SAE International The pan-European magazine of SAE International November/December 2012

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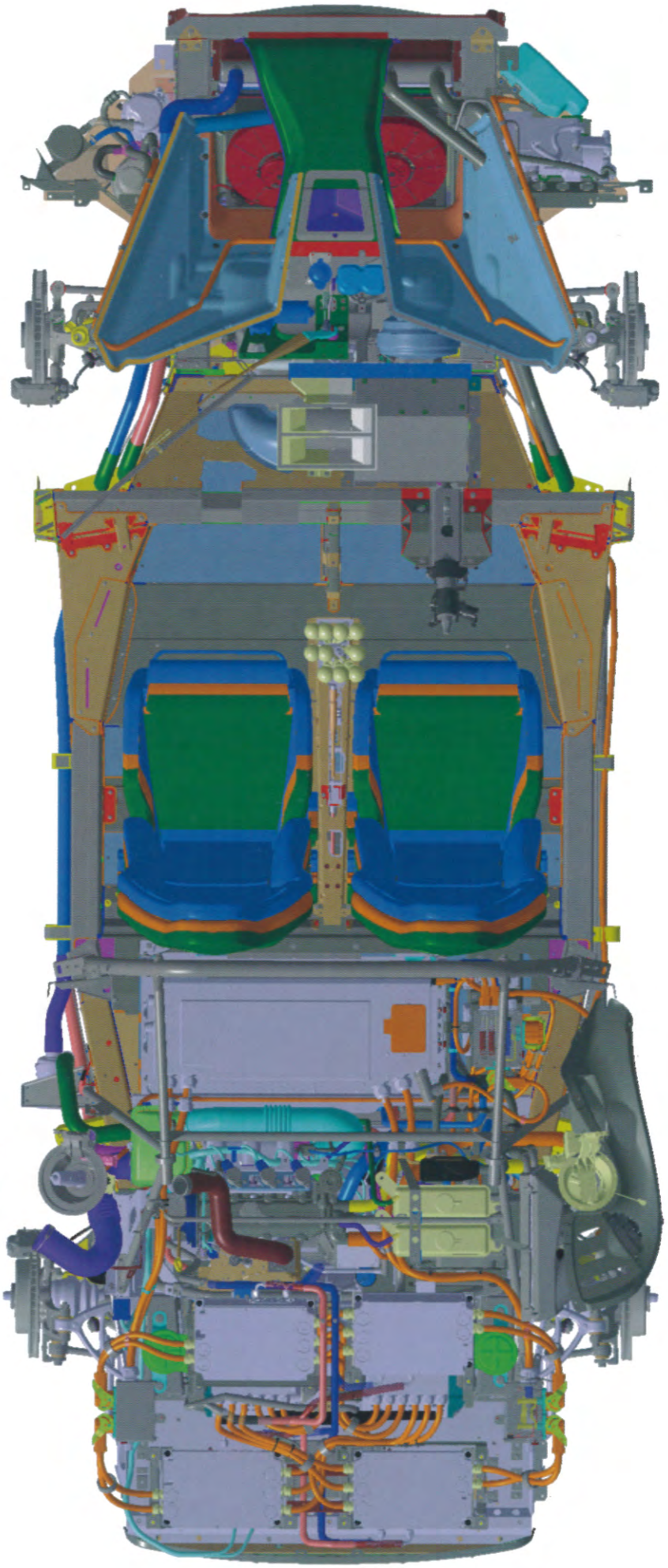
Synthetic oils: why the delay?

