SAE INTERNATIONAL

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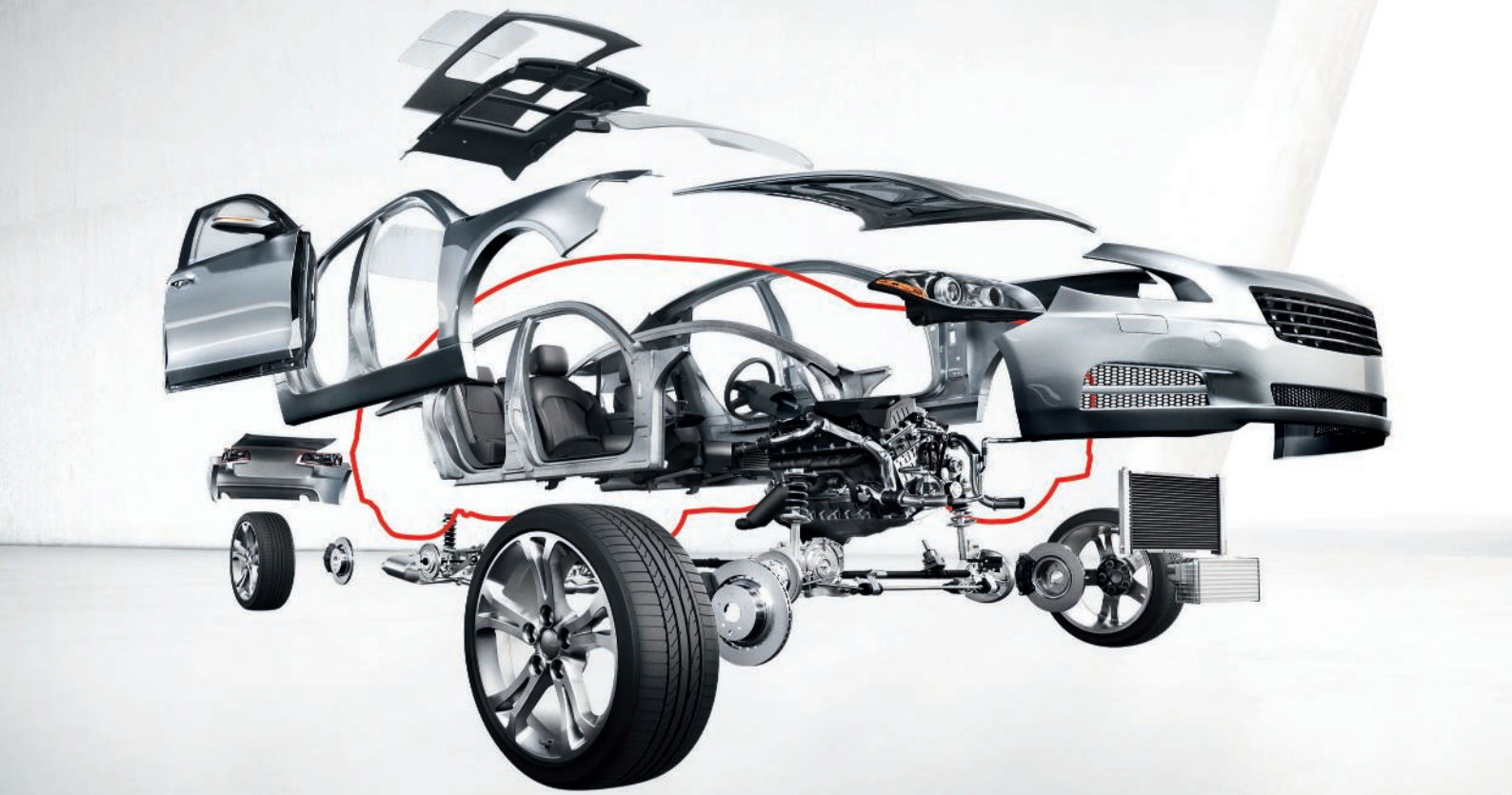
September 2014

INTERVIEW:
DANA'S FUTURE MAPPED OUT

FOCUS ON:
EXTERIOR STRUCTURES
EXHAUST-INDUCTION SYSTEMS
STEERING TECHNOLOGY

JAGUAR LIGHTS THE WAY WITH ALL-NEW ALUMINIUM XE

THE POWER OF BEING EVERYWHERE. IN EVERY CAR.



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As a global leader in automotive adhesive, sealant and functional coating solutions, Henkel can be everywhere in car manufacturing. Our innovative technologies enhance all leading automotive brands across the entire value chain. **Visit our website** to find out how to reduce total costs per car body up to a quarter with our combined solutions – from chassis, powertrain, body-in-white to electrical/electronics, HVAC, exterior and interior.

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Contents

Motor Drive and Power Management Solutions

Compelling Automotive IC Solutions that Put You in Control

Brushless DC Motor Drivers (BLDC)

Allegro three phase controllers set the standard in the industry for high performance and robust features

Brush DC Motor Drivers

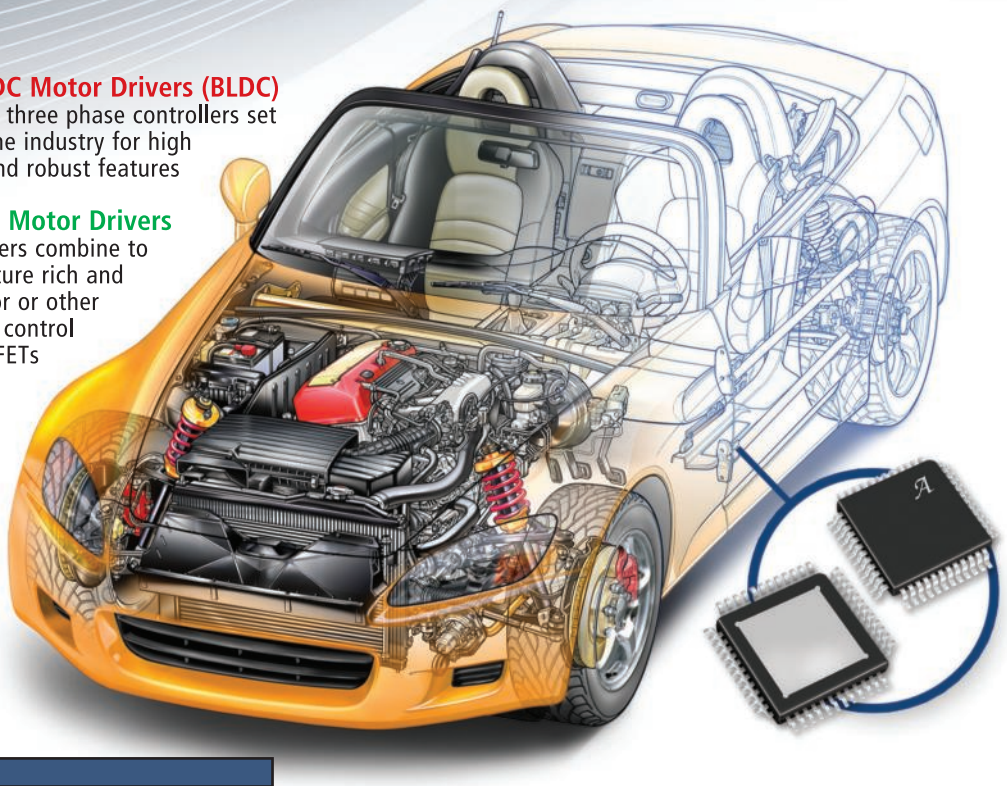
Allegro full-bridge controllers combine to provide an arrangement of feature rich and versatile control for brush motor or other actuators that require full-bridge control using N-Channel MOSFETs

Stepper Motor Drivers

Allegro bipolar stepper motor driver with integrated 1.5 A MOSFET outputs features a simple step and direction interface and excellent diagnostic and protection

Power Management

Allegro offers a comprehensive product lineup to address the need for wide input and multiple output voltage specifications, high switching frequencies to avoid the AM band, and robust fault protection



	Part Number	Features
Brushless DC Motor Drivers	A3930 / A3931	Three-phase N-Channel pre-driver with Hall inputs and 6 step commutation state sequencer
	A4933	Three-phase N-Channel pre-driver with charge pump, serial diagnostic read back capability, enhanced gate drive capability
	A4935	Three-phase N-Channel pre-driver with charge pump and serial diagnostic read back capability
	A4910	Three-Phase MOSFET driver with serial/parallel interface, extensive serial diagnostics, 3 sense amps
	A4939	Three-Phase MOSFET driver with parallel interface with internal linear regulator, diagnostics, and 165°C operation
Brush DC Motor Drivers	A3941	Full-bridge N-Channel pre-driver with 5.5 V to 50 V input range and ENABLE and PHASE inputs
	A4940	Full-bridge N-Channel pre-driver with 5.5 V to 50 V input range and four direct drive inputs
	A4950	PWM controlled DC motor driver IC with integrated FETS capable of ± 3.5 A; Small 8L SOIC package
Stepper Motor Drivers	A3981	Parallel/serial controlled 1.4 A stepper motor driver IC includes stall detect features and comprehensive diagnostics
	A4980	Parallel/serial controlled 1.4 A stepper motor driver IC with low-voltage operation feature allowing the IC to run down to a load supply voltage of 3.3 V
	A4990	Parallel/serial controlled 1.4 A stepper motor driver IC includes stall in small 20L eTSSOP
	A4992	Parallel controlled (IN1-IN4) 1.4 A stepper motor driver IC in 20L eTSSOP
Regulators	A8582 / A8583	Single output regulators; 40 V input for load dump; 250 KHz to 2.4 MHz; Power OK output; Sleep mode; Over voltage protection; Short to gnd tolerant at every pin
	A4402	Dual output regulator; 50 V input for load dump; Fixed on-time with up to 2 MHz operation, Integrated Power-On reset and watchdog timer
	A4405/6/7	Multiple output regulators (A4402/06 Dual, A4405 Triple, A4407 Quad); 40 V input for load dump; 2 MHz operation; Supply tracking; Power-On reset; Multiple protection schemes
	A8450	Quad output regulator; 45 V input for load dump; Supply tracking; Fault flag

Typical Applications include:

- Electronic Power Steering (EPS)
- Fans (Engine Cooling, Hybrid Battery)
- Pumps (Water, Oil, Fuel)
- Transmission Actuators
- Instrumentation Cluster/ Center Stack
- HVAC Motor Control
- Infotainment
- Body Control

Features:

- Automotive grade parts - AEC qualified
- Temperature ranges up to Ta = 150°C
- Small profile, thermally efficient packaging

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A bright future

These are heady times for Jaguar Land Rover, especially the former.

It has been a pioneer of lightweight aluminium structures, but the new XE – as you can read on pages 18-22 – is a potential game changer for the marque. Not only in terms of sales globally but, also, for British manufacturing and engineering as a whole and the automotive sector in particular.

Ramping up production will draw more suppliers into the UK not just to satisfy JLR but the other OEMs that see the UK as an ideal staging post for sales into Europe and elsewhere. There's optimism that the UK will be second only to Germany shortly when it comes to automotive manufacturing output.

It is also good to see a technology that I first drove way back in 2002 finally making it into production. Albeit under a different brand, see the Audi new story on page 6, but what makes that news story even more interesting is that shortly after that presentation, Audi firmly nailed its colours to the 48v mast in a public statement when Prof. Dr. Ulrich Hackenberg, member of the board of management for Technical Development at Audi said of the technology "It enables us to make more energy available. That paves the way for new technologies with which we can make our cars more sporty, more efficient and more convenient to use."

Bearing in mind JLRS aluminium strategy for lightweighting our report on composite crashboxes (page 24) must surely point the way to the next generation of safety systems.

Elsewhere in this issue we learn about the next generation of camera-based detection systems from TRW (page 32) that, potentially, democratises safety systems down the food chain into less expensive, smaller cars.

Ian Adcock, Editor in Chief

Audi boosts power, torque and response – without sacrificing fuel efficiency

Audi will introduce its new twin-turbo V6 diesel, fitted with a Valeo electric compressor in the S-line version of its new Q7 SUV, in 2016, according to Prof. Dr Ulrich Hackenburg, board member for technical development Audi.

The electric motor spools the compressor to 70,000rpm in 250 milliseconds, up to an engine speed of 3,000rpm, before the smaller Honeywell G30 low pressure turbocharger has built up enough boost; this boosts until 3,800rpm, at which point a larger, Honeywell G17 turbo comes into play. As a result, the three-litre V6 bi-turbo develops 750Nm between 1,250 and 3,500rpm and 383kW.

The electrical energy required to drive the compressor is largely generated by recuperation during coasting phases, so that the end effect is, essentially, neutral with regard to energy consumption. It is supplied with power via a separate 48v electrical system, complete with its own compact lithium-ion battery in the boot and power electronics. A DC/DC converter provides the connection to the 12v electrical system.

