 km. The car features a number of innovative solutions that transform the already efficient conventionally powered e-Up production car into a more economical EV. The pioneering efficiency of the e-Up is attributable to a very good 0.308 Cd value for a car of its size, optimised tyre rolling resistance, highly effective regenerative braking and a particularly efficient air-conditioning system.

As technology partners to the automakers, industry suppliers have played a big role in making many of these, and other fuel-consumption and emissions reduction advances, possible. One new example hails from GKN Driveline. The company has developed a unique 'disconnect' all-wheel drive system for the 2014 Range Rover Evoque that is designed to improve fuel efficiency, while providing enhanced off-road performance. The Active Driveline reacts to the driving environment and driver intention by automatically disconnecting the major rotating driveline components to reduce energy losses.

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ONE CHAMP, TWO

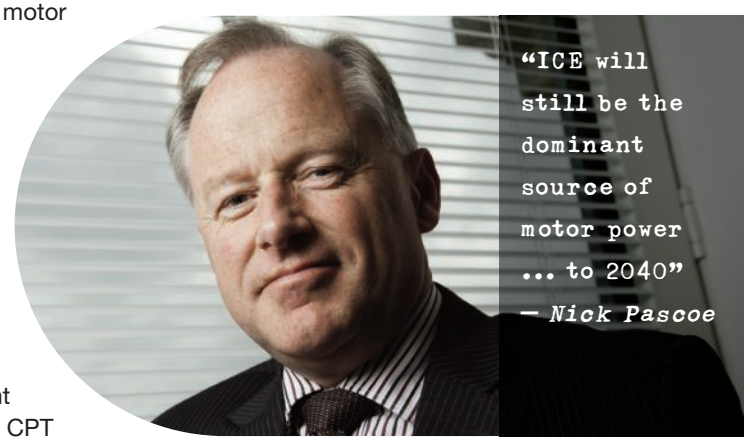
Breakthrough battery technology and electric power assist are the key factors that will accelerate the transition to 48 volts, says Ian Adcock

Despite all the attention being paid to electric vehicles (EVs) and advanced fuel cell powertrains, it is becoming increasingly obvious that, while these two alternatives to the internal combustion engine (ICE) will play a role in future transportation, in both cases it is going to be later, rather than sooner. Control Power Technologies' CEO Nick Pascoe echoes what Prof Dr Thomas Weber, member of the board of management Daimler, and responsible for group research and Mercedes-Benz cars development, said in the last issue of *Automotive Design* – namely that the internal combustion engine has a lot of life left in it and that its imminent demise has been greatly exaggerated by some.

"I agree that EVs and fuel cells will be major players in the future," says Pascoe, "but the ICE will still be the dominant source of motor power and continue growing to 2040, and only then will it start to decline.

"EVs will grow slightly from 2020, with fuel cells a further decade on before they're economically viable." Of course, you could argue that Pascoe might well say that, given that CPT has a suite of technologies designed to maximise the ICE's efficiency. But there is logic to his argument, in that battery costs are not coming down at the pace people thought they would and, in any case, electrification isn't a step-change, but "a continuum from no electrification to full electrification".

The lowest cost means of achieving better fuel economy is to downsize the engine. Down speeding



CONTENDERS

is an intermediary route, but downsizing gives the best CO_2 benefit. "Then," says Pascoe, "the issue is driveability, and hybridisation is being redefined as being more about driveability and controlability than about driving the wheels."

With existing 12 volt systems, there is already a degree of 'hybridisation', with electric power steering pumps, cooling fans, water and oil pumps and air-conditioning either already electrified or will be over the next few years.

However, vehicle energy demands are climbing and premium vehicles struggle especially to live with the electrical supply that comes from a conventional alternator.

Even though their output has risen, the rate of use of electrical energy has risen even faster: LCD displays, interior lighting, satellite navigation and infotainment systems are all powered off the battery

"Cars need more power; it's as simple as that," says Pascoe, adding: "When you have all of those devices electrified, you have a problem, in that you would like a higher voltage architecture, because your electrical losses are reduced, the higher the voltage; but, once you get above 60 volts, a different set of regulations kicks in for safety requirements and that means cost. So, 48 volts is an ideal compromise for performance and cost."

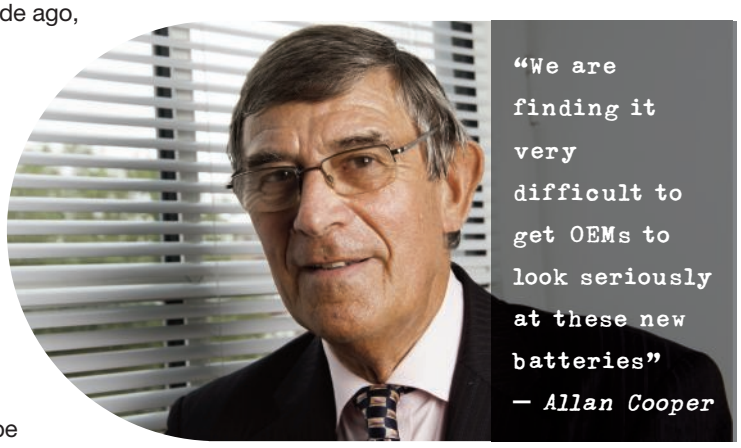
THE ENERGY FACTOR

If that sounds familiar to the 42 volt architecture that was being promulgated a decade ago, it is. But that was defeated on cost grounds and it didn't have fuel economy as its main driver. Which brings us on to kinetic energy and recuperation; if the energy that is currently wasted during braking can be economically harvested and stored, it could then be released when needed to either help power the car directly or drive electrical systems that would fill in and compensate for the weak(er) characteristics of a downsized engine, especially when installed in larger and heavier vehicles.

To achieve that, there needs to be a revolution in battery technology. Mild and full hybrids are mainly nickel metal hydrid with lithium-ion for full hybrids, explains Allan Cooper, a consultant to the International Lead Association, "which is a fairly costly way of reducing fuel consumption", he points out.