Vehicle controls: the human touch

HETHEL'S HYBRID: LATEST LOTUS PUTS FUN INTO GREEN



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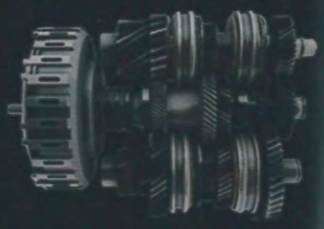

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Supply line under siege

It seems that Germany's production sector, from the OEMs to the supply chain, is coming under pressure of rising costs. On page 10, you can read how ZF's chief executive officer Dr Stefan Sommer wants to save half a billion Euros on supplier expenditure in the next two years and is looking for ZF's downstream suppliers to take their fair share of the hit in reducing material costs. He is also clearly intent on thinning out ZF's supply chain not just in Germany, but on a global basis.

Not only that, but Volkswagen chairman Ferdinand Piech told the Bild am Sonntag newspaper that spiralling energy costs were forcing it to switch purchasing parts from domestic to foreign suppliers. Something that would have been unthinkable, even a few years ago.

And as the US begins to ramp up production of cheap natural gas from shale deposits to power its domestic manufacturing supply chain, it could have a significant energy-cost advantage over the European supply chain, locked in, as their countries are, to costly gas contracts with Norway and Russia for at least the next eight years or so.

The European Union might have just announced an action plan to boost the Continent's flagging car industry, but it just goes to show that the manufacturing sector as a whole is at the mercy of events beyond its control.

So it's time for the politicians and bureaucrats to realise that the automotive industry, from the petrol pump attendant to the CEO of an OEM, is the financial driver of many economies.

Are the global oil giants preventing the car industry, and its customers, benefiting from synthetic oils? That's the argument being posited by Mathias Woydt in his interview with Tony Lewin on page 12 – and very interesting reading it makes, too. I look forward to the oil industry's response…

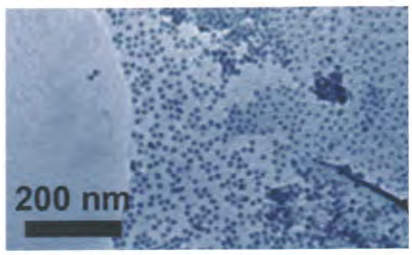
Ian Adcock, Editor in Chief

Cobalt-graphene breakthrough could see platinum replaced

Brown University chemist Shouheng Sun and his students believe they may have found a less expensive and more durable alternative to platinum catalysts for use in hydrogen fuel cells. The new material – a graphene sheet covered by cobalt and cobalt-oxide nanoparticles – can catalyse the oxygen reduction reaction nearly as well as platinum. Indeed, according to Shaojun Guo, a postdoctoral researcher in Sun's lab, it "has the best reduction performance of any non-platinum catalyst".

The oxygen reduction reaction occurs on the cathode side of a hydrogen fuel cell. Oxygen functions as an electron sink, stripping electrons from hydrogen fuel at the anode and creating the electrical pull that keeps the current running through electrical devices powered by the cell. "The reaction requires a catalyst and platinum is currently the best one," said Sun. "But it's very expensive and has a very limited supply, and that's why you don't see a lot of fuel cell use, aside from a few special purposes."

Lab tests performed by Sun and his team showed that the new graphene-cobalt material was a bit slower than platinum in getting the oxygen reduction reaction started. But, once the reaction was going, the new material actually reduced oxygen at a faster pace than platinum. The new catalyst also proved to be more stable, degrading much more slowly than platinum over time. After about 17 hours of testing, the graphene-cobalt catalyst was performing at around 70% of its initial capacity. The platinum catalyst that the team tested performed at less than 60% after the same amount of time.