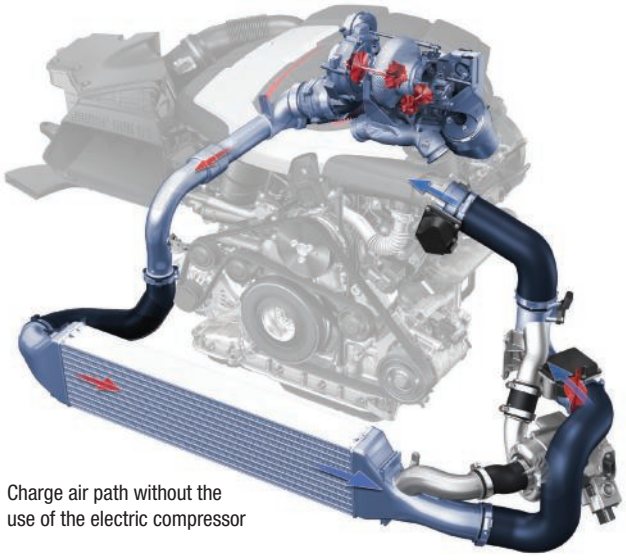
The new 48v subsystem offers major advantages. It can supply the high-performance electrical consumers of the future – thermoelectric heating elements, electromechanical rear brakes or engine auxiliaries, such as oil and water pumps – with more energy than the 12v system. Higher voltage means lower currents, allowing for smaller cable cross-sections and thus reduced weight. Audi plans to introduce the 48v electrical subsystem to multiple model series shortly.

Automotive Design exclusively revealed this technology in September 2012 when Valeo demonstrated it in a Renault four-cylinder, 1.2 pfi engine, the French supplier using the electric compressor to give the engine the power, torque and response of a larger capacity engine without sacrificing fuel efficiency.

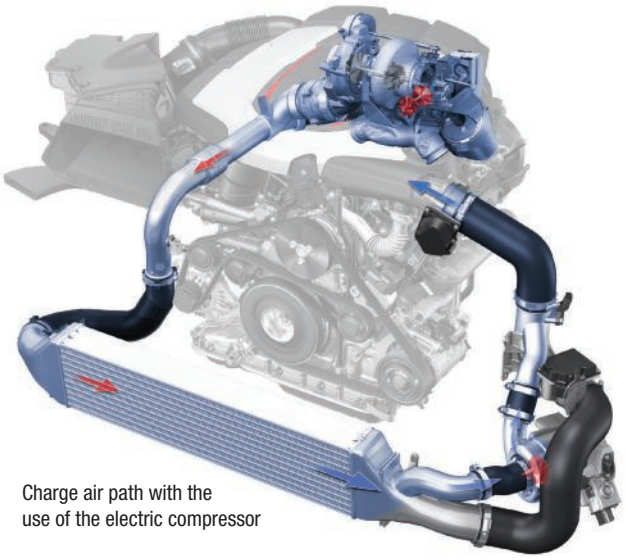
However, the technology pre-dates that by a decade to 2002 when it was originally launched as the Visteon Torque Enhancement System, designed to fill in the unwanted black hole of turbo lag on diesel engines.

A management buy-out by CPT acquired and developed the system until it was bought by Valeo following a three-year development partnership with the British company.

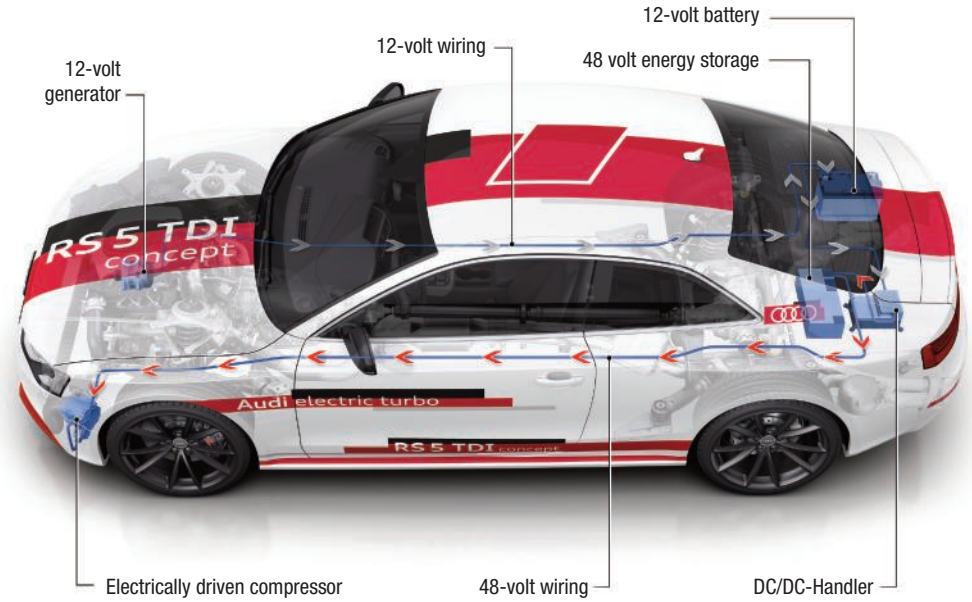
Audi V6 TDI Biturbo with electric compressor



Charge air path without the use of the electric compressor



Charge air path with the use of the electric compressor



BMW on the charge

The BMW i8 safety car for the upcoming Formula E race series, together with the BMW i3 support cars, has been fitted with Qualcomm's inductive charging system for the first time.

According to Graeme Davison, vice president of technology for Qualcomm Europe, the pad measures about 350mm x 250mm, "roughly the size of an i-Pad", and will allow the safety car to remain charged and ready for use, without needing to be plugged into the mains. Davison revealed that the system, which also features an anti-object and living object failsafe mode, runs at 85Khz charging frequency – recently recognised by the SAE as the new global standard – to ensure it doesn't interfere with pacemakers, mobile 'phones and other transportable electronic devices.

Qualcomm is currently in the final stages of negotiations with several OEMs for the use of its technology and, according to vice-president business development and marketing, Dr Anthony Thomson, the first series production wireless charging will appear in "top end" electric vehicles by 2017.

The big news for Formula E is that, as from next year, teams will be free to develop their own electric motors and battery systems, although the chassis, aerodynamics and suspension etc will be common.

"We're looking at up to seven OEMs joining the series," said a Formula E insider, who didn't want to be named, adding that BMW was "in the frame".

Tier One supplier Schaeffler is already involved with the German Team ABT Sportsline and, in a recent statement, its member of the management board for technology Professor Peter Gutzmer admitted:

"Schaeffler is going to support the further development of the race car and its components, with the know-how and experience of our engineers, in the future."

Land Rover tests the waters with new laser technology

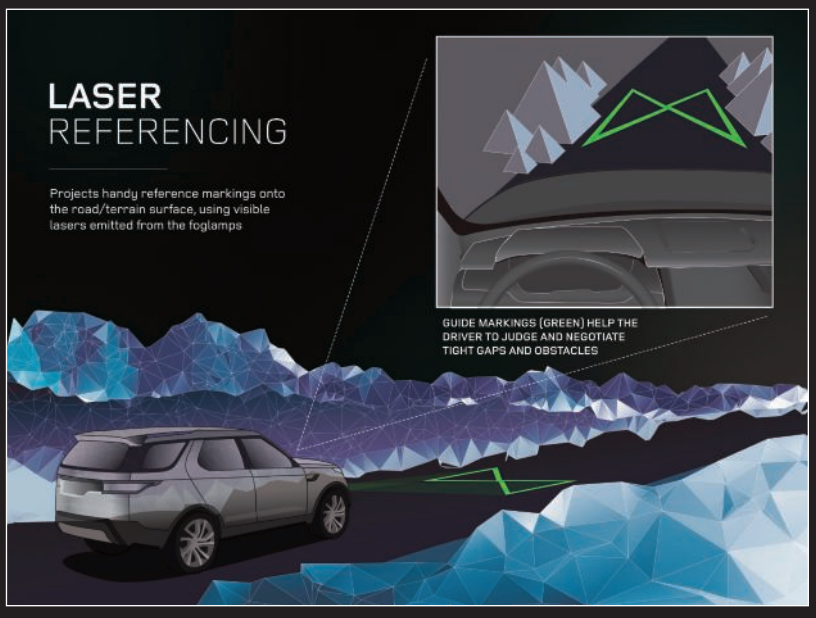
Lasers that can measure the depth of water before a vehicle starts wading will commence testing by Land Rover later this summer; the 4x4 marque is also developing laser systems that project a vehicle's width on the road ahead to ensure it can pass through narrow gaps, as well as laser-based headlight systems.

The Jaguar Land Rover patented technology measures the refraction of the laser through the water. If it is murky or silted, the laser is scattered to make measuring even easier.

It was described by Paul Widdowson, a member of JLR's 'Towards Driverless Car' team, as "schoolboy physics" and he added: "We couldn't have been more surprised that it wasn't already patented – it's such a simple concept."

According to Widdowson, JLR has listed "hundreds of ideas for using coherent light on a car with étendue". The measuring 'bow tie' prototype uses a galvanometer and a mirror, so that, as the laser hits the mirror, it sweeps across the road, creating the lines delineating the car's width.

The laser consumes only 3w, but emits 3,000 lumens – nearly double that of a conventional 100w bulb. Widdowson also revealed that JLR is "actively" working with law makers both in the USA and Europe to allow laser headlights in the future, adding that there had been a "very cautious response so far".



Tata's ideal material for vehicle crash structure

Tata Steel has launched the latest in its family of dual-phase steels, DP1000HY-GI, making it one of the first to bring this innovative product to market. This high-yield ultra-high-strength steel (UHSS) comes in response to market requirements for stronger and lighter automotive steels. Its combination of strength and formability, with no increase in processing effort and a reduction in weight, makes it the ideal material for the crash structure of a vehicle.

The high-yield strength of DP1000HY, which allows the material to endure high stress during deformation and therefore absorbs more crash energy, is most suitable for making components, including A- and B-pillar reinforcement, sills, door beams and cross members.

The strength of this steel also allows designers to reduce material consumption, offering the potential of an 8-15% decrease in component weight, depending on the steel grade being replaced. Its superior formability makes it suitable for creating relatively complex shapes, while its optimal energy absorption capability is ideal for making crash-relevant components. DP1000HY incorporates carbon and manganese to increase the strength and hardenability of the steel. A critical consideration of this new grade was creating a product that doesn't require customers to alter their processing facilities to handle it. Tata Steel worked closely with customers throughout development to ensure

Gasoline Technology Car: fuel and CO_2 friendly

Schaeffler and Continental have co-developed an innovative mild hybrid car, the Gasoline Technology Car (GTC), that is claimed to cut fuel consumption and CO_2 emissions by an additional 17%, compared to the already efficient Ford Focus 1.0-litre EcoBoost 3-cylinder petrol engine.

In addition to changing the standard fuel injection and ECU with Continental systems, it also features Continental's 48v Eco Drive System as mild hybridisation and Schaeffler's electronic clutch (e-clutch) for power transmission, as well as its thermal management module and an Emitec electrically heated catalytic converter.

Despite the modified, ignition-timing-optimised operating strategy, and to allow for the use of additional hybrid driving strategies, the GTC features an independent second drive unit, the 48v Eco Drive System, to ensure driveability. This includes an electric motor with integrated decoupling tensioner. The electric traction motor/generator is connected via a modified belt drive to the combustion engine.

A DC/DC converter facilitates electrical energy flow between 12v and 48v by using a lithium-ion dual-battery design. This hybridisation supports the combustion engine electrically in the lower speed range as an e-boost function to ensure a good response, without turbo lag.

The Schaeffler electronic clutch makes 'coasting' possible, where the clutch decouples the engine from the drive train. As the engine is idle, more energy is available for recuperation. This energy, in turn, facilitates other efficiency-enhancing measures, such as the electrically heated catalytic converter.

This uses the recuperation energy from the previous drive cycle to attain a faster working temperature for cold starts.

A Schaeffler split cooling architecture with rotary slide valve facilitates graduated thermal management in the GTC to combat the challenges posed by hybrid drive strategies. The engine can be temporarily decoupled from the coolant cycle, in order to more quickly attain the required temperature or retain its temperature for longer periods. This rapid heat-up reduces engine friction losses, which, in turn, increases efficiency, a goal also pursued by using friction-optimised components. As part of a forward-looking operating strategy, cooling can also be switched off in time for anticipated recuperation phase when going downhill.

The engine control unit (ECU) is designed to relieve the engine of the complex task of controlling the mild hybrid components, including the operating strategy. The ECU gets a head start on the forthcoming EMS 3 (Engine Management System 3) platform strategy. Its open AUTOSAR-based system architecture flexibly supports a variety of partitioning schemes and electronic topologies, in conjunction with hybridisation and electrification.