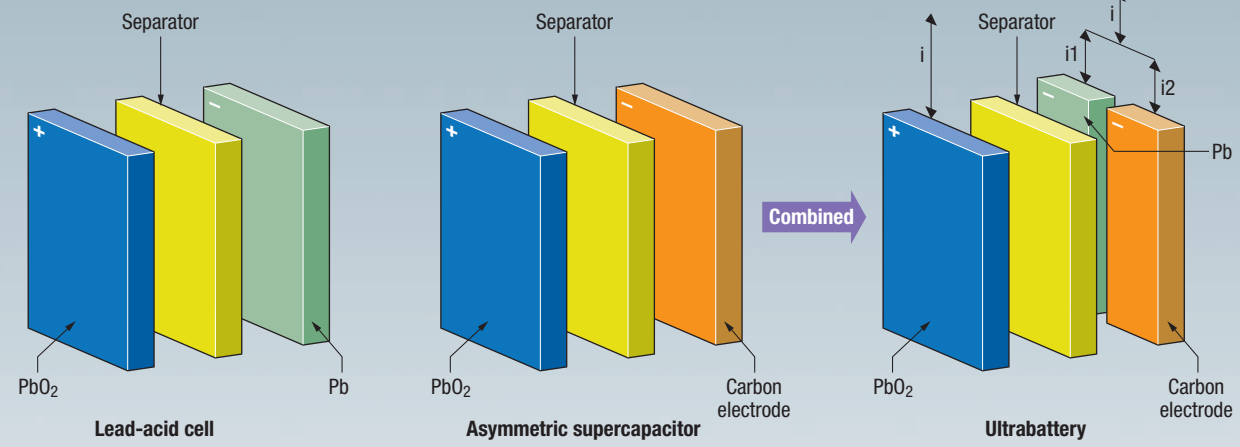
"Customer acceptance isn't improving either and there's the hidden thought: 'What about the car's residual value, if the battery fails halfway through the vehicle's life?'"

As you progress from micro hybrids, like stop-start, through to mild, full hybrid and plug-in, the actual cost for each per cent of CO_2 reduced increases dramatically; and that cost increase is largely dominated by the battery. So, to make 48 volt hybridisation work, employing downsized engines, there needs to be a rethink in both engine architecture and battery chemistry.



"We are finding it very difficult to get OEMs to look seriously at these new batteries"
— *Allan Cooper*

UltraBattery features a part regular negative plate, connected to a carbon-based, ultra-capacitive plate



Through CPT – a management buy-out from Visteon in 2007 – Pascoe and his colleagues acquired the rights to an integrated starter-motor and generator, an exhaust gas energy recover device called Tigers, and an electric supercharger. The last of these has now been acquired by Valeo, although CPT retains the rights to heavy-duty applications for both on- and off-highway.

The common link between all the systems is that they are built around switch reluctance (SR) technology, with very similar integrated electronics. Being SR motors means they don't rely on magnets and are therefore not exposed to the price volatility of rare earth metals.

"What do you need to do to get fuel efficiency from 48 volts?" asks Pascoe, "If you look at the New European Driving Cycle (NEDC), in the first mode the electric motor is used to give torque assist. Far more importantly is where a lot of fuel is consumed, preparing the engine for the next activity. If the driver wants to accelerate, he's not going to wait a second for that.

VERY LEAN CALIBRATION

"If you accept that the hybrid element delivers the driveability, then the base engine only has to focus on fuel efficiency. That means you can back off the fuelling to a very lean calibration and use the electrical energy to provide the driveability; and that's the key change in thinking with this strategy. It retains the conventional ICE for driving the wheels, but electrification gives the dynamic response and that's an important step in delivering economy; finally, using the deceleration periods on NEDC to top the battery up.

"This is when things like state of charge kick in. If you have a very high state of charge, there's nowhere to store it. But, if it's a low state of charge, it will accept it very readily."

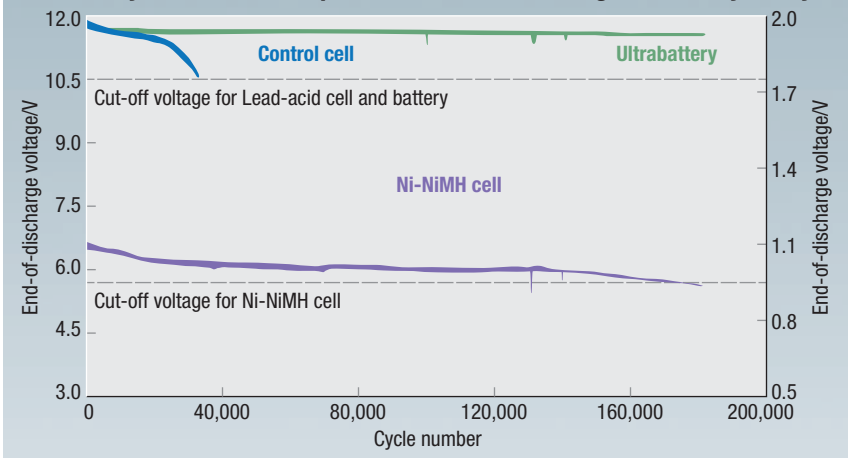
The remaining challenge with moving to 48 volts to allow sufficient regeneration and storing that energy is the battery system. Lithium-ion and nickel hydride are too costly, while lead acid is too cumbersome, and can't live with the deep draws and recharging cycles that a hybrid would put them through.

Super Caps are not much better, explains ILA's Cooper, as they are very good at delivering short bursts of high amounts of energy, but limited to the amount of energy they can store.

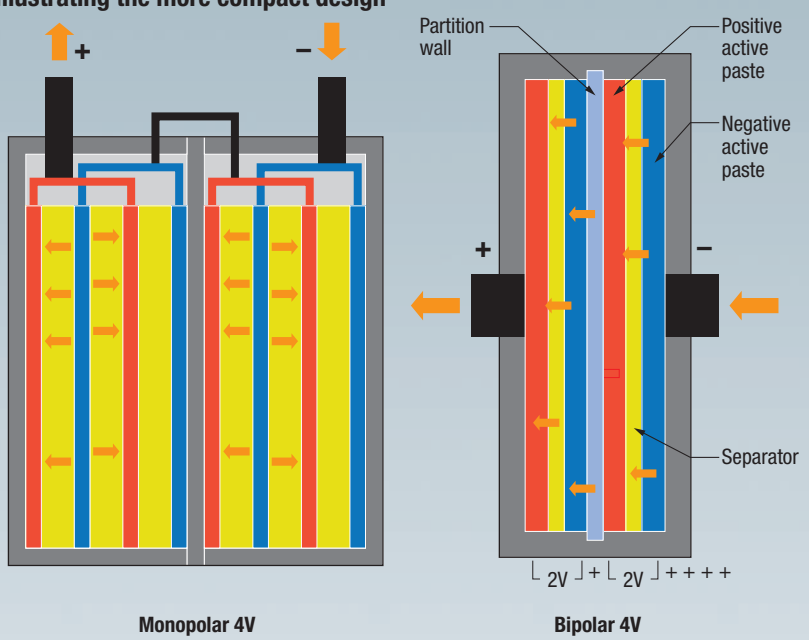
The breakthrough came with the Advanced Lead Acid Battery Consortium's development, using carbon in the negative electrode, the results of which, Cooper claims, are "quite extraordinary", pushing its life out to 300,000 cycles. Furthermore when assembled into an ultra battery pack, the module's voltage and state of charge remained virtually stable, a phenomenon that remains unexplained, according to Cooper.