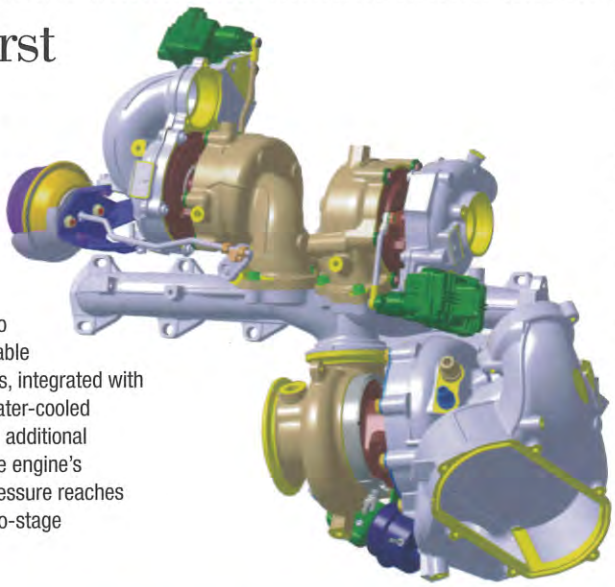
Nanoparticles of cobalt attach themselves to a graphene substrate in a single layer

Cobalt is an abundant metal, readily available at a fraction of what platinum costs. Graphene is a one atom-thick sheet of carbon atoms, arranged in a honeycomb structure. Developed in the last few years, graphene is renowned for its strength, electrical properties and catalytic potential.

Tri-turbo first

BMW's latest M Performance three-litre, six-cylinder diesel owes it performance (280kW and 740Nm) to BorgWarner's latest three-stage turbocharging system – the world's first for a diesel.

The system consists of two small BV45 high-pressure variable turbine geometry turbochargers, integrated with one larger B2 low-pressure, water-cooled turbocharger. By integrating an additional high-pressure turbocharger, the engine's capability to generate boost pressure reaches a new level, compared with two-stage turbocharging systems.



The three turbochargers are activated successively at different engine speeds: the first high-pressure turbocharger starts at just above idle; with increasing revs, the larger low-pressure turbocharger comes into play. To further increase performance, the second high-pressure stage turbocharger comes on line as well, with all three turbochargers working in harmony.

For effective and efficient boost pressure, the exhaust flow and air supply is precisely regulated. At particularly high speeds of the low-pressure turbocharger, the wastegate valve is opened by a vacuum actuator to avoid backpressure, while pneumatically activated flaps control the air supply. Indirect charge air cooling optimises the compressed air temperature in all three turbochargers to increase engine output.

Detecting fatigue, in a heartbeat

Plessey has developed a novel solution to monitor driver fatigue, based on its EPIC sensor technology.

Until recently, measuring ECG in a car meant the driver having a set of electrodes attached to their skin, using gel. However, because the EPIC sensor utilises capacitive coupling, it doesn't rely on skin contact measuring ECG through clothing and seat cover fabric. By monitoring a parameter called Heart Rate Variability (HRV) – a measure of how stable the heart rate is from beat to beat – it is possible to tell when the driver is starting to become sleepy.

Plessey recommend an array of sensors built into the seat back, so that the optimal sensing location can be chosen, regardless of the driver's height and build. Movement noise is minimised by placing the sensors away from the shoulders on the lower part of the seat back. The system uses a capacitive-driven ground plane, which can also be placed under the seat cover fabric on the base of the seat for a completely hidden system. Further noise reduction can be achieved by coupling this driven ground to the steering wheel. The system has been shown to be immune to electrical noise sources within the car.

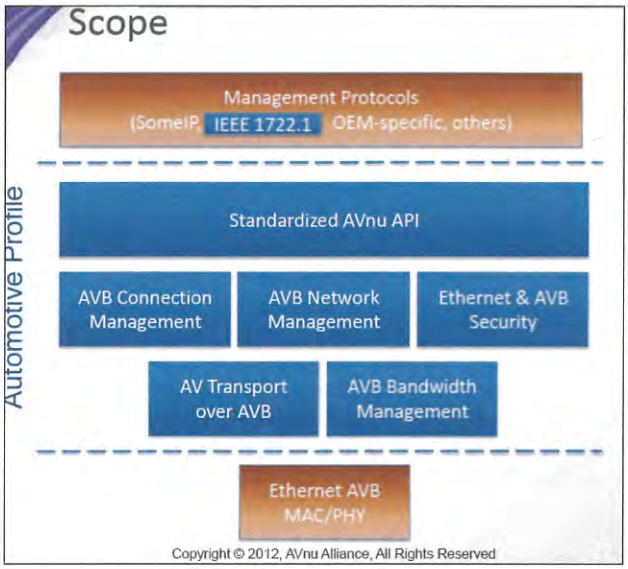
Plessey now has available evaluation kits for OEMs and suppliers. Its own tests show that more than 95% of heart beat peaks were detected during a 10-minute trial over a variety of driving conditions.