Also, the ECU makes recommendations on optimised gearshift ratios. The additional electric driving torque allows the driver to use these optimised gearshift ratios without any negative impact on driveability, helping to improve fuel economy.

the chemistry of the steel would not alter its manufacturability in existing systems.

DP1000HY has been specially developed by Tata Steel to meet the requirements of the German association of car manufacturers, the Verband der Automobilindustrie (VDA). This ensures that DP1000HY is able to meet stringent automotive safety requirements demanded by vehicle manufacturers globally.

Sander Heinhuis, Tata Steel's European marketing manager for automotive, said: "Through the development of DP1000HY, Tata Steel has combined high yield, ultra high strength and formability, allowing automotive manufacturers to reduce the thickness of the steel they use. They can consequently achieve impressive crash protection and, at the same time, have the option of reducing weight. We are working closely with our customers to demonstrate the benefits they can achieve from using this product."

DP1000HY is available in a range of dimensions, with a thickness of up to 2mm and a width of up to 1,400mm. It is finished with a hot-dipped galvanised coating, offering good corrosion protection and making it a cost-effective body structure solution.

This latest addition to Tata Steel's range of dual-phase steels means the company can now offer three strength levels of 600, 800 and 1,000 megapascals.

Ultra small solution for use in crash dummies

The new DTS 6DX PRO is claimed to be the world's smallest, high-shock, 6 degrees-of-freedom sensor package for use in crash dummies. Designed for applications measuring high rates of shock and angular velocity, the DTS 6DX PRO packages three accelerometers (2000 or 20000 g) and three angular rate sensors (18,000 or 50,000 deg/sec) in a compact, rugged enclosure that is less than 19 x 19 x 14.5 mm. Focused on human injury assessment testing, the 6DX PRO weighs only 12 grams, is shock rated to 20,000 g and is sealed, making it ideal for cadaveric work.

"DTS has helped collect data from manikins in jetliner and helicopter crash tests, from a stunt high diver plunging over 10 metres into only 300 mm of water, from rodeo riders, aerobatic pilots, cadavers and many more unique, human injury-related applications," says Steve Pruitt, president and co-founder of DTS.

The 6DX PRO is calibrated and meets NHTSA, FAA, ISO 6487 and SAE J211 practices.

DC-DC converter claims 98.7% efficiency

A consortium led by Prodrive has successfully run a silicon carbide-based multiport DC-DC converter in an electric car. The converter controls power flow between multiple energy sources and has been able to achieve an efficiency of 98.7%, while increasing power density and reducing the size and weight of the converter when compared to silicon-based systems. The converter acts as a hub that transfers energy between key components of the vehicle's high voltage electrical system. It has four ports: two connect to the traction motor and high voltage battery; a third connects to a secondary energy source, which in this test car is a super capacitor bank; and the fourth powers the vehicle's 12v systems.

The converter is able to match the voltages of these components and transfer energy between them, in response to CAN commands from an external supervisory controller.

The test vehicle is a Tata Vista EV demonstrator vehicle, developed by the Tata Motors European Technical Centre in Warwick, which has a 220v battery and 37 kW traction motor. The vehicle also has two 200 kJ super capacitor banks, which operate at 75-150v.

Mark Willows, Prodrive electrical systems and control specialist, explained: "In normal driving, the converter boosts the battery voltage to around 400v to optimise motor performance and can supplement the battery supply with additional energy from the super-cap banks when the situation demands it. During regeneration, the converter transfers energy from the motor to the battery or super-capacitor banks, as

Wakey, Wakey

Car seats that warn drivers if they start to fall asleep at the wheel are being developed as part of a study by the UK's Nottingham Trent University researchers.

Professor Tilak Dias and William Hurley of the university's Advanced Textile Research Group will be working with Plessey on a feasibility study to investigate how to integrate an electrocardiogram (ECG) sensor system directly into the fabric of car seats, in an effort to save lives.

The study is being funded by the UK's innovation agency, the Technology Strategy Board.

With driver fatigue a contributory factor in one in five motorway accidents, the aim is to embed a fabric-based sensor system within the seat that can detect the heart signals that indicate a driver is losing alertness. The data would be used to send a warning to the driver to pull over.

Professor Dias said: "Plessey has already demonstrated that cardiac signals can be measured unobtrusively using capacitive sensors mounted within the driver's seat; the requirement now is to improve the consistency and reliability of the data, so that it can be used for the intended purpose.

"This requires a novel approach to the design of the electrodes and Nottingham Trent University's knitted conductive textile technology offers the potential to produce robust electrodes that can be easily incorporated into automotive seats."

A similar project is being undertaken by the EU-funded HARKEN project with researchers at the Instituto de Biomecánica de Valencia (Biomechanics Institute - IBV), Spain.

The biggest challenge is non-invasive detection of the driver's heart rate and respiration, and not confusing these with signals given off by the car or driver's movements.

Unlike the Nottingham project, the Spaniards are locating the sensors in the seat belt webbing.

Designers and engineers at JBL and smart collaborated closely to create a customised audio system that would ensure optimal sound in the compact interior of the smart vehicle. Aware that space is at a premium in the smart, JBL and smart made the subwoofer removable to extend the trunk volume when drivers need to load extra baggage.

requested by the supervisory controller.

"Energy can also be transferred directly between the battery and super capacitor ports. The system can be configured to support other energy sources, such as fuel cells, or could supply multiple traction motors."

A key aspect of the converter is the use of silicon carbide devices. These operate at a much higher frequency than equivalent silicon components – at 75 kHz in the test vehicles – with a significant reduction in switching losses.

This has resulted in a significant reduction in the size of the magnetic components, and has enabled the converter to achieve its 98.7% efficiency, gravimetric power density of 10.5kW/kg and volumetric power density of 20kW/litre.

The use of silicon carbide power modules could also allow much higher temperature operation than conventional silicon modules. This provides the potential to integrate the power electronics and IC engine cooling systems in hybrid applications.

The consortium is now working on a follow-up project that increases the converter operating voltage to 750v, further increases power density and demonstrates operation at increased coolant temperatures.

"For this project, we have developed a rolling test bed, based on a light commercial vehicle chassis, which has a 75 kW traction motor," added Willows.

"The energy storage consists of a 320v Li-ion battery and two super capacitor banks, all of which were built by Prodrive specifically for this project."

Sustainability pitched at heart of production

Professor Peter Wells and Dr Paul Nieuwenhuis, from the Centre for Automotive Industry Research at Cardiff Business School, have developed a model for sustainable, local car manufacturing that pioneers the use of more lightweight, durable and sustainable materials

The aim of the Micro Factory Retailing (MFR) project is to create a comprehensive new business model for vehicle manufacturing that puts sustainability at the heart of production. This means shifting car manufacturing towards small factories in local markets, with all aspects of the industry based on a local level – from design and manufacturing to sales and maintenance. The MFR model focuses on low volume production and the use of more durable, sustainable materials. This contrasts with the traditional model of high volume-low unit cost, which has led to an over-supply of new cars.

The researchers worked with both UK-based and international firms when developing their business model, which has already been adopted by car manufacturer Axon Automotive. The research also helped Gordon Murray Design to demonstrate the foundations for its own model for sustainable car manufacturing.

News in brief

Blackberry picked

The Volkswagen Group is taking over BlackBerry's European research and development centre in Bochum (Germany). With the newly founded Volkswagen Infotainment GmbH, the Wolfsburg-based automotive group is further expanding its expertise and capabilities in the field of vehicle connectivity.

Hub located

The Advanced Propulsion Centre (APC) has selected the University of Warwick as the site for its Hub location, supporting the 10-year £1 billion industry and government commitment to the development of low carbon propulsion systems.

The central Hub, together with a national Spoke structure, will provide the UK automotive industry with resources and facilities to develop advanced propulsion systems and supply chains. In doing so, the aim of the APC, in partnership with industry, is to secure and grow over 30,000 UK jobs currently engaged in the research, development and production of vehicle powertrains as the industry transitions to a low carbon future for all modes of transportation.

Tyre technical centre

Kumho's European Technical Centre (KETC) has further expanded its burgeoning resource with the creation of an innovative new tyre-testing facility at Papenburg in Lower Saxony, Germany.

Its activities will be supported by novel high-tech GPS-based measurement systems and digital evaluation of the tyre footprints. The new centre will manage all KETC's outdoor test requirements, while any additional needs will be catered for by a mix of the facilities at Idiada (Spain), Nardo (Italy), Nürburgring (Germany) and Ivalo (Finland).

New design chief

Kevin Rice has been appointed Mazda Motor Europe's new design director, effective 1 September. The 50-year-old British national returned last fall as creative director to Mazda's European R&D Centre in Oberursel, Germany, where he spent five years in the 1990s. Rice also gained valuable automotive experience working at different brands in Europe, including BMW. He succeeds Peter Birtwhistle, chief designer at Mazda Europe's R&D Centre.

Sparkling solutions add the 'wow' factor

Designers at BASF's Coatings division have published their automotive colour trends for 2014/2015, with the development of special effects setting new accents and opening up unusual colour ranges. BASF's designers are predicting that this will make automotive colours more complex and more individual in the future.

This means that what counts is not attention-grabbing, but rather the "wow" effect at second glance. Innovative special effects create these accents. For instance, the latest collection contains the newly developed XSpark special-effect coating, which boasts very fine glass particles that reflect the light, thus creating a distinctive sparkle. "XSpark opens up brand new opportunities for translating new values and a new quality awareness into automotive colour," said BASF designer Florina Trost, adding: "Classic colours like blue or silver develop a completely individual behaviour, visually reinforcing the car bodies' geometry with brilliant sparkle."

Mark Gutjahr, head of design BASF Europe, explained the significance of special-effect coatings: "For years, the differences have basically only been between solid, pearl-effect and metallic. Now, we are starting to see some movement in this area. The targeted interaction between colour and special effects is making automotive colours more complex and multifaceted. This development will also continue to accompany us for a few years. We haven't yet exhausted the potential in the special-effect palette."

Audi springs into action

Audi is introducing new, lightweight suspension springs made of glass fibre reinforced polymer (GFRP) before the end of the year.

The GFRP spring, which Audi developed in collaboration with an Italian supplier, is light green, the fibre strand is thicker than the wire of a steel spring and it has a slightly larger overall diameter with a lower number of coils. Most importantly, however, it is some 40 % lighter. Whereas a steel spring for an upper mid-size model weighs nearly 2.7 Kgs, a GFRP spring with the same properties weighs just approximately 1.6 Kgs. Together, the four GFRP springs reduce overall weight by roughly 4.4Kgs, half of which is unsprung mass.

The core of the springs consists of long glass fibres twisted together and impregnated with epoxy resin. A machine wraps additional fibres around this core — which is only a few millimeters in diameter — at alternating angles of plus and minus 45 degrees to the longitudinal axis. These tension and compression plies mutually support one another to optimally absorb the stresses acting on the spring. In the last production step, the blank is cured in an oven at temperatures of over 100°C.

Vegemight!

Ford and Heinz are investigating the use of tomato fibres to develop sustainable, composite materials for use in vehicle manufacturing. Dried tomato skins could become e-wiring brackets in a Ford vehicle or storage bins a customer uses to hold coins and other small objects.

"We are exploring whether this food processing by-product makes sense for an automotive application," said Ellen Lee, Ford plastics research specialist. "Our goal is to develop a strong, lightweight material that meets our vehicle requirements, while at the same time reducing our overall environmental impact."

At Heinz, researchers were looking for innovative ways to recycle peels, stems and seeds from the more than 200 million Kgs of tomatoes that the company uses annually to produce its best-selling product, Heinz Ketchup.

"We are delighted that the technology has been validated," said Vidhu Nagpal, Heinz's research and development associate director. "Although we are in the very early stages of research, and many questions remain, we are excited about the possibilities this could produce for both Heinz and Ford, and the advancement of sustainable 100 per cent plant-based plastics."

All the right

George Constand BSc, MSc

CV

George Constand is chief technical and quality officer of Dana Holding Corporation. He joined Dana in 2005 as vice president of global engineering for the company's light axle operations.

The move to Dana came after 20 years at Ford Motor Company and Visteon Corporation, where he held positions of increasing responsibility in manufacturing, engineering and product design. In these roles, he held executive positions in both companies, became a Six Sigma champion and a leader of lean manufacturing techniques and stage-gate development processes.

Constand earned Bachelor of Science and Master of Science degrees in mechanical engineering from the University of Michigan.

He is married with two children, a boy and a girl.

CONNECTIONS

With 2013 sales of $6.8 billion, Dana is a leading tier one supplier. Ian Adcock catches up with its chief technical and quality officer George Constand

Dana's light vehicle division is one of five business units within the corporation and, in itself, can be divided into drivetrain, sealing, thermal management and fuel cell – which, at first glance, might not appear to have that much in common with each other. But, as George Constand explains, they do share mutual denominators. "We always look at the market and technology trends that occur in the industry. We have very specific core capabilities at Dana to deliver not only products and technology, but solutions to customers. And even though they may seem unconnected, we do work in light vehicle technology to see how we can very easily connect these together.