Although the battery, he says, is only about half the price of that

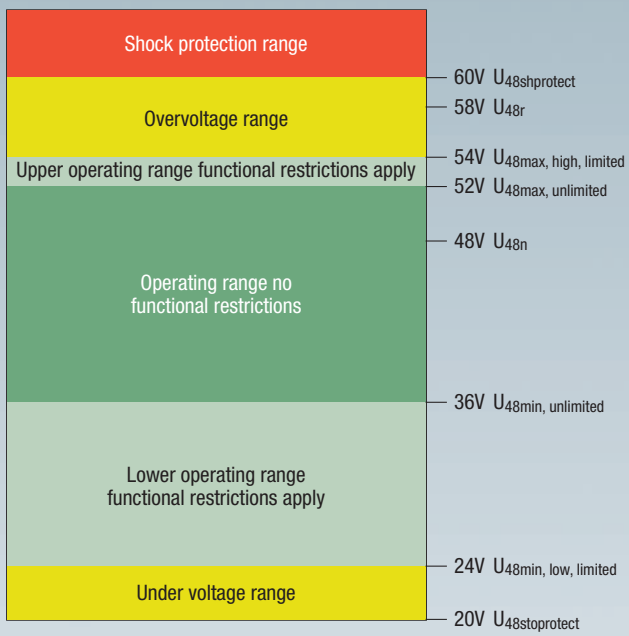
UltraBattery outlasts more expensive NiMH cell in testing to EUCAR hybrid cycle



Atraverda bipolar versus monopolar cell construction, illustrating the more compact design



48V LC Super Hybrid has been built to meet VDA specification



quoted at the Frankfurt Motor Show by Johnson Controls for its €750-€900 Lithium-ion micro hybrid battery and 25% of the cost of lithium ion at the pack level, "it's about five years behind the game and we are finding it very difficult to get OEMs to look seriously at these new batteries", he points out.

Perhaps an even more exciting development has been the breakthrough in chemistry resulting in to what Atraverda chairman Tony Davies describes as the "Holy Grail" of bi-polar batteries – with the outcome being a removal of one-third of the lead in an equivalent-sized battery.

"Lead is about 70% of the battery's bill of materials; we save 40% of that," he reports. "We replace it by a ceramic substrate, because the key problem with a bi-polar battery is that you have to efficiently pass the current through a conductive plate of some kind across its flat surface. That has to act as a barrier for the lead, as it can't leak from cell to cell."

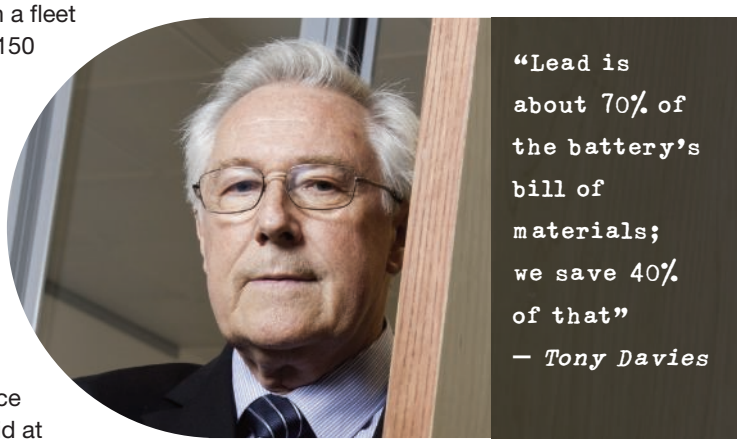
Atraverda's breakthrough came when it discovered how to strip out one oxygen molecule from the pair in titanium oxide, transforming the white powder to black, which is where the Ebonex name comes from. That black powder is processed with a thermoset resin, ending up with black 2mm thick substrate, up to 61cms square. Atraverda has patents on the powder, the furnace and manufacturing processes. According to Davies, Atraverda's initial targets will be e-bikes in China and India, as well as golf buggies and mobility scooters in the 'States.

The first automotive application will be in a fleet of electrified Ford F150 pick-ups that start field trials in 2014, before going into production in 18 months' time.

"We sit between lead acid and lithium-ion in compactness, yet have the performance of nickel metal hydrid at less cost than lead acid," Davies points out. "The stop-start battery could be a market, but our focus is on mild hybrids."

Now under evaluation by an Asian OEM that is trialling its batteries for EV applications, Atraverda has a head start over its rivals, he believes, but welcomes the competition, as it "validates our work".

There's no doubting that the automotive landscape is now shifting, and for the better, but electrification – it seems – doesn't have to mean range anxiety.