Real-Time Road Sense

In-car audio-video solutions have moved way beyond simple DVD playback. Infotainment and navigation systems can now be in tune with a multitude of other in-car systems, leading to the need for traditionally separate domains to communicate effectively.

The actual interaction between devices is more important than ever – and increasingly sophisticated. It is this cross-domain interaction that the AVnu Alliance is working towards, with its Audio-Video Bridging (AVB) Protocols.

Sensors for vehicle speed, wheel revolutions etc need to be linked with safety-related devices, such as lane-departure warning systems and infotainment devices that combine navigation with audio/video. Camera signals for active safety features, such as driver attention and eye position monitors, need to be routed near instantaneously to the control unit.



Another example is electronic sound synthesis. Rick Kreifeldt, president of AVnu Alliance and vice president R & D, Harman International, explains: "Harman, for instance, generates electronic sounds that are played outside the vehicle. To make the sound authentic, we need a linkage with the speedometer, engine control and amplifier." All these options require far greater bandwidth. They also add to the need for a standards-based A/V networking architecture.

Several years ago, efforts were started within the IEEE 802.3 (Ethernet) working group (later moving to IEEE 802.1) to define an Ethernet that would directly address the challenges of A/V streaming. Harman and other companies formed the AVnu Alliance, with the goal of bringing together different industries and promoting adoption of these IEEE 802.1 Audio Video Bridging (AVB) standards for streaming audio and video. The AVnu Alliance now has a broad-constituency membership and engages with A/V streaming in three areas: professional A/V, consumer electronics and automotive. Its primary deliverables to members are AVB certification and interoperability tests to simplify configuration of A/V networks.

The AVB protocols are an open standard, allowing multiple suppliers to deliver silicon solutions for automotive usage. So, instead of a proprietary solution, or a solution exclusively for the auto industry, automakers have an entire ecosystem of silicon providers that also serve other markets.

The Automotive AVB2 Council is already at work, its mission being to collaborate on the needs of the automotive industry to feed next-generation AVB requirements. On the wish list is a converged Ethernet backbone for growing cross-domain communication. Interoperable devices, using the Ethernet-based AVB standard with AVnu certification, will enable the automotive market to capitalise on new opportunities. Also on the agenda is support for Flexray, CAN and LIN (IEEE 1722a) – presenting a real opportunity for unification and cross-domain communication.

Hot news: longer service life

Solvay Specialty Polymers USA, LLC, has expanded its range of Amodel polyphthalamide (PPA) resins for automotive under-bonnet applications. New high-heat (HH) grades of Amodel PPA can extend the service life of components used in high-temperature air induction applications, such as air cooler housings, resonators, charge air hoses and components for exhaust gas recirculation.

According to Mark Wright, global automotive marketing manager for Solvay Specialty Polymers: "This innovative material was developed specifically to help our customers meet the challenges of continuously rising operating temperatures and tougher lifetime service requirements."

Engine downsizing has placed high-temperature demands on air induction components, especially those between the turbocharger compressor exit and the hot side charge air cooler housing.

Amodel A-4133HH (33% glass reinforced) and Amodel A-4145HH (45% glass reinforced) PPA resins deliver better long-term thermal stability than competitive polyamide-based materials and polyphenylene sulfide (PPS), it is claimed. Testing is said to show 75% retention of tensile strength after heat ageing for 3,000 hours at 230°C and after 1,000 hours at 250°C.