"We are able to take more of a systems solution to the vehicle. So, with our drivetrain, we are able to take some of our technologies from, say, our thermal products group and be able to incorporate those with our drivetrain technologies. An example of an area that we are looking into is heating the lubricants. So, by taking our thermal technologies, we are able to capture energy and transfer that into the drivetrain itself."

Its involvement in commercial, as well as off-highway, vehicles means Dana can leverage expertise from these sectors into light vehicles, as Constand describes: "Because Dana plays in different markets – light, commercial, off-highway – we're able to take the durability, reliability aspects that are extremely important in commercial and off-highway applications, and drive some of those solutions into light vehicle systems, and that's one of the key benefits Dana has. We're able to cross our business units with technology, providing lightweight solutions that are both very durable and reliable.

> **"We always look at the market and technology trends that occur in the industry. We have very specific core capabilities at Dana to deliver not only products and technology, but solutions to customers."**

FUTURING CHALLENGES

"As an illustration between commercial and light vehicles: for a commercial, we typically need to design systems that go 1.6m to 2.0m kilometres versus light vehicles, where typical products are in the 161,000 -483,000 kilometre range. We are able to take some of the design solutions we've done for commercial and transfer that into the light vehicle sector."

But, of course, such solutions are heavily dependent for their success in a business where legislation and regulations seem to be developing almost exponentially. Surely this must make futuring a challenging and complex process?

"Absolutely. If you look at it, regulations and legislation have a major impact in many areas of the world. So, from a futuring standpoint, technology trend and solution standpoint, we absolutely look at that. Also, in parallel, we factor in what the marketplace is pulling, in addition to what the regulations and legislation are demanding for pure efficiency, lightweighting and more efficient vehicles. When we're looking at trends, we look at a wide variety of pull factors and it works quite well. We're able to develop solutions and products that hit the market at the

right time and positively affect our end customers.

"There are some trends that go across the globe, so fuel efficiency, emissions control, lightweighting, all of those are across the markets, whether the western or emerging sectors. There are areas that we watch very closely, when it comes to regulations and legislation. So, for instance, in the 'States obviously we're very familiar with the light vehicle regulations, but recently truck regulations were put in place, in terms of improved fuel consumption. Fortunately, we had anticipated that, and have products that will hit the market in time and ahead of those regulations.

"And we do the same whether it's in China, Europe or Brazil. They're all a little bit different when it comes to timing, but we are anticipating and work very closely with our people in the countries, as well as with governments, to try to understand when the regulations and legislation will occur."

LIGHTWEIGHTING FOCUS

Lightweighting is a key focus for Dana, especially in its drivetrain systems, as Constand explains: "The use of lightweight materials themselves is one of the keys to achieving these lower weights; so, for example, the use of aluminium throughout our light vehicle and commercial vehicle off-highway business units is being highly utilised. As an example of aluminium driveshafts, which Dana has been involved with for more than 20 years, we have expanded the use of these, because in the past it has been torque limited, in terms of where you can use aluminium and where you can't.

"But we have proprietary technology that utilises magnetic pulse welding, which, essentially, joins steel end fittings that are needed for the higher torque applications. Using an aluminium shaft, we're able, in a commercial vehicle application, to save over 45Kgs. In light vehicles, it's somewhat less, but it's still very much a desired attribute to take that weight out and it's something that only Dana can do."

The "beauty" of this solution, according to Constand, is that it doesn't use exotic high-grade aerospace aluminium, but "a rather more common aluminium grade in our tubes. But not such that it becomes a cost inhibitor. I don't want to get into the specifics on materials, but I would say that you suggesting 3000-4000 grades is quite close".

Composites, too, are in the frame as an option, says Constand. "We're looking at applications for composites. We have had composite driveshafts in the past, but we're not currently using them today, although they're certainly an option. We find that, between our steel and aluminium solutions, we don't a see a need at this point for composites. We're more in the advanced stages of looking at composites for other areas of the drivetrain.

"In fact, Dana had provided prop shafts with a woven structure back in the 1990s. It is a technology that's out there and I think it depends on the application as to what's required in higher volume applications. We're finding right now that between the aluminium solutions that we have

and our proprietary technology that we can meet most requirements, whilst there are also steel applications that our customers demand."

SIGNIFICANT IMPROVEMENTS

Hybridisation across the on-road and off-road sectors is very much a buzz word, as OEMs strive to achieve forthcoming fuel efficiency and CO_2 demands in the next decade or so. "We have various areas of hybridisation that we look at that provide significant improvements in fuel efficiency, operator performance and durability. Across the business units, we offer several different hybrid solutions that could be electric or hydraulic. We're looking at kinetic and also fuel cell solutions.

"My general comment here is that each application has a different optimal solution. What I am pleased with is where our engineers and technologists are taking us at Dana to deliver different optimal solutions, based on the application that customers and OEs demand, and we have the expertise to deliver.

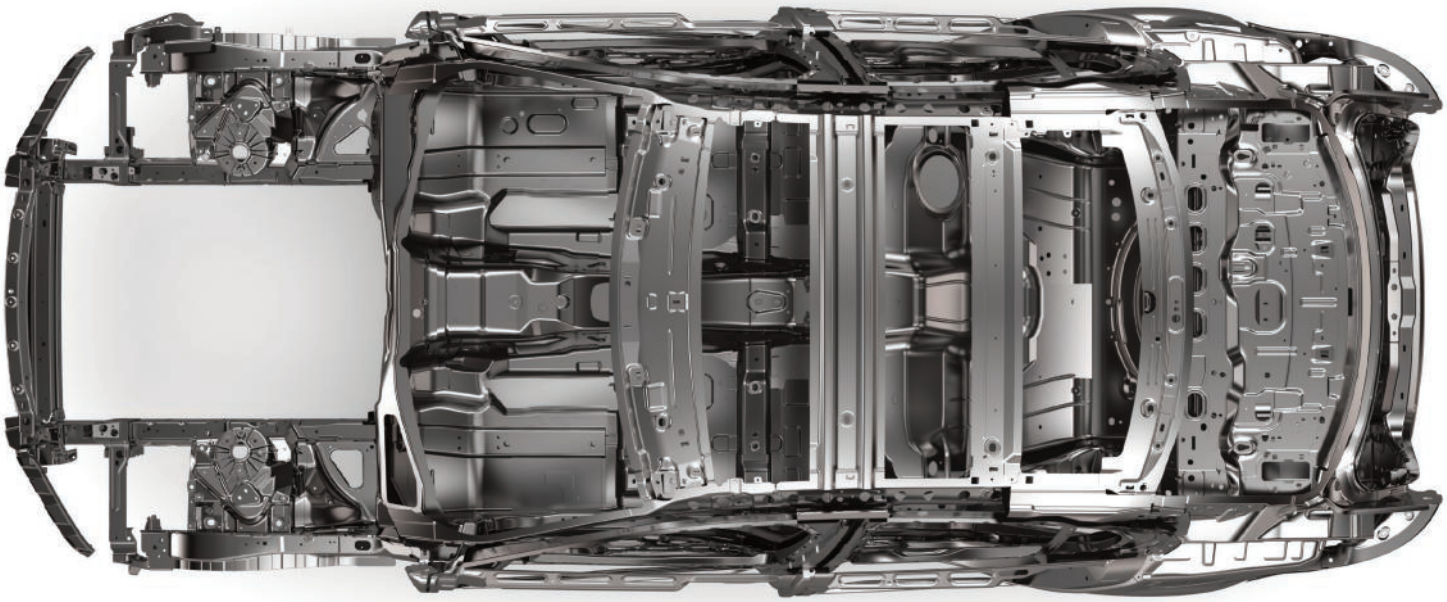
"I think that we at Dana can provide solutions, whether they are electric, hydraulic, mechanical kinetic, depending on the application. We've got some of our advanced technologists working on those solutions.

"I don't want to give a specific answer as to when our kinetic recovery system would be available. That's dependent on working with specific OEs. It's a future technology and application; when it will arrive depends on the maturity of the technology and how our OEs want to implement it. It's really too early to comment on a specific timeframe."

In summing up, Constand emphasises: "The other thing Dana is doing is utilising data to drive our differentiator solutions. The solutions that we are developing are based on and backed up by data that enables us to deliver, for example, lightweight fuel-efficient technologies that can be customised to add even greater value to individual vehicle platforms. We also believe that the future of the automotive industry will be driven by utilising data and network solutions, either from or for our customers and producers to make the right decisions."

"I think that we at Dana can provide solutions, whether they are electric, hydraulic, mechanical kinetic, depending on the application. We've got some of our advanced technologists working on those solutions."

Test mules covered thousands of kilometres at the Nurburgring to hone its dynamics (left).
All new aluminium structure is state of the art, but contains steel as well to achieve perfect 50:50 weight balance (below)



JAGUAR'S LIGHTWEIGHT CHALLENGER

Ian Adcock uncovers the secrets that make the XE saloon, Jaguar's most important car yet.

This, the aluminium intensive XE, is arguably the most important car that Jaguar has launched in its 92-year history. There have been more iconic, notably the E-Type, but it's fair to say Jaguar's future hinges on this new mid-size saloon poised to take on the might of German rivals like the BMW 3-series, Audi A4 and Mercedes-Benz C-class.

But there is more to XE than that. It represents a turn round in British automotive engineering and manufacturing and a faith in its home lands ability to design, engineer and manufacture cars that bear scrutiny against the best in the world. It stands alongside transplants from Nissan, Toyota and Honda or the Mini's revival as an affirmation that the UK is, once again, a centre for automotive manufacturing and engineering excellence equal to any.

However, to make an impact against its Teutonic rivals Jaguar's management has taken the bold move to offer a car brimming with technological innovation. It is rare these days to launch a completely new car, but Jaguar has had the confidence to do just that: aluminium intensive body structure, a new engine range, new suspension, even the transmissions have been given a thorough overhaul and update.

> At just 251Kgs ... Jaguar believes the bodyshell is the lightest in its class and features a number of material advances over other aluminium vehicles from Jaguar Land Rover.

Parent company, TATA, has invested £1.5 billion in the project creating 1700 new jobs and erecting a new 160,000 sq.mtr production facility at its Lode Lane site that will see a vehicle appear every 78 seconds at maximum production capacity. And at 85,000 sq.mtr the aluminium body shop is the largest in Europe with 613 robots and unique 'Trunnions' developed with the Expert Group to hold bodyshells in place while riveted.

SHEDDING THE KILOS

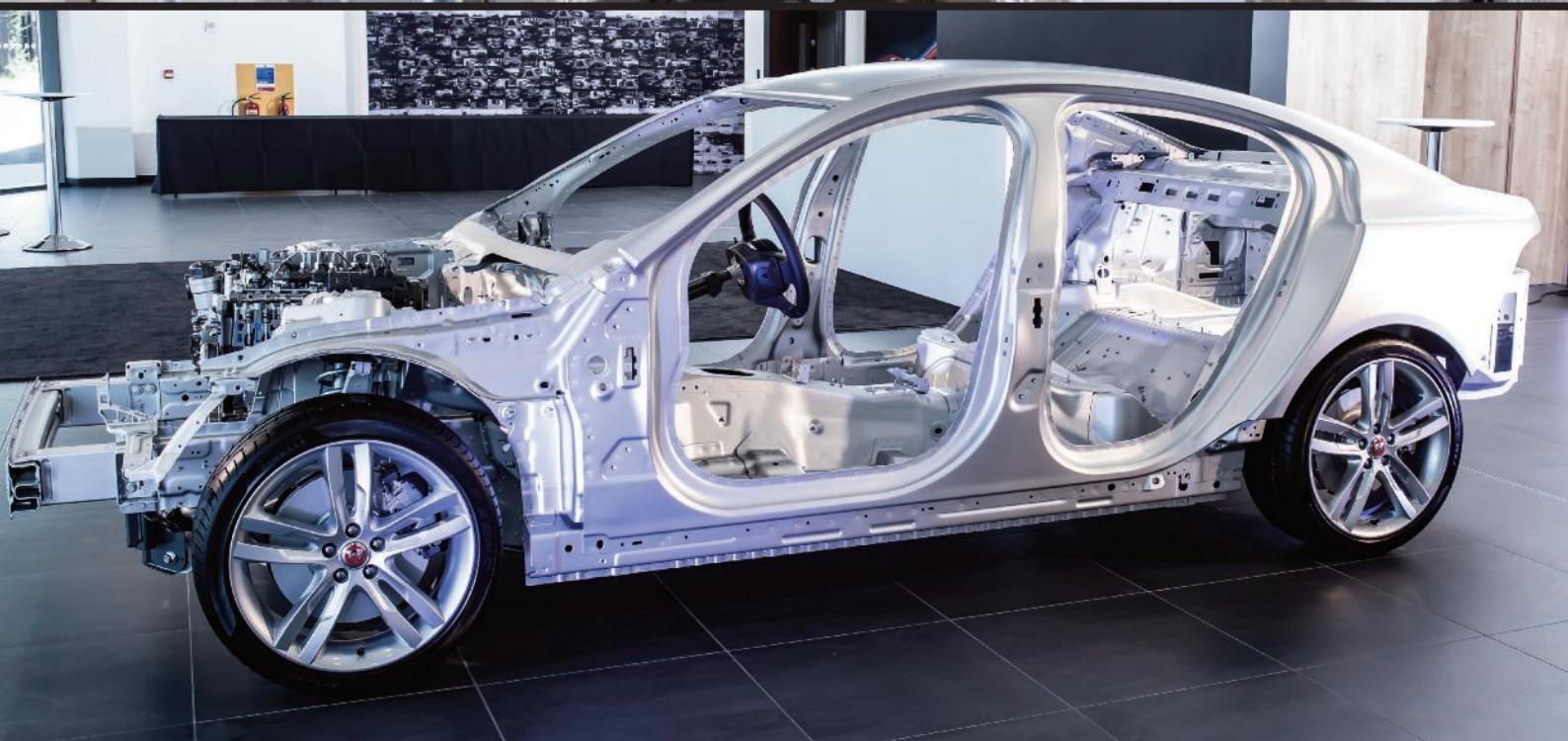
The Jaguar XE, known internally as project X760, is based on a completely new platform (D7a) that will underpin future generations of both Jaguar and Land Rover products.