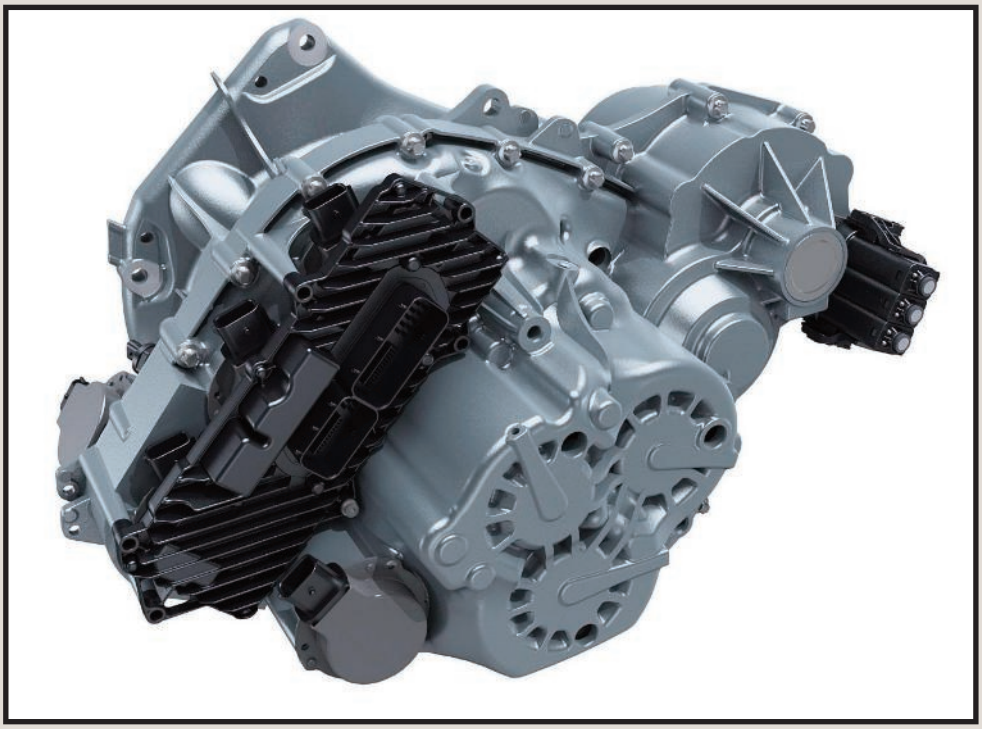


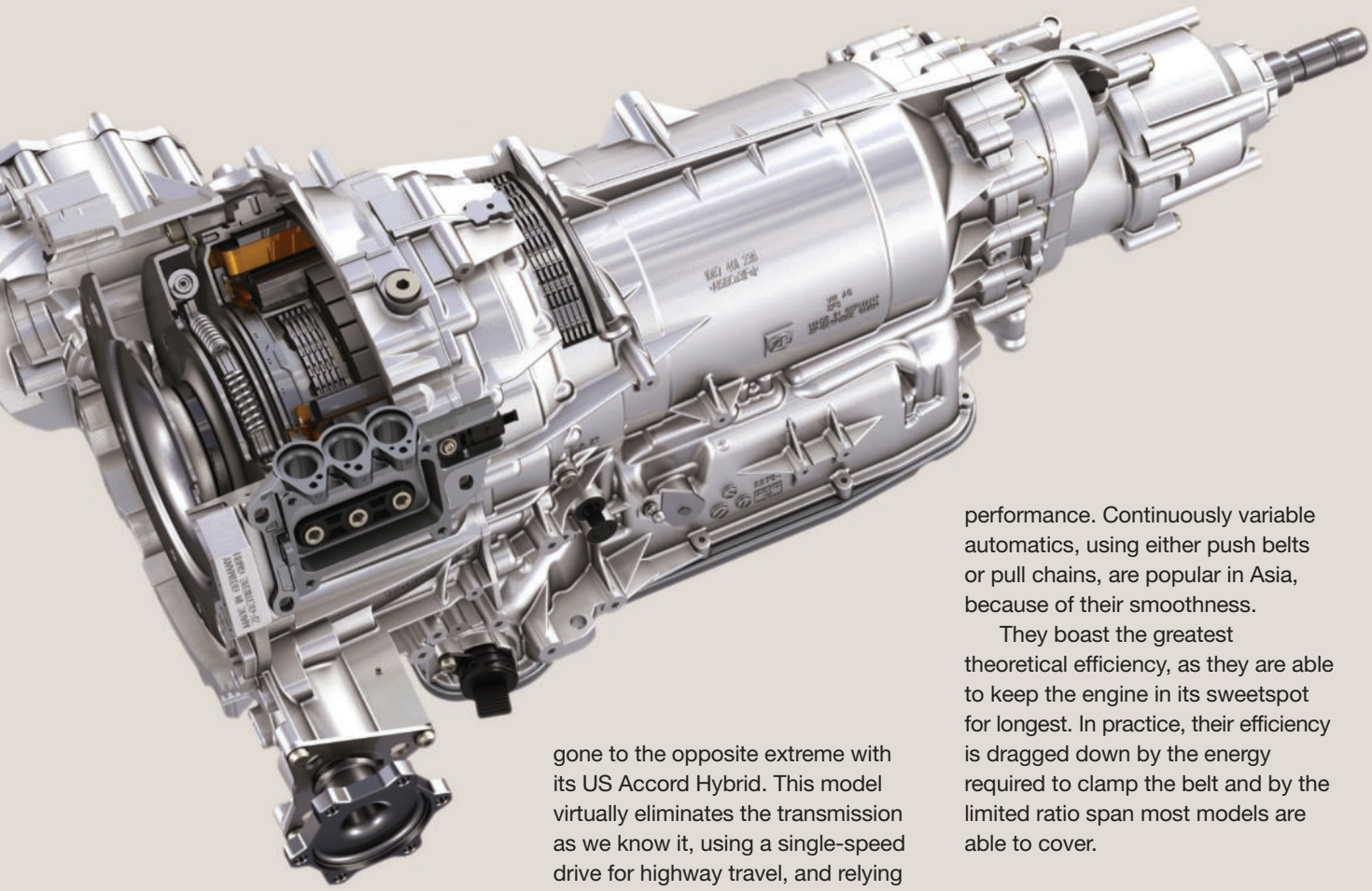
More *power* to the transmission!

Once a more minor player, the transmission now enjoys a starring role as 'the brain' at the core of the modern powertrain, as Tony Lewin reports

The transmission of a vehicle used to have just one job: vary the ratio of the drive from the engine to the wheels to allow the vehicle a useful range of road speeds. Now, with the emphasis so firmly on fuel efficiency and CO_2 emissions, the transmission has gained a potentially even more significant role as the central element in the modern powertrain – the intelligent brain in the middle that, as well as adjusting the drive ratio, also keeps a continuous watch on every metre of the vehicle's progress, selecting between its power sources to maximise energy efficiency and exploiting its kinetic energy to maximum effect.

The transmission is thus a key enabler of other technologies that are vital to saving fuel. Already, most cars





have engine stop-start systems to save fuel in city centre conditions; some models can coast with the drive disconnected, so as to conserve momentum, with others soon to shut the engine down, too. And, of course, hybrids depend totally on their transmission systems for a smooth and efficient blending of torque from their electric and combustion motors.

GREATER DIVERSIFICATION

With this broadening of the transmission's responsibilities has come a much greater diversification of transmission types and also some contrasting trends as regards complexity. While OEMs such as ZF, Daimler and GM-Ford are investing in eight- or nine-speed designs, and Volkswagen has announced its intention to market a DCT with no fewer than 10 speeds, Honda has gone to the opposite extreme with its US Accord Hybrid. This model virtually eliminates the transmission as we know it, using a single-speed drive for highway travel, and relying on the electric motor for launch and lower speed driving. And all of the pure electric cars now on sale have single-speed gearboxes, though some hopeful new entrants are advocating as many as four.

Mihir Kotecha, CEO of Getrag, which makes both manual transmissions and DCT automatics, believes the world is heading towards automation and that the crossover point where automatics outsell manuals has already been passed.

"The big exception so far is Europe, but here we also see a strong development towards much more automatic transmissions," Kotecha told Automotive Design at the 2013 Frankfurt show.