Solvay has also confirmed that HH grades of Amodel PPA maintain mechanical properties when thermally aged at lower temperatures of 160°C and 190°C. Test pieces during thermal ageing exhibited a smooth surface appearance and no bubbles. Both new high-heat materials provide the broad chemical resistance typically expected from a PPA and crystallise quickly, resulting in a 10% cycle time reduction versus other materials.

MIRA Technology Park has opened its 4000 m² Control Centre. Built at a cost of £6 million (€7.4m), the building is the first milestone in MIRA's quest to become Europe's most advanced independent transport technology facility.

Amongst its latest clients are: Bosch Engineering, Lockheed Martin, Ashok Leyland, Norgren and Triumph Motorcycles.

News in brief

48v enables super efficiency

Controlled Power Technologies (CPT) says that the new 48 volt standard proposed by leading automakers provides an ideal compromise for performance and cost in the development of a new generation of affordable super fuel-efficient cars.

"The convergence of global standards for fuel economy and CO_2 emissions means that the auto industry will need to embrace exhaust gas energy recuperation, as well as kinetic energy recovery by electro-mechanical means, as the next major step for CO_2 reduction," says CPT's chief executive and chief technology officer Nick Pascoe.

Altium releases new TASKING C compilers

Altium has released two new TASKING C compiler solutions for automotive application development, delivering support for the RH850 microcontrollers from Renesas and the Power Architecture-based microcontrollers from the Freescale Qorivva/5xxx and STMicroelectronics SPC56 series. These new solutions extend the range of TASKING toolsets for automotive microcontrollers, such as XC2000, ARM, ST10 and TriCore.

High-temperature turbo ducting

Technyl polyamide from Rhodia Engineering Plastics has been chosen by Röchling Automotive for the manufacturing of turbocharger air ducts which have to resist temperatures up to 210°C. The new polyamide 6.6 blow-moulding material – Technyl B2(2) – is the established grade in Rhodia's Technyl range of products for turbo systems and has been used by Röchling Automotive for over a year in 300,000 vehicles.

Touch sensitive

Atmel Corporation has launched new automotive-qualified maXTouch controllers for in-car control systems. Expanding the Atmel portfolio of maXTouch automotive-qualified devices, the new mXT143E and mXT224E touch controllers are designed for small automotive touchscreens and touchpads up to 18cms in diameter.

Engaging gears

Developments in electric vehicle powertrains will be at the forefront of the debate at the upcoming CTI Symposium on Innovative Automotive Transmissions in Berlin this December. What is sure to be a hot topic is the number of gears that an EV really needs: AVL List's executive vice president Dr Robert Fischer will argue that four is enough, while competitors Oerlikon Graziano from Italy press for more flexibility, with only top-performing supercars requiring so many ratios.

Extending the scope of the discussion to all types of powertrain, top engineers from Getrag will state that ratio count could be seen as a regional preference and that, in many situations, alternative concepts and architectures could be applied, instead of simply adding more gears.

Getrag will, in any case, be firmly in the spotlight: in September, it revealed the core models in its new range of modular dual clutch and hybrid transmissions for front-drive vehicles, and hinted at the additional variants that would broaden the scope of the range to one that spans the very smallest cars to the most powerful. Symposium attendees will be keen to hear how the new transmissions perform and to see how Getrag manages the high levels of component commonality it claims for this new line-up.

Exotic vehicles have not been forgotten either: a senior engineer at Ferrari will reflect on transmission design at this most elite of sports car makers, while, from the Porsche side, the technical director of the highly advanced 918 Spyder plug-in hybrid supercar programme will explain how top-level racing technology has been applied to a car for the public road.

Noticeable, too, in the list of technical papers is a raft of presentations on manual transmissions, showing how even this most straightforward type of gearbox is having to improve its efficiency, in the face of competition from highly sophisticated, multi-speed automatics and DCTs.