At just 251Kgs, (unpainted complete body 342Kgs) Jaguar believes the bodyshell is the lightest in its class and features a number of material advances over other aluminium vehicles from Jaguar Land Rover.

Foremost is the first application of RC5754 developed with Novelis as Dr. Mark White, chief technical specialist light weight vehicle structures explained: "We will be generating a lot of processed scrap in higher volumes with this car and we will be getting end of life vehicles starting to come back in 5-10 years time so we decided to take the pioneering step towards full closed

Photos: Mark Fagelson and Stuart Writtle

The XE benefits from many of the improvements that were integrated into the 2012 Range Rover. The main breakthrough being in the reduction in riveting cycles which is now down to 78 seconds



The 'A' posts and cant rail are purely a sheet based design all using 6000 series and a combination of AC600 and AC300T6I in major crash structures. The 'B' posts comprise of a combination of aluminium, steel and structural foam to, effectively, form a sandwich structure to achieve side impact performance.

loop recycling including aftermarket scrap. RC5754 is the first of a highly recycled alloy used in automotive application and we will go on to develop more."

Novelis supply the sheet metal for the bodywork including 6000 series which has allowed Jaguar to reduce material thickness from 1.5mm to 1.1mm resulting in a 27% weight reduction with no loss in strength or durability. AC300T61 is used in the front crash structure with Sapa, Hydro and Constellium providing extrusions, Magna the shock tower castings whilst Meridian supplies the magnesium cross car beam and front end carrier.

VARIED MATERIALS

The XE is not 100% aluminium, and features steel closing panels for the doors and deck lid and the rear boot underfloor. "This," says White "was to achieve perfect 50:50 weight distribution with a low centre of gravity for refined ride and class-leading dynamics."

The 'A' posts and cant rail are purely a sheet based design all using 6000 series and a combination of AC600 and AC300T61 in major crash structures.

White is particularly pleased with the 'B' posts which comprise of a combination of aluminium, steel and structural foam to, effectively, form a sandwich structure to achieve side impact performance.

Dimensionally, the D7a underpinnings will form the basis of both future Jaguar and Land Rover products; the dimension from the front bumper to the back seat heel board remains the same, with hard points like the sills, front and rear suspension points remaining constant. However, it would be possible to reduce the rear floor's length as well as make the vehicle taller. Although the width is stable it would be feasible to 'cheat' by making the sill thicker.

XE is 20% stiffer than the XF body with what White describes as "good modal separation between body and powertrain"; 70% of the materials are high strength alloys with the remaining 30% 5000 conventional grades.

The big challenge for White and the manufacturing team was to develop systems that would make assembling an aluminium body-in-white in almost the same time as a conventional spot welded steel body-in-white, and at 78 second cycle time, White believes Jaguar has achieved that. Getting the riveting cycle down to sub 2 seconds was the key and that has been achieved by developing with Henrop more flexible rivet guns that can feed more than one rivet, switching from hydraulic to electric guns which are quicker and more precise and blow feeding the rivets rather than using a tape system, "We've gone from 6 seconds per rivet per car to 1.5 seconds, to put that into perspective the original aluminium XJ's cycle time was four and half minutes, the XE is 78 seconds."

In total 2772 self piercing rivets, per car, and 455 guns are employed in production. Each car is bonded using 115 metres of structural adhesive which, although they haven't changed in composition, are now applied from heated barrels, lines and dispenser to achieve the correct viscosity time/temperature performance that was needed; the adhesive used between the steel and aluminium acting just as much as an isolator as an adhesive.

"We know that other cars in the future will have a lower cycle time, but we think that XE is pretty much state of the art. It's about the number of rivets you can put on in a cycle. Getting the riveting down to less than 2 seconds and, depending on the station, can put in anywhere from 6 up to 30-40 rivets."

The lightweight theme is continued elsewhere in the car from its all-new Ingenium alloy-block four-cylinder engine to the modular front double wishbone suspension and integral link rear axle, a first in the size sector.

SLIPPERY CUSTOMER

With a Cd of just 0.26, XE is the slipperiest production Jaguar to date with its aerodynamics wholly developed using Computational Fluid Dynamics that assisted development of a smooth underfloor running from the front spoiler to the rear diffuser that equalises airflow over the car.

CFD also helped reduce wheel rotation losses with airflow guided into the front wheel arches via the front spoiler intakes and 17-inch aerodynamic wheels. The more powerful models will also benefit from integrated brake cooling scoops mounted to the front suspension that direct cooling air to the front discs as well as active cooling shutters that open and close according to vehicle speed and engine temperatures.

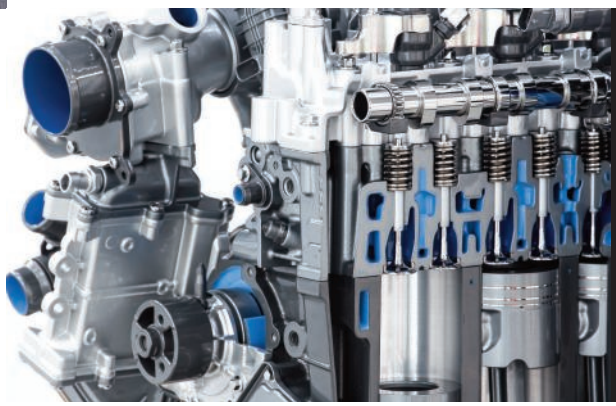
Merging the engineering departments of Jaguar and Land Rover has resulted in some interesting crossover of ideas and technology, not least of which on XE

is the, again, patented All Surface Progress Control (ASPC) which was born out of Land Rover's Terrain Response technology, albeit much simplified for this two-wheel drive application: this functions like a low speed cruise control between 3.6 Km/h and 30 Km/h under slippery or split μ conditions when traction is minimal. The driver simply sets the speed and the car's engine management system will deliver precisely the right amount of power to deliver optimum traction for the conditions without the driver needing to operate the throttle, simply concentrating on steering.

INGENIOUS INGENIUM

Meanwhile the new family of Ingenium petrol and diesel engines, it is claimed, have some 20 patents pending many in software and control algorithms but also, a mechanical one designed to reduce noise from the timing chain driving the high pressure fuel pump. To change the sinusoidal input, Jaguar engineers distorted the fuel injector drive sprocket into an oval by just 0.5mm to eliminate unwanted noise.

JLR is gradually weaning itself away from its Ford and PSA engine partners, the first step of which is its £500+ m investment in a new 100,000 sq mtr engine plant which will see a new derivative of the Ingenium family launched every 3 to 6 months for the next 2 years before, eventually, the factory will be producing an engine every 39 seconds.



New Ingenium engine range feature switchable piston cooling jets, computer controlled variable oil and coolant pumps, simplified cam drive system and offset bore and low friction piston ring packs

The first engine to be revealed, more will follow at the Paris Motor Show in a few weeks time, is a 99g/kms CO2 two-litre, four-cylinder diesel.

Both petrol and diesel engines are based on a common 500cc cylinder capacity with key parameters such as bore centres, deck heights etc. shared allowing all derivatives to go down the same production line; in fact, JLR claim a 30% commonality between the petrol and diesel engines with items such as the balancer shaft and cam shaft needle roller bearing common although the shafts themselves will be unique. Whilst the common bore size allows them to add or subtract cylinders as needed.

Ingenium has also been future proofed for cylinder deactivation, variable inlet camshaft timing and hybridisation.

Steel
High strength steel
Aluminium
High strength aluminium
Cast aluminium
Cast magnesium

X760 BIW less Closures (unpainted) – 251kg
166kg aluminium (66%) & 85kg steel (34%) by weight
75%/25% by surface area
JLR D7a BIW concept designed to be class leading weight relative to Premium OEM's
Body less Doors mix of 6000 & 5000 aluminium, with Steel/HSS rear end under-body
Closures are aluminium at front of the car & steel at the rear for weight distribution
Target to achieve 50/50 weight distribution for vehicle for optimum vehicle dynamics

Kevin Jost, The Columnist
SAE International Editorial Director

High APEAL

Long a favourite of enthusiasts and others, the M version of the BMW 3 Series has been replaced with the M3 four-door saloon and the new M4 two-door coupé. Both models surpass their predecessors by nearly every performance measure.

A further reinforcement of their favourite status is that the 4 Series was recognised as the most appealing compact premium car in its segment, according to the J.D. Power 2014 U.S. Automotive Performance, Execution, and Layout (APEAL) study released in late July. The study shines the spotlight on new-vehicle benchmarks, with owners evaluating their vehicles across 77 attributes that combine into an overall APEAL score measured on a 1,000-point scale.

HIGHEST RANKED

In the 2014 study, Porsche was the highest-ranked nameplate in APEAL for the 10th consecutive year at 882, compared to the premium industry average of 840. For the first time, Hyundai ranked the highest among non-premium brands, at 804, marking the first time a nameplate has ranked highest among non-premium brands in both APEAL and IQS (Initial Quality Study) in the same year.

Dodge and Porsche received three segment awards each, the former for the Challenger, Charger and Dart, and the latter for the 911, Boxster and Cayenne. Receiving two segment awards each were Audi (A8 [tie] and Q5), Ford (F-150 LD and F-250/F-350 Super Duty), Mercedes-Benz (CLS-Class and S-Class [tie]) and Nissan (Rogue and Quest).

Amidst all of the award winning, some of the findings were not quite so rosy. The overall APEAL score for all cars decreased slightly to 794 from 795 in 2013. Fuel economy was the only category that saw improvement, jumping six points. Study researchers attribute this boost in part to an average decline of 3% in fuel prices during the survey period, compared with 2013, and average reported fuel economy improvements to 25.0 (US) mpg from 24.5 in 2013. However, fuel economy continues to be the lowest-scoring category in the study by a wide margin, says Renee Stephens, vice president of U.S. Automotive at J.D. Power.

MAJOR CHALLENGE

While satisfaction in areas such as fuel economy has improved, one major challenge is the usefulness of controls and functions for navigation, voice recognition and other technology applications. To differentiate new models from the pack, automakers must continue to design systems that are not just attractive, but also intuitive and easy to use, according to Stephens.

User-friendliness will be all the more important, since the J.D. Power 2014 U.S. Automotive Emerging Technologies Study released in May shows that the technologies consumers want most are those that allow them to access the entertainment, information and connections they currently get from their smartphones. The solutions from automakers and suppliers will have to approach the ease-of-use and continuous improvement demonstrated by the manufacturers of mobile devices.

focus@sae.org

BOXING CLEVER

Damien Guillon and Matthieu Kneveller of Cetim, and Alain Leroy and Jean-Philippe Sauvaget of Momentive Specialty Chemicals Inc, describe how composite crashboxes save weight and cost

To use composite materials in primary structures of vehicles and mobile equipment, it is necessary to control their crash behaviour. Solutions exist in sports cars to reach an energy absorption level of typically 50 to 80 kJ per kg of crushed composite material. These solutions are based on carbon/ epoxy materials with complex pre-forming and manufacturing, and are therefore not economically applicable for common vehicles.

The main requirements in the automotive industry are low cost and high manufacturing rates of the parts. Current designs use metallic crashbox and body-in-white (BIW) to absorb the required amount of energy to protect the passengers, thanks to yielding created by local buckling.

Such design costs somewhere in the region of €3/kg of parts to be produced, and may be made thousands of times per day, due to processes like stamping and welding.