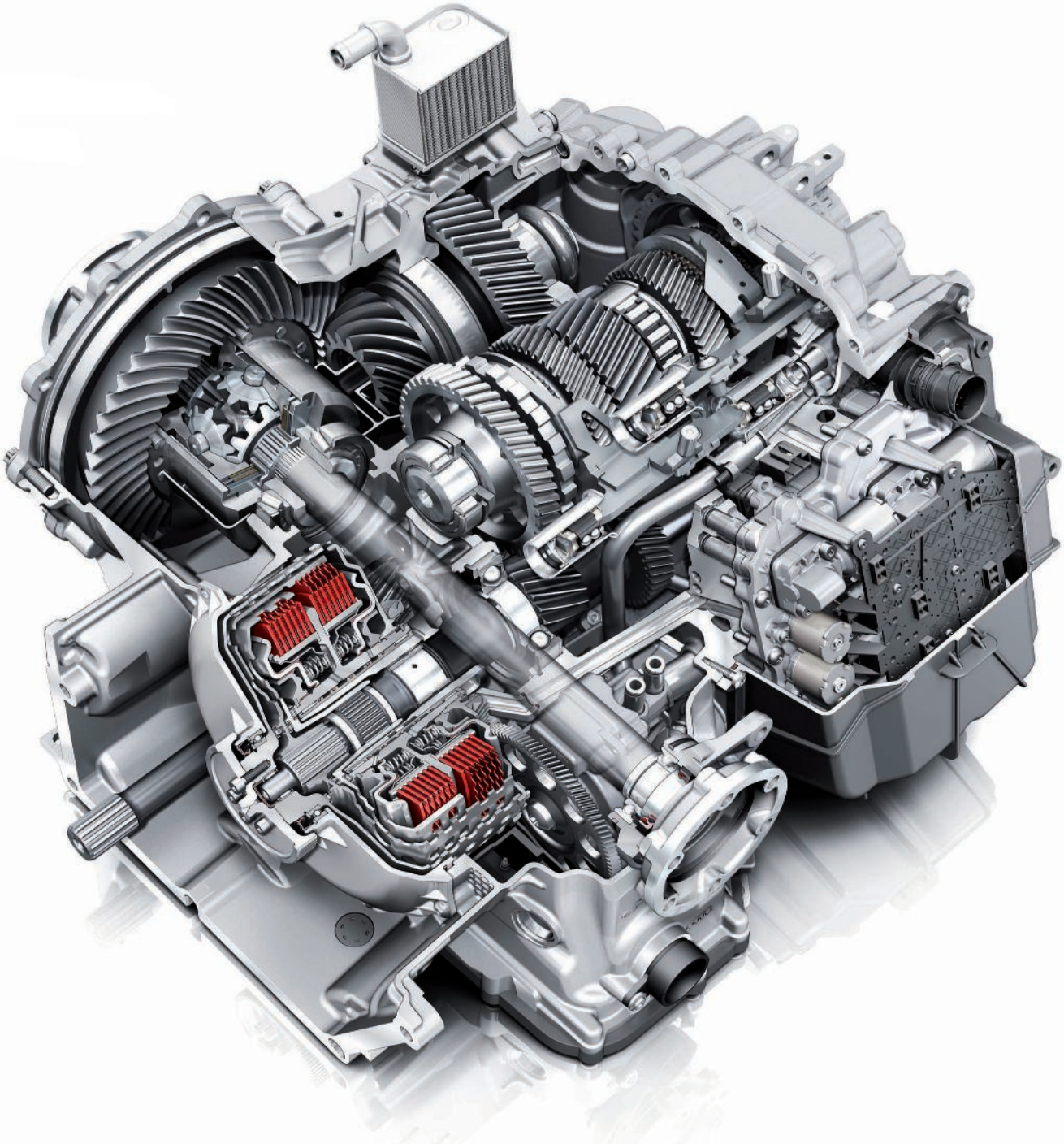
Where transmissions differ sharply from other CO_2-saving systems is that the choice of technology is driven much more strongly by consumer tastes and market preferences than by technical performance. Continuously variable automatics, using either push belts or pull chains, are popular in Asia, because of their smoothness.

They boast the greatest theoretical efficiency, as they are able to keep the engine in its sweetspot for longest. In practice, their efficiency is dragged down by the energy required to clamp the belt and by the limited ratio span most models are able to cover.

KEY DEVELOPMENTS

Recently, however, CVT market leader Jatco introduced its CVT7 with a novel secondary planetary gear, expanding the unit's ratio range to allow a taller cruising ratio, and thus lower NVH and CO_2 emissions. Other developments, such as improved fluids and feedback-controlled clamping pressure, promise to keep CVT competitive with other technologies.

Dual clutch transmissions (DCTs) offer the enticing prospect of combining the top-level mechanical efficiency of a layshaft manual transmission with the convenience and comfort of an automatic. DCTs first became available in the volume market on VW-group products over 10 years ago. Since then, they have become de rigueur in ultra high performance sports cars, such as the Bugatti Veyron, McLaren MP4 12C and P1, and across both Porsche



sports car families and the whole Ferrari range. More recently, the focus has shifted towards saving energy in the shift and clutch actuation mechanisms, and increasing the number of ratios.

SHIFT IN FOCUS

On the latter point, Didier Lexa, chief technology officer of Getrag, questions the trend: "The number of gears is a side discussion. It's not the main issue," he asserts. "Above eight or nine, the effect on CO_2 is neutral or even to make it worse."

What is important, he continues, is the ratio spread, as well as the flexibility of ratios. "With DCT technology, we have quite a high spread. We can go up to 8.6, which is more than sufficient, and we can have a first gear up to 18 or 19, if necessary. You can't get that with most automatic transmissions."

Seven is the optimum number of gears, insists Lexa, and this architecture will feature on Getrag's new 7DCT300 and its hybrid derivative, set for release in late 2014. Meanwhile, Getrag's new entry-level DCT, the 6DCT150, appears to settle another argument – that of the double clutch system. Citing torque capacity and thermal performance, Getrag has opted for a wet clutch arrangement, with only a marginal sacrifice in efficiency, compared with a dry clutch.

PLANETARY AUTOMATICS

Here is where there has been the most dramatic increase in complexity. Today's transmissions are routinely six- or seven-speed, compared with just four or five a handful of years ago; both eight- and nine-speed units are already on the market, with 10-speed systems promised from Hyundai and others. Yet the basic principles remain unchanged, with a torque converter as the launch device and several sets of planetary gears,

often nested together, to give the required permutations of ratios.

ZF has been responsible for many of the advances in this sector, including the development of pressure accumulators and electric fluid pumps to enable engine stop-start. CEO Stefan Sommer says that the nine-speed – especially the new 9HP for transverse-engined front-drive vehicles – is a very efficient solution and that additional gears would provide no further benefit. Nevertheless, he says, some gains may still be possible through improvements to shifting elements. ZF engineers point out that the torque converter, normally a source of losses as it slips, runs in lock-up mode for almost the entire drive cycle.

Yet, in any pursuit of the ultimate efficiency, states Getrag's Didier Lexa, basic engineering principles still matter. What counts is the number of gear meshes, with planetary boxes having four to six sets engaged, but DCTs having just two. Lexa also points out that kinetic energy cannot be recuperated through a torque converter.

Electric motors have a wide speed range and begin producing torque from zero rpm; it was thus believed for some time that EVs needed neither a launch clutch, nor a gearbox. Yet consumer concern about range means the priority will soon be to achieve maximum efficiency in the use of the battery's limited store of energy. This, in turn, points to the inflexibility of the overall gearing, which is a compromise between launch performance and maximum speed. Engineering consultancy Drive Systems Design has shown that multiple speeds can reduce energy consumption by 10-15%, enabling increased range, a smaller motor or a less expensive battery.