Much interest is sure to surround ZF's engineers, as they present the company's ambitious TraXon suite of modular driveline

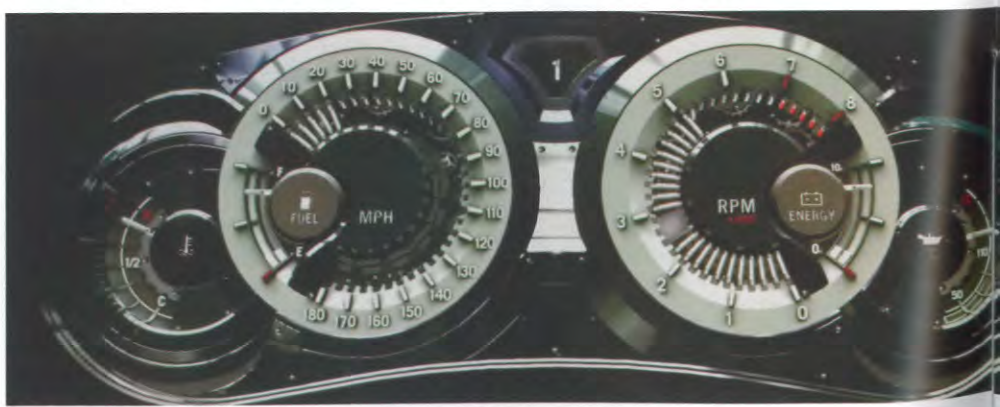
Visteon's future vision drives up safety

Visteon has teamed up with Japan Display Inc (JDI) for its latest premium reconfigurable instrument cluster.

Visteon's third-generation reconfigurable instrument cluster platform and JDI's high-definition thin film transistor (TFT) display deliver, they claim, superior graphics and animation. This technology supports complex 3-D graphics and video features, such as driver awareness and camera inputs.

Visteon's latest platform allows the 31.2 cms display resolution to deliver 1920 x 720 pixels and an 8:3 aspect ratio – considered unmatched in the automotive market. Consumer research conducted by Visteon shows that vehicle owners are becoming accustomed to HD-quality displays in their personal devices and prefer reconfigurable instrument clusters, with high-resolution graphics. Consumers say high quality displays provide them with an added sense of safety, because the driver information is clear and can be read quickly and effortlessly.

In a separate announcement, Visteon has joined forces with the UK's BAE Systems to



components for heavy goods vehicles. TraXon comprises units ranging from hybrid modules to single and dual-plate clutch packs, planetary or geared transmissions and splitter boxes, torque converter modules for ultra-heavy hauling and, perhaps most significantly, a dual clutch module to make ZF, alongside Volvo, the first to bring the fuel- and momentum-saving benefits of DCT to the heavy truck world.

One of the more intriguing presentations in the technical programme is likely to be that given by a senior engineer from Oerlikon Graziano. Titled '6+2 automated manual transmission with torque infill from hybrid module for sport car application', the concept promises to bring new thinking into advanced transmissions – just like the same company's four-speed eDCT did for electric vehicle gearbox design two years ago.

The 11th International CTI Symposium and Exhibition Innovative Automotive Transmissions, Hybrid & Electric Drives, runs from 3-6 December at the Maritim Hotel in Berlin. Details at www.getriebe-symposium.de/engl.

develop advanced head-up displays (HUD). The two are developing what they maintain will be an industry-leading display image quality, with a compact and efficient optical design.

Bringing BAE's state-of-the-art aerospace technology to the automotive market, Visteon is applying its expertise in electronics, mechanical design and packaging, software, display integration, thermal and electromagnetic compatibility (EMC) management. Initial development projects include both combiner and windscreen head-up display systems, using a TFT image source.

Focused on helping drivers manage cognitive workload, Visteon's head-up display systems are designed to display different types of critical information directly in the driver's line of sight, including vehicle speed, blind spot detection, turn-by-turn navigation and collision avoidance warning.