Currently, decreasing the costs is seen as more important than reducing the weight. Compared to a penalty of €95/g of CO_2 emissions above the regulatory target that will be applied by the European Commission after year 2020, a cost of €9.5/kg of lightweighting may be acceptable, as a 10-kg reduction in the vehicle weight results in a CO_2 emissions reduction of approximately 1 g/km.

Concerning the process time, production of 1,000 parts/day is needed to address the mass market. Additional requirements are given by adaptation constraint of the vehicle to its environment:

A front-end module is fixed on the crashbox and must be kept linked with the BIW, even after the crash;

Crashbox must be easily mountable and dismountable for final assembly in factory and reparability in after-sale workshops;

Dimensions are limited by the targeted vehicle compactness;

Finally, performance must be consistent on a broad range of test parameters, as crash scenarios change from one case to another. In particular, performance in off-axis crushing must be checked.

Conical geometry, Epoxy 1K aerospace grade matrix, 24K carbon fibre: influence of bias angle and crash inclination

	Mean of SEA (kJkg)	Standard deviation (kJkg)
Bias angle : 25°		
Crash inclination: 0°	50.5	2.3
Crash inclination: 15°	35.5	2.3
Bias angle : 30°		
Crash inclination: 0°	48.6	6.1
Crash inclination: 15°	33.2	Only one value
Bias angle : 45°		
Crash inclination: 0°	47.6	4.0
Crash inclination: 15°	44.2	1.3

ASSEMBLY SOLUTION

On account of the high cost of the material, especially carbon fibre (CF), design-to-cost analysis shows that only very simple shapes can be used for the crashbox design. Material waste must be reduced to a minimum; therefore pre-form must be produced by an in-line process. In addition, a one-step process should be chosen, including the triggering mechanisms.

The assembly solution for linking the crashbox to the car is a key aspect of the innovation. The tested solution will not be detailed here, due to patent-pending matter, but the following principles are used:

Mechanical clamping with simple interface parts, on easily produced shape, with tolerance to manufacturing scatter;

Clamp length adapted to fulfill off-axis bending strength requirement;

Regular or symmetrical shape to avoid localised effect that may change the crash behaviour.

Several processes adapted to this design have been evaluated to check the achievable performance. Due to the variety of tested parameters and to the manufacturing constraint, a complete experimental plan has not been set up.

A crashbox has been made with a conical geometry of 150 mm length, approximately 5 mm thickness, 100 mm outside diameter at the larger end, and 2° of apex angle.

The conical geometry has several benefits, including crash behaviour that is progressive and robust in case of off-axis crush; more efficient in the proposed assembly concept; and it facilitates the demoulding, which will be a plus at high production rate.

Triaxial braided pre-form has been used and the following parameters have been tested:

Carbon tow: 24K (Toray T700S) or 50K (SGL Group Sigrafil);

Bias fibre orientation: Pre-forms are made with 50% of axial fibre and 50% of bias fibre with ±25°, 30°, or 45° orientation;

Matrix: Mono component epoxy (resin transfer moulding [RTM] toughened aerospace grade) or bi-component epoxy (high-pressure RTM [HP-RTM] EPIKOTE resin 05475/EPIKURE curing agent 05443 and developmental grade) from Momentive Specialty Chemicals; or mono component thermoplastic (PA6).

Conical geometry, Epoxy 1K aerospace matrix, 30° bias angle: influence of carbon tow and crash inclination

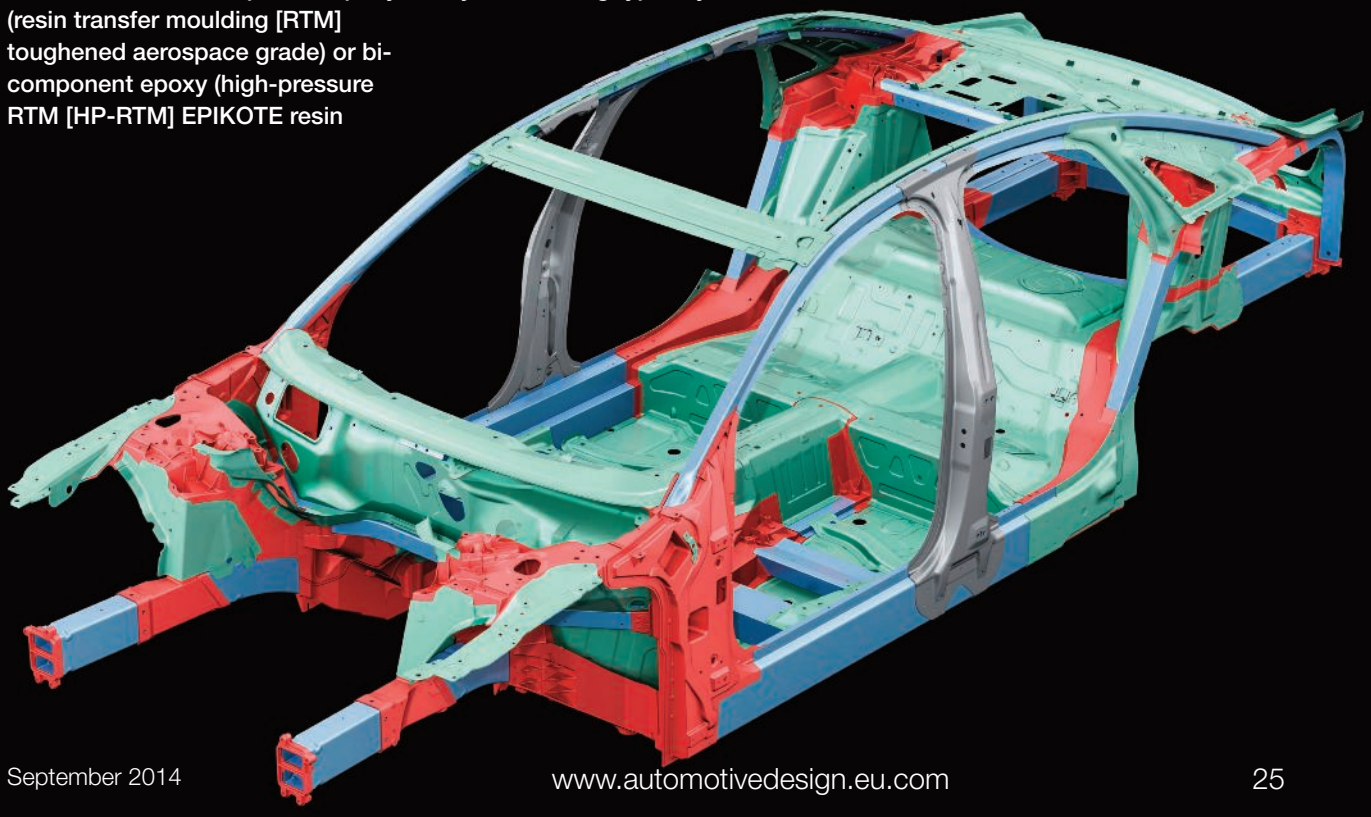
	Mean of SEA (kJkg)	Standard deviation (kJkg)
Carbon tow 24K		
Crash inclination: 0°	48.3	4.3
Crash inclination: 15°	37.8	5.1
Carbon tow 50K		
Crash inclination: 0°	39.6	4.4
Crash inclination: 15°	29.5	2.3

COMPLEX PARTS

All configurations have been produced in the same RTM mould. Epoxy RTM systems are already well established on the market, while thermoplastic RTM still need process development. 50K carbon tows were selected as the low-cost CF product option.

The RTM aerospace system is a one-component (1K) toughened system, curing typically at 180°C, offering low processing viscosity and a wide processing window up to 10 h. It offers the ability to design complex parts.

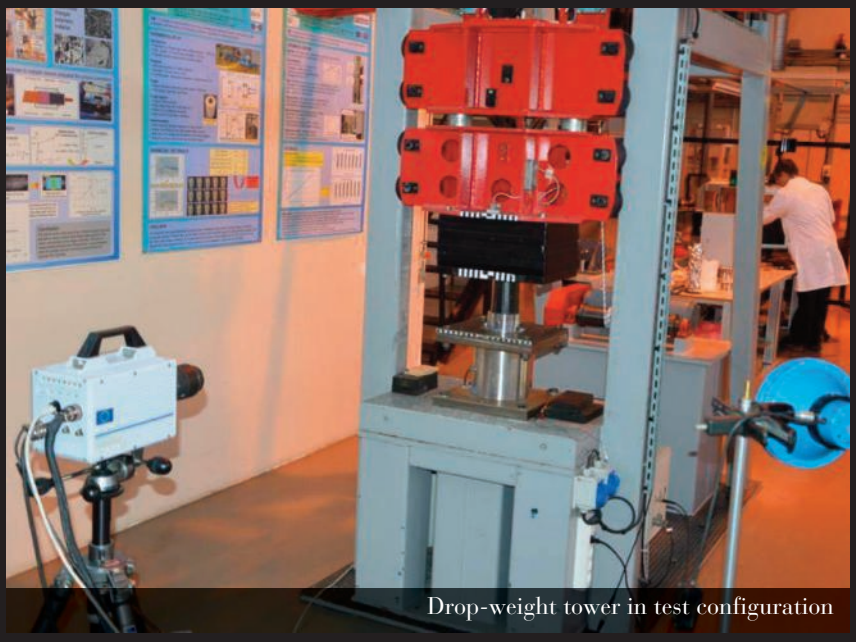
The new thermo-latent fast cure EPIKOTE/EPIKURE epoxy resin systems allow the rapid and reliable processing of structural composite components, using high-volume manufacturing techniques. These systems have a cure cycle time of approximately 5 min and 2 min at 120°C, and can be processed via all common RTM techniques, such as multi-component low-pressure and high-pressure RTM machines.



The new systems provide benefits such as a very low viscosity of less than 50 mPa·s at the injection temperature and a thermo-latent behaviour, allowing a relatively long injection window up to 90 s before reacting. The resin system features excellent wetting and adhesion to carbon fibres, superior thermal and mechanical performances, and very low VOCs, making them viable solutions for a wide range of future applications.

The EPIKOTE/EPIKURE resin system, with the internal mould release agent HELOXY Additive 112, has been used to build the first series of crash cones at high production rate. This system cures fully within 5 minutes at 120°C and allows reaching the target production rate of 1,000 parts/day, and consequently enables a cost-viable solution.

A new thermo-latent fast cure and enhanced epoxy resin system is under development to offer enhanced impact performances. The PA6 Evolite from Solvay is a polyamide-based matrix suited to continuous glass or CF composite materials. It offers enhanced impregnation capability generated by the high fluidity of its polymer compounds.



Drop-weight tower in test configuration

CRASH TEST RESULTS

A high number of crash tests have been performed in the framework of this study. The results revealed that the axial crash performance increases slightly as bias angle decreases. On the contrary, for 15° off-axis, better performances are achieved with 45° bias angle.

This could be linked to the enhanced hoop stiffness, which stabilises the crush mode in off-axis crash. Crash mode is mainly fragmentation for all these tests.

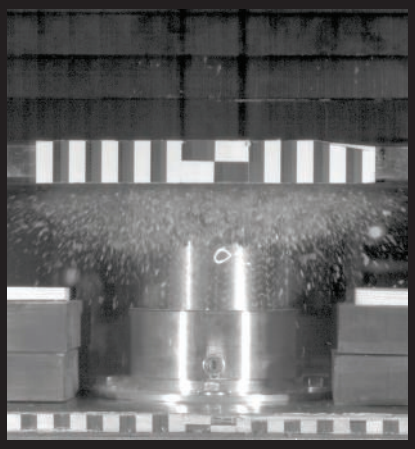
Axial and off-axis crash performance decreases when low-cost heavy tow is used. The performance gap is around 25%, which is approximately the price gap between the fibres. The fast-curing epoxy offers the same level of performance as the aeronautic 180°C grade epoxy. Higher performances were obtained when using a toughened, non-commercial, fast-curing epoxy grade. This grade also offers an attractive crushing mode, with a good compromise of fibre and matrix fragmentation.

Fluid TP PA offers slightly lower performances than the epoxy systems tested. Obviously, the process conditions need to be adapted, as the PA parts presented dry fibre domains that may explain the lower results. The crushing mode observed is different, as the thermoplastic folds and limits the fragmentation of the carbon fibres. Work is still underway to evaluate other types of thermoplastics material with this crashbox.

For process optimisation matters, the influence of the fibre twist on crash performance of the composite has been examined. Fibre twisting may be useful to facilitate the textile process, but the impact to material performances needed to be reviewed. Concerning crashworthiness, it has been found that twisting does not influence the test results. Tests on cylindrical weaved tubes have led to the same conclusion.