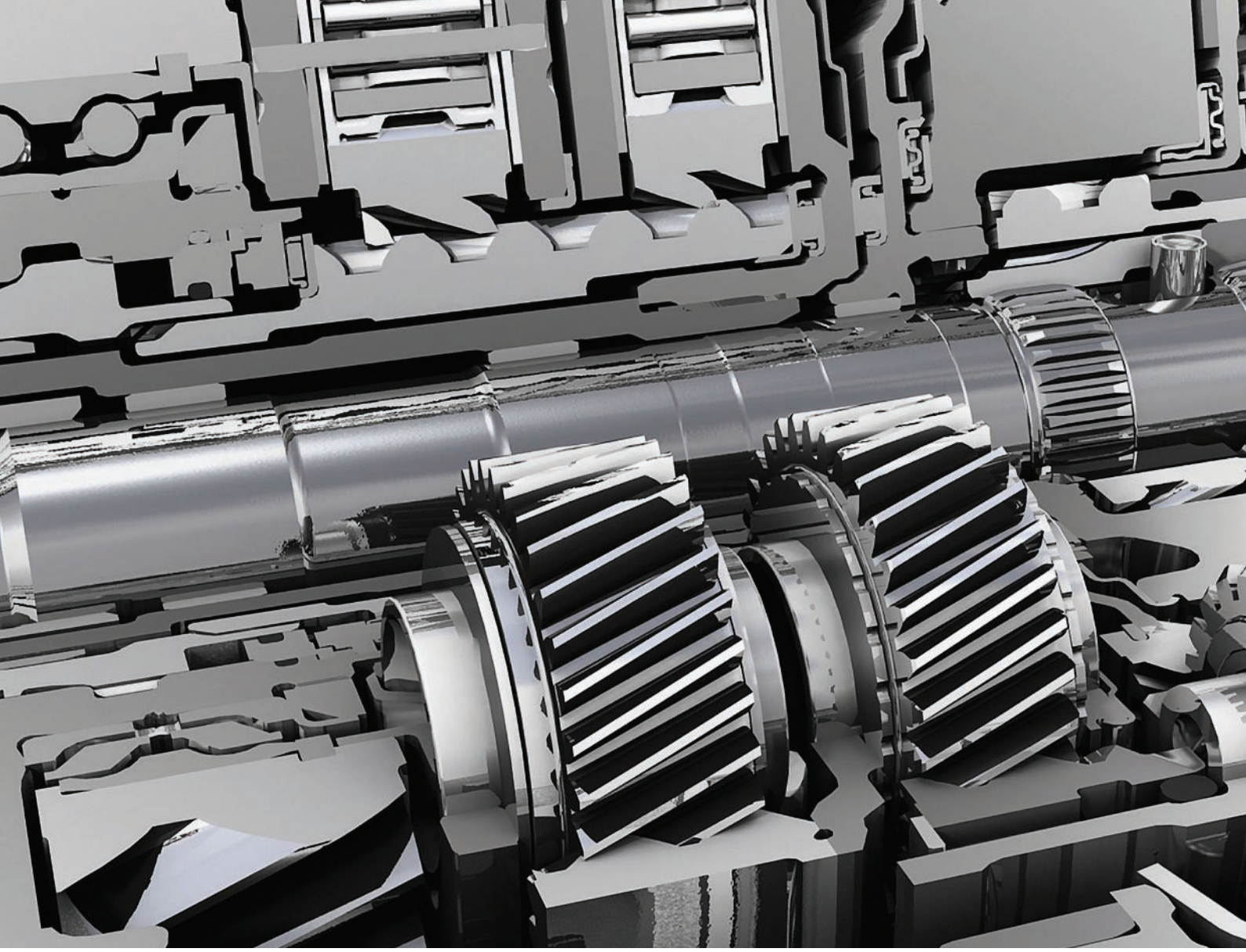
IMPORTANT INNOVATIONS

Equally ingenious solutions have been demonstrated by Oerlikon Graziano, with a twin-motor design that uses the principle of a dual clutch transmission to provide gearshifts free of torque interrupt.

Among hybrids, there is even greater variety of transmission design and the promise of important innovations. One of the favoured solutions for large rear-drive cars is to replace the torque converter with an axial electric motor and an extra clutch, enabling engine-off coasting and electric-only launch. For front-transverse installations, many next-generation modular DCT designs incorporate the electric motor within the casing, while non-stepped solutions, such as Toyota's Prius and the Chevrolet Volt, cleverly combine ratio variation and torque blending through twin e-motors acting via a mechanical planetary gear system.

Further weight savings and efficiency gains may become possible in Honda Accord type architectures where the generator is coupled permanently to the crankshaft and could even be integrated into the flywheel. More enticing still could be the opportunities opened up by magnetic gearing and the novel Magsplit eCVT from Magnomatics.

This is, in effect, a magnetic planetary gearset and could perform most of the tasks required on a hybrid, saving between 3-5% in consumption in the process.



Nine speeds good

Ford and GM have finally consummated transmission joint development, potentially saving the duo millions of euros in costs, as Lindsay Brooke reports

They have now made it official: GM and Ford will jointly develop new 9- and 10-speed automatic transmissions for use in the companies' cars, crossovers and trucks.

The announcement, which was long anticipated, comes months after the news broke of the pending MOU (memo of understanding) in the 26 September 2012 edition of the *Powertrain & Energy* digital magazine. Actually breaking the news was delayed, due to negotiations over intellectual property, according to engineers familiar with the agreement.

The public announcement was accelerated by the 2013 SAE World Congress, 16-18 April, and by the 2013 CTI Transmission Symposium in May, insiders told *AD*.

"We expect these new transmissions to raise the standard of technology, performance and quality for our customers, while helping drive fuel economy improvements into both companies' future product portfolios," reveals Jim Lanzon, GM vice president of Global Transmission Engineering.

The Detroit arch rivals are once again cooperating on transmission

The new GM-Ford 9-speed fwd automatic features clever packaging of its internal mechanism, including 'nested' gearsets to help enable use in small fwd vehicles, according to engineers. Shown is ZF's benchmark 9-speed 9HP48

– 10 better?

technologies, building on their landmark 2002 agreement to jointly develop 6-speed (Ford 6F and GM 6T70/75) front-drive automatics.

That deal, in which Ford and GM invested a combined $720 million (€528.8 million), has produced 8 million units for nearly 30 vehicle applications worldwide since production began in 2006.

By cooperating on the hardware design, engineering, testing and validation, the automakers saved hundreds of millions, versus developing unique units independently. They also reduced risk and saved considerable time.

"We've already proven that Ford and GM transmission engineers work extremely well together," states Joe Bakaj, Ford vice president of Powertrain Engineering.