"Visteon views head-up display technology as a natural extension of the current driver information and advanced HMI solutions we provide to vehicle manufacturers around the world," said Christian Feltgen, Visteon global director of cockpit electronics technologies.

"We are excited to be able to demonstrate this technology to our customers in the coming months," he added.

Nissan steering breakthrough

Japanese auto maker Nissan has developed an 'Autonomous Emergency Steering System'. This offers a high level of collision avoidance capability by applying automatic braking and steering in situations where a collision is imminent and evading obstacles by braking may not be effective. The system takes effect in situations where unpredictable risks arise, such as sudden intrusions onto the road in low-speed zones, or when a collision at high speed is imminent, due to the driver's delayed recognition of the tail end of a traffic jam.

Nissan claims it has succeeded in developing technology that, through high-precision sensing technology and on-board control technology, automatically steers the vehicle away from potential collisions, when braking alone is insufficient.

The Autonomous Emergency Steering System, using the information provided by the front-mounted radar and camera, the two left and right rear radars, and the five laser scanners attached around the vehicle, initially acts on a risk of collision that cannot be avoided. Simultaneously, it checks if there is a forward zone free of obstacles, and that there are no vehicles approaching from the rear, and then displays to the driver the direction in which the vehicle should be steered. If the driver cannot immediately do so, the system takes over automatically to help to avoid a collision.

Nissan has established the Vision Zero safety goal, which aims to help to eliminate traffic fatalities and serious injuries. The guiding force behind this goal is the concept of the 'Safety Shield', which identifies six stages of driving conditions, from normal through to post-accident, and works to provide the most effective counter-measure against sources of danger that occur at each stage. Its 'Autonomous Emergency Steering System' is based on this initiative.

Dummy testing is far from dumb

TRL has developed a family of articulated dummies for pedestrian avoidance testing. The three dummies represent 50th percentile male, 50th percentile female, which also represents a teenager, and a six-year-old child. TRL claims they are unique, in having articulated leg movement to provide a more realistic representation of a walking pedestrian than a static dummy.

The low-profile mobile platform is self-propelled and has been designed to withstand being run over by vehicles travelling at speeds of up to 50 Km/h, without causing undue damage to either the base or vehicle, with the lightweight dummies breaking away in the event of an accident, allowing them to be reattached for continued testing.

As well as their articulation, the dummies have a more human profile from all angles. TRL says this is essential, because the mobile platform can be user programmed to move at varying speeds along complicated paths, with the side of the dummy presented to the system being tested changing as it follows its course.

This flexibility allows a wider range of collision scenarios to be tested, enabling a high degree of repeatability.

Carbon fibre key to weight loss

Ford has unveiled a prototype carbon fibre bonnet that is 50 % lighter than a standard steel part. As a result of an on-going research project involving engineers from the Ford European Research Centre, production time for an individual carbon fibre bonnet is fast enough to be employed on a production line – a significant step towards using more lightweight materials.

The involvement of the research centre in the Hightech.NRW research project follows Ford's partnership with Dow Automotive Systems – a collaboration announced earlier this year that will investigate new materials, design processes and manufacturing techniques. Dow Automotive Systems and Ford will focus on establishing an economical source of automotive-grade carbon fibre, as well as high-volume manufacturing methods.

Advanced materials, such as carbon fibre, are a key component of Ford's plans to reduce the weight of its cars by up to 340kg by the end of the decade.

Ford has partnered with specialists from the Institute of Automotive Engineering at RWTH Aachen University, Henkel, Evonik, IKV (Institute of Plastics Processing), Composite Impulse and Toho Tenax for the Hightech. NRW research project.

Initial testing suggests that CFRP components, such as the prototype Ford Focus bonnet, will meet Ford's high standards for stiffness, dent resistance and crash performance. The component has also performed well in pedestrian protection head-impact tests, thanks to its innovative construction of a special foam core, sandwiched between two layers of CFRP.