Cylindrical geometry, 48K carbon fibre: influence of weaved preform type and crash inclination

	Mean of SEA (kJkg)	Standard deviation (kJkg)
Wrapped		
Crash inclination: 0°	41.5	5.9
Crash inclination: 15°	31.7	0.6
Interlock		
Crash inclination: 0°	45.5	2.0
Crash inclination: 15°	36.2	1.5



Crashbox MSC

Cetim and its partner Momentive Specialty Chemicals Inc propose to automotive designers a composite crashbox, based on a conical design. A manufacturing study was performed and it demonstrated that, with only one braiding machine, one standard bi-component RTM press, an injection tool allowing simultaneous injection of nine crashbox parts and a fast-curing epoxy system, a 1,000-parts-per-day production is feasible. The cost of one part should be about €10.

Easily adaptable to current vehicle design, the conical crashbox concept assists with the lightweighting of a vehicle's BIW – a 66% weight reduction can be achieved, compared to current steel parts. In addition, obtained specific crash performances are tripled to those of a traditional steel part.

Research strategy on composites is focused on the development of a new process to allow easier use of thermoset and thermoplastic material in the automotive industry. This study obtained comparable results between fast-curing epoxy and high-performance aerospace epoxy with carbon-fibre composite. PA processed for the first time by RTM offers slightly lower performances than the epoxy systems tested. (Previous study on composite with high-performance thermoplastic matrix has shown greater SEA for this type of composite.)

Additional research can be conducted to enhance the findings in both plastic families (modified epoxy, pre-form quality, enhanced fibre fraction, fibre/matrix adhesion, less porosity etc), leaving the door open to many future developments toward tailor-made composites performances. R&D work with textile manufacturers is also needed to find better ways to produce pre-forms at a lower cost and with higher performances.

CONVERTING to a better future

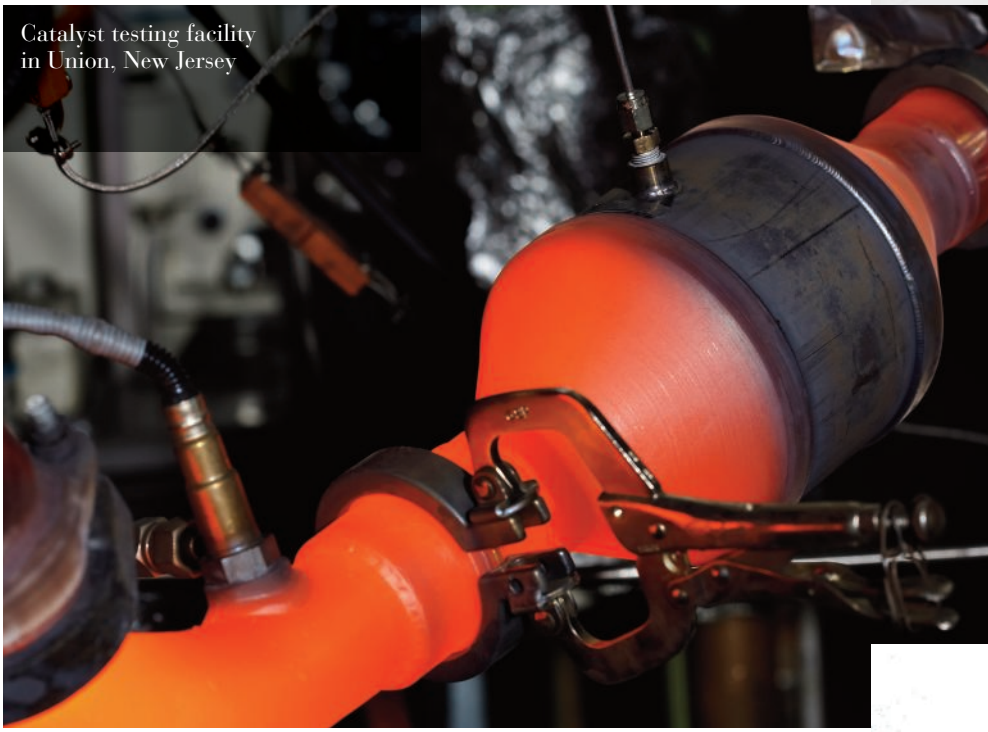
Inlet and exhaust systems aren't the most glamorous of technologies, but, as *Automotive Design* discovers, they are becoming increasingly important

In the past 40 years, catalytic convertor technology has made huge strides forward: today, it takes more than 100 cars with catalytic converters to produce the same emissions from just one pre-1974 vehicle. But there are packaging and cost issues, as underbonnet space is now at a premium and rare metal prices are soaring.

Volvo Cars, in conjunction with Emitec, has developed a standardised catalytic converter architecture for its Drive-E diesel and gasoline engines – the scaleable Compact Cat. The system covers both Euro 6 and SULEV applications for gasoline engines, as well as Euro 6 applications for diesel engines.

The standardised design using shared parts results in a considerable reduction in unit costs and tooling requirements. Moreover, vehicle attributes are also improved, such as reduced fuel consumption, by means of better heat management and efficient back pressure balance. The system's compactness allows for liberated space, which could be used, for instance, in case subsystems for electrification are needed.

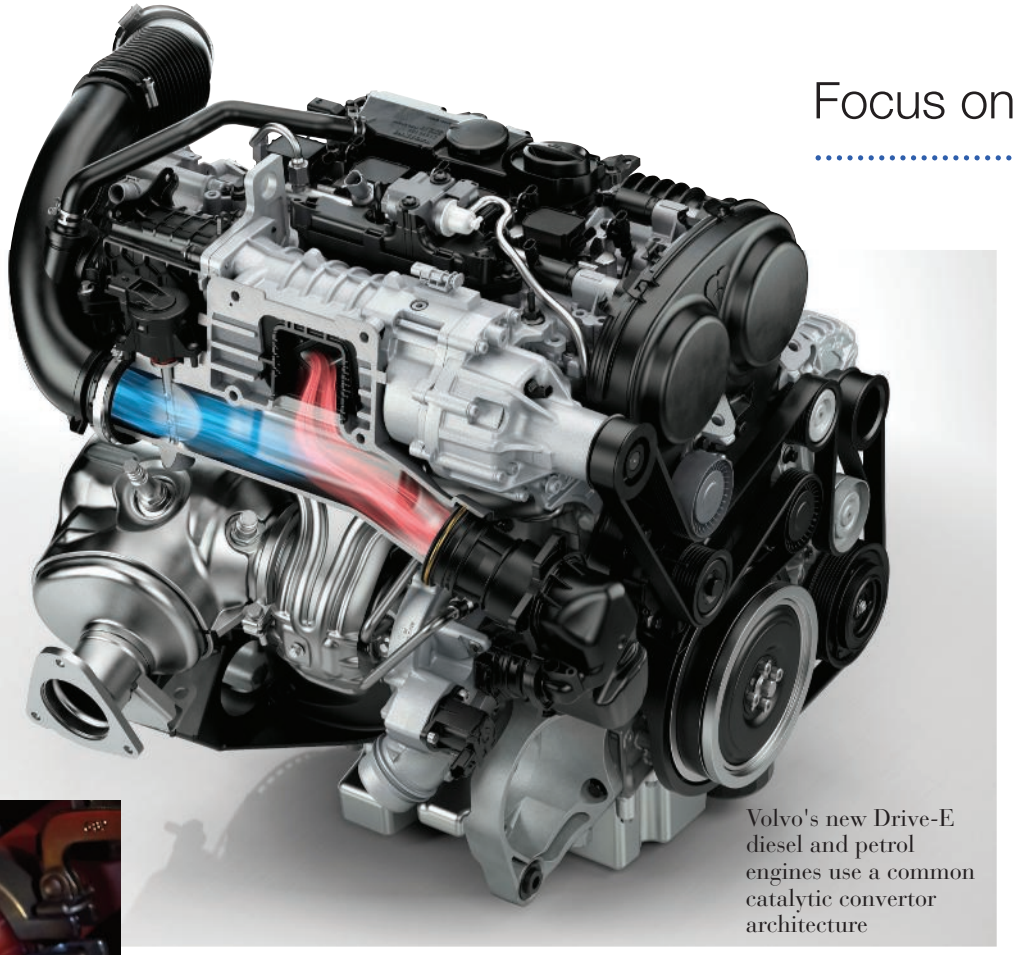
While working with engineers at Chrysler, Emitec questioned what would happen to light-off temperature and hydrocarbon conversion, if the zoning – ie, the concentration of the Platinum Group Metal (PGM) in specific areas of the catalyst – was changed. By shortening the zone length from 50% of catalyst space to 10%, while retaining the same overall mass of palladium per part as the zoning faction decreased, concentration of the palladium increased. This resulted in catalyst light-off, or operating temperature, performance peaking at a zone fraction of 15%, with an overall improvement of 18% or 11 mg/mi of combined NMOG+NOx emissions obtained, without using additional PGM.As palladium contributes to, on average, 85% of the total precious metal cost in the emissions system, the potential financial benefits that might be gained are clear.



Catalyst testing facility in Union, New Jersey

NOVEL COATING DESIGN

BASF is another supplier that offers different solutions to achieve SULEV standards. Its Three-Way Conversion (TWC) catalyst features a novel coating design that optimises the use



Volvo's new Drive-E diesel and petrol engines use a common catalytic convertor architecture

of precious metals (eg, platinum, palladium, rhodium). These designs, it is claimed, help to outperform conventional three-way conversion catalysts in the oxidation of hydrocarbons (HC) and carbon monoxide (CO).

Additional benefits include: fast light-off performance for hybrid, turbo and gasoline direct injection engines; superior durability and temperature stability; and stable oxygen storage function to help meet On-Board Diagnostics II (OBDII) requirements. Meanwhile, its Four-Way Conversion (FWC) Catalyst is a single component catalyst that can remove Particulate Matter (PM), as well as carbon monoxide (CO), hydrocarbons (HC) and nitrogen oxides (NOx) from gasoline engine exhaust. The FWC catalyst combines the functionality of the TWC with a filter to remove all four pollutants with just one component. Additional benefits include: low backpressure impact, reduction in system complexity and potential to reduce package space.

Meanwhile, on the engine side, its EvapTrap is the industry's first coating-based solution that adsorbs harmful hydrocarbons inside a vehicle's air intake box.

This polymer-based coating is infused with activated carbon and proprietary zeolite, with the coating applied directly onto the surface of the vehicle's existing air-intake box design. The EvapTrap adsorbs harmful hydrocarbons and is said to reduce evaporative emissions by 99.9%

Additional benefits include: zero pressure engine performance drop, and a fully customisable and adaptable application process and tamper-proof solution.

Staying on the inlet side, MANN+HUMMEL's Active Noise Control (ANC) system uses less space, because it does without large resonators. It consists of a controller from Eberspächer, supplier of exhaust and air conditioning technology, and of the loudspeaker and microphone components from MANN+HUMMEL.

Mann + Hummel air filter intake assembly

IN CONTROL

The basic principle is that, depending on speed and load, the controller supplies a signal with the right phase to the loudspeaker. The sound component emitted by the loudspeaker then overlaps with the engine noise. In this process, the peaks and valleys of sound oscillations meet and cancel each other out. A microphone measures the deviation from the required value to enable a control loop. The loudspeaker and microphone are integrated in air cleaner systems.

A feature of the ANC is that the system is effective in a significantly wider frequency range than conventional resonators and reduces the noise more efficiently. Also, the ANC system is more compact, requiring less room in the engine compartment, which is chronically short of space. A further application is the selective generation of simulated operational noise or warning sounds for hybrids.

Tenneco has taken its expertise in clean air technology and systems integration to the next level with its hydrocarbon manifold dosing solution, which injects diesel fuel directly into the engine manifold, providing more efficient regeneration of the diesel particulate filter. The HC dosing vaporiser and injector are integrated into the engine manifold, with the hot environment helping to evaporate the fuel quickly, which, in turn, aids in optimising distribution of hydrocarbon oxidation and mixing performance.

Winds of change **grow stronger**

***Automotive Design* reports on power steering systems and their increasing functionality**

Steering systems, like most other controls in cars, have developed from simple mechanical devices engineered to direct the vehicle according to the driver's inputs into sophisticated electric, hydraulic and electro-hydraulic systems that are beginning to be interlinked with other systems within the vehicle.

While purists may debate whether electric or hydraulic offers the greatest feel to the driver – with Porsche and Jaguar, for example, on opposite sides of the fence – in all probability electrically powered steering is likely to become more prevalent as a means regarding how the driver can have his or her control over the car expanded.

Earlier this summer, TRW demonstrated its Emergency Steering Assist (ESA) at a technology event held at the Hockenheimring in Germany. ESA helps support the driver in an emergency situation when an evasive steering manoeuvre is initiated. The system applies an additional steering torque during the manoeuvre and assists the driver in lateral vehicle guidance.