A typical all-new automatic transmission program costs €59-€66 million in ER&D, plus €183.5-€220 million for a plant, according to industry experts. Licensing a third-party design, such as the latest 8- and 9-speed automatics developed by Aisin and ZF, for example, can cost €22-€73 per unit, depending on details. As one ranking engineer explained, GM and Ford "decided we wanted to avoid that kind of cost burden by joining forces, like we've done so successfully on the 6-speed programmes".

INTO THE FUTURE

The jointly developed GM and Ford step-type planetary transmissions include a 9-speed for front-drive applications (its base design is primarily by GM), and a 10-speed unit for rear-drive trucks and cars whose design DNA is essentially Ford. Jumping beyond eight gear ratios provides the wide ratio spreads vehicles will require to meet the stringent new US and European fuel economy and CO_2 regulations set for the 2017-2020 timeframe. The additional ratios also will help enable the trend toward engine down-speeding, another key to improving fuel efficiency.

Ford and GM are following ZF into 9-speed territory. The German transmission supplier's pioneering 9HP family will debut in the 2014 Jeep Cherokee and 2014 Range Rover Evoque.

Development of the GM-Ford 9- and 10-speed units is underway and component suppliers "have been quoting joint production volumes in the millions, for months", according to vendor sources who asked to remain anonymous. As with the 6-speed units, each OEM will manufacture its own transmissions in its own plants, with many common components, and differentiate them through software controls.

ECONOMIES OF SCALE

"The goal is to keep hardware identical in the Ford and GM transmissions. This will maximise parts commonality and give both companies economy of scale," says Craig Renneker, Ford chief engineer of Transmission and Driveline Component Engineering. Still to come are SOP timing, vehicle applications and technical details. Suppliers expect the 9-speed unit to debut in 2016.

Engineering sources explained that, despite the added complexity of additional gearsets and clutches, the 9- and 10-speed planetary designs still trump CVTs, due to their superior input-torque-handling capabilities.

Comparable CVTs would have at least a €73 cost disadvantage, compared with the step-type gearboxes, given similar volumes, according to supplier experts.

Mehdi Abbadi, Multibase's global marketing leader, talks to Ian Adcock about advances in silicone materials for the automotive industry

COMPOUNDING *the*

Multibase, which has been part of Dow Corning since 2002, has a unique advantage over its rivals, claims Mehdi Abbadi, its global marketing leader, as it can combine Dow's materials expertise with its own solutions. "We are turning to a position where we can provide innovative, responsible solutions, based on silicone technology. Multibase has more than three decades of compounding experience and the unique link we have with Dow Corning, being our mother company, gives us an access that no other compounding company has today, meaning we can provide additives or finished compounds based on this technology and materials expertise.

"If I start with the ready to use compounds, we have a number of applications: the first category I would call 'safety' and in this you have all the airbag covers, driver airbag, passenger, side, curtain etc. We're not talking about the airbag itself, but what the consumer sees. This is one of the main applications; others are window or thermal insulation seals, whether static or semi-dynamic sealing – mainly for window encapsulation or for the ventilation controls, for example.

"Then we have aesthetics and here we're talking about thermoformed or over-moulded skins. We have soft touch feeling for these aesthetic parts; and the last is about reinforcement for rigid or structural parts. "If we talk about the additives, we do provide master batches that either automotive compounders or convertors are using at levels between 0.5% to 4-7%. And they use them mainly for long-lasting, anti-scratch properties for interior parts like dashboards, instrument panels, door panels etc. These are silicone-based technologies.

"The last additive in TPVs is for reducing coefficient of friction in channels where there is friction between the glass and the runner, where there are aspects related to abrasion or even noise reduction, as the glass rises and lowers."

By definition, these are ready to use mono materials, but most of the time Multibase formulates the compounds to the suppliers' or OEMs' individual requirements. "That's our expertise: to fine-tune these compounds when they need some additional features," says Abbadi.

He states that the link to silicone technology is a "real asset", adding: "This gives us the possibility to combine silicone chemistry to the world of plastics and this is how we are able to provide some unique properties supplied by silicone, like the non-tacky, soft touch surfaces; and it's very challenging to obtain that soft touch without a tacky effect, like the majority of TPVs."

It might not seem apparent to the casual observer, but the compounds that Multibase supplies to the industry are going through the same weight-saving regimes as all the other vehicle materials. "This trend is real and we have two basic types of solution for that: first is patented microtalc technology, where we provide compounds and master batches, containing up to 50-70% talc. And, secondly, mechanical reinforcements, with low amounts of fillers; we are combining the properties of some specific grades with other unique compounding conditions, which allow us to keep the property of lighter talc, even after compounding. To achieve the same mechanical properties, flexible modulus and stiffness, with a lower amount of fillers, implies a weight reduction."

On account of the Dow Corning relationship, Multibase has been able to replace some engineering plastics with lower density polymers and, although it's very hard to go into absolutes, because it varies from project to project, comparative studies have been undertaken and the weight difference, maintains Abbadi, "Is not a few per cent, but significant".

Weight saving is a topic that's "on the table," he says, but it does have its challenges. "When you start talking about price, it can be a hurdle. Now we are able to provide economically viable solutions, so, when you start discussing this, you definitely have a better hearing from the OEMs. But if you talk about increasing the price and reducing the weight, then the answer is 'No'."

Abbadi predicts that there will be a "growing trend" of materials migrating

ADVANTAGES

Dow Corning siloxane masterbatch technology from Multibase provides easy-to-use pellet additives with surface stable silicone to lock in long-lasting, anti-scratch performance

from other markets into the automotive sector, pointing out: "Silicone technology is not well known in the plastics industry and we are a bridge to that. It's in our strategy to bring more existing silicone solutions into the plastic world; that's a goal for us."

One typical example he highlights is that of TPSiV – thermoplastic Silicone vulcanizate – a silicone-based thermoplastic, modelled on a unique, patented technology, which contains no plasticiser. It provides, says Abbadi, the best of both worlds, silicone and thermoplastics, and offers the possibility to lower the hardness of most thermoplastic matrices with silicone and without plasticisers.

"It's used mainly in portable electrical devices and Multibase is developing it for the automotive industry for some specific demands, where we have an added value, because we provide a range of different hardnesses, without using any oil. It will come to the European market first within about a year," he concludes.

Dr Anthony Thomson, vice president business development and marketing, Qualcomm

Pull up, charge up

"Qualcomm's Double D Quadrature design offers a number of advantages over other topologies, largely around practicality and ease of use, and also the stray field.

"It allows us to put power over a bigger vertical gap, z gap, and better x and y tolerances for the same size; or even smaller packages. Historically, some of the old topologies we put on buses etc, used a round type of pad with hub and spoke arrangement, with a flat coil on top and ferrite radiating out like wheel spokes.

"The general rule of thumb was that you needed about four times the z height you required for the diameter of the pad. So, if you had a 200mm gap, you needed an 800mm pad. As we started working with OEMs, we realised that wasn't really tenable for vehicle packaging.

"Auckland University came out with this different magnetic topology, which, in effect, reduces by half the length the pad needs to be and shrinks it in other directions as well. So, for putting power over 150mm, we now have a pad that's about 240mm square, which means it's a lot easier to package, but still with good lateral tolerance in the x and y directions. It's doing this, whilst still maintaining full power at the edge of the hot zone and full efficiency.

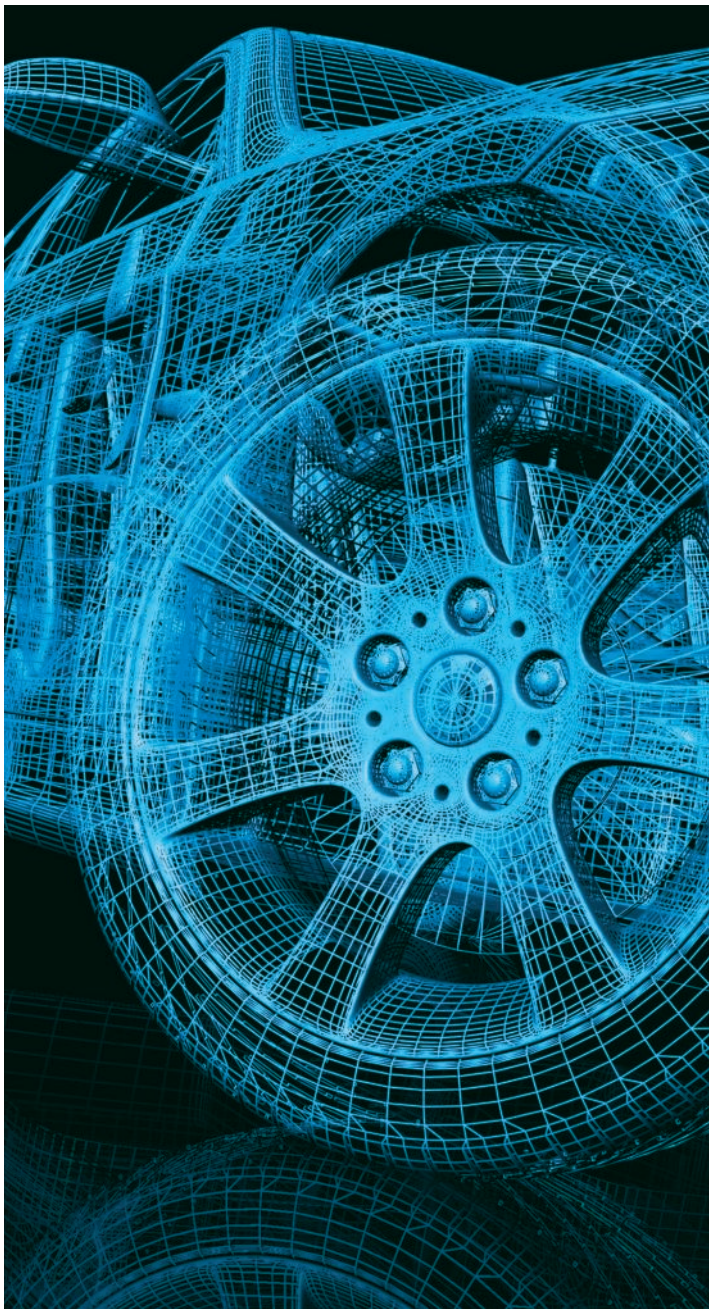
"With this technology, you get flat power and efficiency right out to the edges of the operating zone."

"With some of the other topologies, you tend to get a peak when things aren't perfectly aligned and almost a bell curve as the power drops away, as the misalignment increases. But, with this technology, you get flat power and efficiency right out to the edges of the operating zone, meaning you don't have to be that accurate when placing the vehicle over the top of the pad.

"It's also very well sealed underneath the car and between the pads themselves. That's important for a number of reasons: first, the more field you get going into the pad, the more power is delivered and the more efficient it is; but, also, there's less stray field, so there's less impact on other electronics in the car, people walking by with pacemakers and other powered devices, and just the general radio frequency environment that we live in.

"Compared to conventional plug-in systems, I think its cost is comparable and we're beginning to see some of our Tier One partners producing volume pricing to OEMs, without a premium.

"Also, the systems we've developed are running at 90% efficiency or above. The higher the power you go to, the higher the efficiency, because there are some standing losses that don't increase with power."



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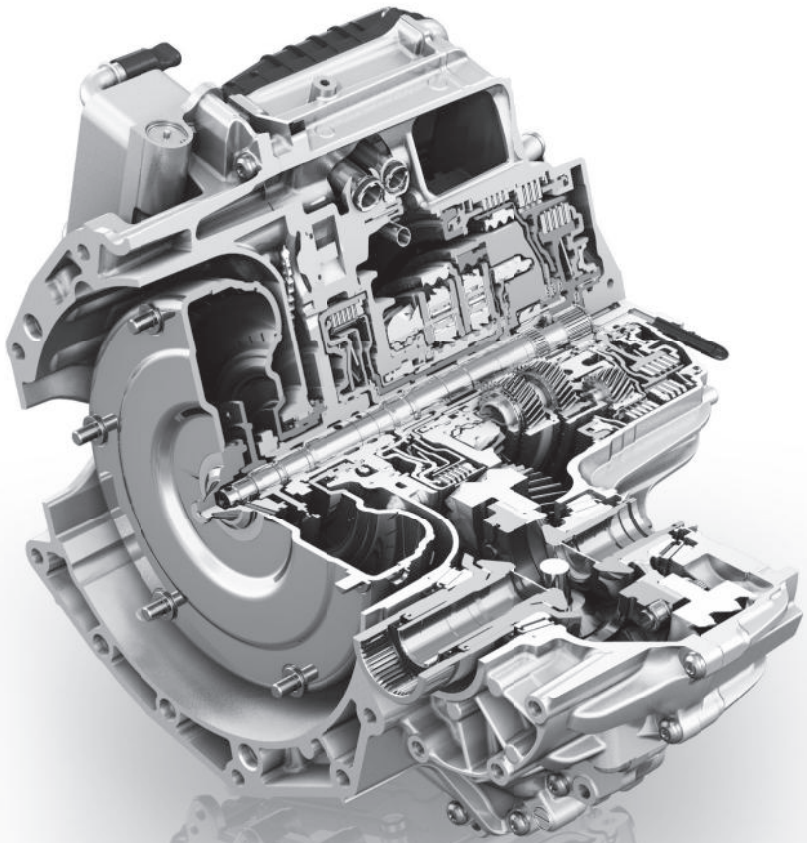

* Compared with today's standard 6-speed automatic transmissions in front-mounted transverse engines