COLLISION AVOIDANCE

Dr Carsten Hass, engineering manager, Integrated Active & Passive Safety Systems, TRW, comments: "Emergency Steering Assist is our next step in collision avoidance. For example, if you swerve to avoid an obstacle, the system will calculate the optimal trajectory around it, and additional steering torque will be applied to help to follow the trajectory and stabilise the car. The driver remains in control of the vehicle and can override the system at all times. ESA is designed to enhance the driver response by helping the driver to react faster and more accurately."

ESA integrates data from TRW's video camera and radar sensors to provide an accurate and real-time image of the road ahead, with an interface to the electrically powered steering (EPS) system. TRW has developed the system together with the TU Dortmund (Technische Universität Dortmund) and anticipates that the technology will be ready for production in 2017 for 2018 model year applications.

So how does it work in practice? Approaching an obstacle at 70 Km/h, the manoeuvre is initiated within 1.3 secs of a collision taking place to allow the driver to control the car, if the system doesn't kick in. The motor feeds in an additional 6Nm torque, resulting in quite a powerful wrench as it applies lock, although this was

Nexteer Automotive's pinion-assist steering system

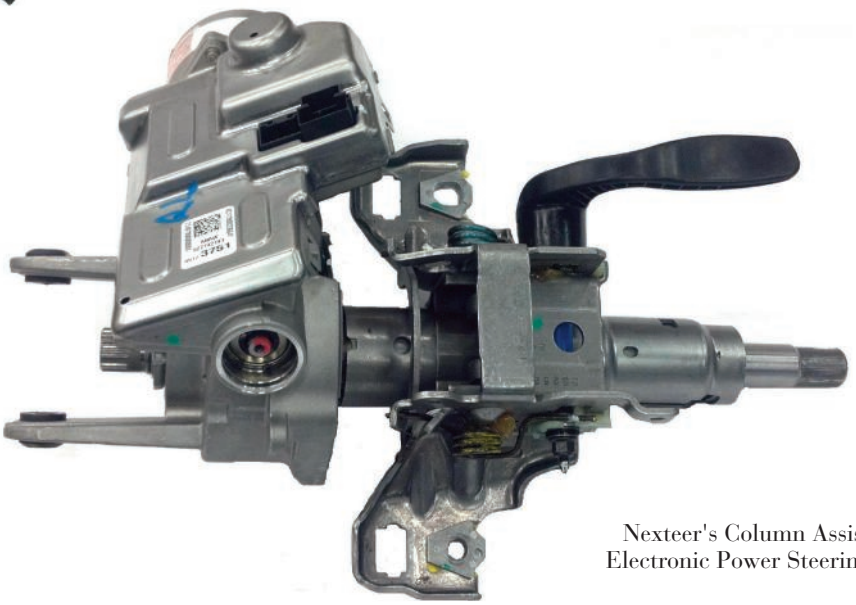
for demonstration purposes only. In the final version, it's likely to be only 3 or 4Nm. At the same time, an engineer admitted that it was a "difficult trade-off" to make it more comfortable, as that would lessen its efficacy.

While it is only steering intervention that is being addressed at present, a TRW engineer revealed they are working on a combined automated braking and ESA, but added that "it's a more complex situation than we have here".

Torque overlay steering has also been developed by Nexteer Automotive, although it is more for vehicle stability control, including yaw, wind gust mitigation, lane keeping and park assist etc. In order to apply these commands, advanced algorithms must be developed, using inputs from various sensor subsystems within the steering system, and for certain features from alternate sensors and subsystems. These must be integrated into the EPS or HPS control system to provide a seamless control to the driver, maximising performance and comfort.

"Our leading edge electronics and software architecture, along with our advanced software functionality, enable our customers to add new driver assist functionality throughout the lifecycle of the vehicle," states Frank Lubischer, vice president of global engineering and chief operating officer, European operations.

Meanwhile, KYB Corporation has worked closely with Nissan Motor Co. Ltd to develop a world-first direct adaptive steering system, debuting on the Infiniti Q50. KYB supplies the electronic control unit (ECU), gear assembly and reaction motor for the new system.



Nexteer's Column Assist Electronic Power Steering

Conventional steering links the driver's request to the vehicle's tyres via mechanical means. The direct adaptive steering system, however, is intuitive to the driver. It feels the force the driver applies to the steering wheel and feeds it into the ECU, which at the same time takes information from the road about what the tyres are doing.

The ECU processes all this information and only feeds back to the driver what he needs to know. In real terms, this means the steering wheel doesn't vibrate or jump; it stays still. The front wheels respond to even subtle changes in course.

FORGING AHEAD

KYB has established an Electronics Technology Centre, which will strengthen its electronics technology by concentrating a team on the design, evaluation and manufacturing technologies for electronic components.

At the same time, KYB's wholly owned subsidiary KYB Trondule Co Ltd has established a dedicated factory for vehicle-use ECUs, which are currently under production. A new production line has also been set up for the assembly of reaction motors and gear assembly.

Moving forward, KYB will have an integrated system for electronic components that covers everything from product development to the prototype, evaluation and mass production stages, further strengthening its development and manufacturing capabilities.

It's a big step forward in the development of steering, but it's likely to be only the first, as 48 volts, hybridisation and full electric vehicles make their impact felt on the automotive scene. But it also most likely spells the beginning of the end of more traditional steering systems, in much the same way as automatics are now taking over from manual transmissions in all but a few specialised sectors.

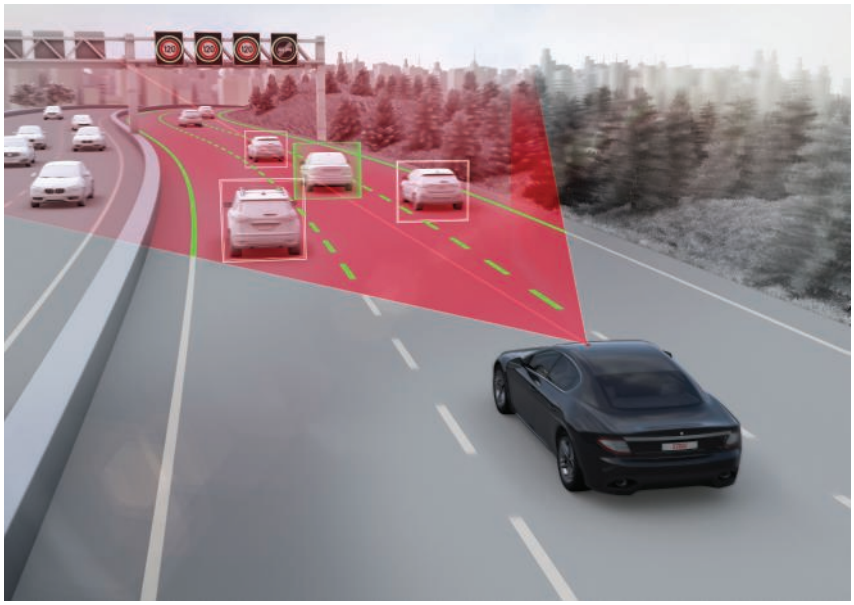
SHARP EYE

Andrew Whydell, director product planning, TRW Global Electronics, talks to Ian Adcock about advanced camera-based driver assistance systems

TRW is now working with its partners on a more sensitive and accurate third generation of camera-based sensing technology, as Andrew Whydell explains: "We have a couple of different types of camera in production today. Radar is a direct sensing technology that sends out a pulse. The echo returns, so you can calculate speed and distance very accurately. The camera estimates distance by looking at the relative size of an object, the rate of change of an object, so that, as it moves closer, how quickly the image expands in the field of view; and, thirdly, where in the field of view the subject sits. We can estimate distance to within 5-10% just by analysing the images.

"The next-generation camera that we're working with Mobileye on is a mono camera system that, basically, takes about 35 frames per second (FPS), analyses each picture and compares it to the previous one to look for changes.

"Today's camera uses a processor called an IQ2 from Mobileye; the next-generation processor is six times more powerful, so it's processing high definition images, but doing that three times faster. Current cameras run at around 12-13 frames per second. With the quicker next generation, we can collect more information and recognise more objects in a library of things of interest, including large animals, like a horse, deer, cow etc.



IMAGES ANALYSED

"Basically, the camera analyses each picture – a bit like the game where you match a pair of cards. Each scan of every image looks for pedestrians, cars and other objects of interest. By comparing successive frames, it can work out if a pedestrian is walking along the path or about to step into the road, so it can build up a trajectory and predict a path each of the objects is moving in, including cars around me, cars pulling out in front of me etc. By doing that and being able to track other vehicles, we can also now introduce camera-based adaptive cruise control.

"With the third-generation camera, there are a couple of key changes: it has gone from standard definition imagery to high definition and, whereas the current camera is a 752 x 480 wide VGA, the new one is 1280 x 960: like a high definition television. Combined with the new, bigger, lens, it significantly extends the camera's range to 140-150 metres – up from today's 90 metres.

“This means that, for the first time, a camera-based adaptive cruise control (ACC) facility can be offered in a bigger bundle of features, including lane departure, pedestrian detection and headlight control: In Europe, and for smaller cars, OEMs can’t afford to put in both radar and a camera, but have to pick one or the other… we’re now taking some of the features that, in the past, were reserved just for radar and making them available across a broader range of vehicles.”

The camera’s sensitivity and accuracy have even surprised Whydell and his colleagues, being able, under test conditions, to detect the difference between the road and verge, even with a covering of light snow. “The camera is looking for parallel lines within the standardised lane width. If it can find a contrast there, it will attempt to use it.

“So, it could be linked into the vehicle control system for longitudinal or lateral control or steer and maintain a safe distance from the vehicle in front, whilst it could also detect potholes or foreign objects in the road and help the driver steer round them.”

TRULY ADAPTIVE SYSTEM

However, one of the most intriguing potential applications for this new generation of cameras is linking it to a car’s adaptive suspension system, which would transform it into a truly adaptive system, claims Whydell.

“On the suspension side, what you can do is, if you detect a bump or a pot hole, soften or stiffen the shocks to improve the car’s ride comfort or stability,” he states.

“With a traditional system today, if a front wheel hits a bump, that might be the first time you know about it and, maybe, you still have time to do something with the rear suspension before it encounters it. By using a camera to scan the road in advance, you can now predictably change the setting for the front wheels ahead of the encounter, rather than waiting for the front wheels to hit something. It would also be able to control the suspension settings laterally, as well as fore and aft.

“The camera can see as well as, or a little bit better than, the human eye. But for comfort features like ACC, if the weather is really bad, the system would not be available. Essentially, there would be a warning saying visibility is impaired and these aren’t suitable driving conditions – heavy rain, snow, fog whatever – to be able to engage ACC. There’s only 1 or 2% driving time when the weather is sufficiently bad to inhibit some of the comfort features anyway.The camera would still be there to provide safety features, like automatic emergency braking, which are supporting, not driver replacement, features.”

Prof Dr Ulrich Hackenburg, board member for technical development Audi

Emissions – a fine balance

"95 g/Kms CO2 are a group target that includes Audi. VAG in total is 95. If you go to the different brands, some will be below 95 and others a bit above, but in total we will have 95. It depends on volume and the multiplication of the volume, which makes it a bit complicated, because the volume can be unstable with one brand selling more and another less, and so on.

"In the future, you have to see what money you have to spend on electric drive and hybrids, and what you can realise with diesel. If we can further develop diesel for low CO2, that costs some money. And if you go to electric drive, that also costs some money. So, if you combine them, you have two expensive technologies coming together, but you always have to see what the result is. We're looking very carefully up to which level we are doing this combination.

"Gasoline technology will not reach the efficiency levels of diesel for CO2 emissions. Diesel has better efficiency and, even with the new turbocharged, direct injection gasoline, will still have an advantage.

"Beyond Euro6, we're looking at SCR, lean NOx traps and combinations of them.

"I think the challenge of diesel is not performance; it's more how we can manage emissions: NOx in combination with performance. We will use all the technologies we can; 48v electrification – we call it iHEV (intelligent Hybrid Electric Vehicle) – with a starter-generator system to reduce CO2 and electric turbocharger, so we are playing the entire piano.

"Diesel has better efficiency and, even with the new turbocharged, direct injection gasoline, diesel will still have an advantage."

"We will have 48v and I2v. So, for the smaller engine, I2v is possible, although it's more dependent on the performance of the generator, but also on the charging capacity of the battery. Okay, 48v is more expensive than I2v, but 48v also gives more potential for recuperative recharging.

"48v takes up some space, as we also need I2v, which makes packaging easier and is cheaper, but it doesn't have the performance that's required.

"WLTP [the new World Light Vehicles Test Procedure] will make it more difficult to realise, so that's another challenge we have. In general, it's a good thing we have harmonisation, so WLTP makes sense, but we have to look very carefully at the difference between WLTP and NEC, because communicating about 95g/Kms CO2 is based on NEC [the EU National Emission Ceilings directive] and, if we switch to WLTP, we have to see where we make corrections."

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