VCT set to boom

BorgWarner is expanding its variable cam timing (VCT) technology with a new family of cam phasers for I4 engines. The modular design supports a variety of cam-phasing technologies, including cam torque actuated (CTA) and torsional assist (TA) phasers with optional mid position lock technology.

Each phaser also features an integrated centre bolt and spool valve for smaller package size and easier installation. The technology is planned to launch with a major global automaker on diesel and gasoline applications in 2015.

"Fourteen engines have captured about 75% of the global engine market and are forecast to power over 17 million additional vehicles in the next seven years. Our new cam-phasing technology is engineered to offer automakers customised, fast-to-market VCT solutions to support increasing demand for

efficient, downsized engines," said Joe Fadool, president and general manager, BorgWarner Morse TEC. "BorgWarner's modular cam-phaser technology gives automakers more flexibility in choosing the configuration that best meets their performance parameters, with the added benefits of a compact package and simplified installation."

BorgWarner's new family of cam phasers showcases its broad expertise in VCT technology. Using the existing torsional energy in the valve train, CTA phasers actuate more quickly, use less engine oil, and operate under a wider range of engine speeds and temperatures than conventional VCT systems. TA phasers, which use torsional energy and standard engine oil pressure to actuate the phaser, offer a wide range of authority, achieving 70 degrees of crank rotation or more.

For added calibration opportunities, BorgWarner's patented mid position lock technology allows an increased range of camshaft positioning, with a default stop at an intermediate position within the expanded range of travel. The built-in failsafe ensures the phaser returns to the middle position for reliable engine starts in nearly any potential operating condition.

Measuring up to the task

Oscilloscope manufacturer Tektronix has released its new dedicated Automotive Resource Centre that provides online tips and guidance on common automotive measurement challenges.

The centre provides a content-rich webpage, enabling electronic designers to easily access information to debug and verify the latest embedded designs, such as common automotive serial buses – CAN, LIN, FlexRay, BroadR-Reach and MOST - which will speed integration of these embedded technologies and build confidence in their design.

With a click of a button, they can view comprehensive tips and insight to ensure their automotive testing is streamlined.

"We offer a vast variety of technical documentation, videos and webinars, as well as software downloads for the automotive market," said Johann Winterholler, Tektronix sales director for Germany/Austria/ Switzerland.

ZF slashes supply chain

ZF is reorganising its production materials purchasing and, in the next two years, wants to save half a billion euros on supplier expenditure by reducing the number of suppliers significantly, while purchasing volumes will be bundled and processes harmonised.

By 2015, ZF is aiming at sales growth of over €20 billion, compared to €5.5 billion today. ZF's chief executive officer Dr Stefan Sommer explains: "In order to be able to meet the strong customer demand, we have to make substantial investments in new plants and production facilities. These considerable advance payments put our results under more pressure – and this pressure has to be passed on moderately to our suppliers."

ZF wants to leverage lower prices for production materials, together with standardised purchasing contracts and a central negotiation partner.

"When selecting our suppliers in the future, we will pay more attention to their global approach", said Sommer. "In the context of reorganising our supplier relations, we will also clearly reduce the number of our suppliers."

Mercedes' new LED system light years ahead

The all-LED lighting on the new Mercedes-Benz S-class is certainly a major advance in automotive lighting, but that's not the half of it.

The optional motorised masking system for this flagship car's high-beam headlamps, and a new night vision system that can recognise people and animals straying on the road, makes the S-Class's lamps the most advanced in the world.

Developed in collaboration with Automotive Lighting, Bosch's old lighting division now owned by Magnetti Marelli, the optional headlamp system is called Adaptive Highbeam Assist Plus and each unit is expected to cost about the same as a current Bi-Xenon headlamp.

Using a new stereoscopic camera system, the Mercedes systems will recognise either on-coming headlamps or vehicles ahead. It then uses a moving motorised masking system, which actively vignettes the light sources ahead to prevent those drivers being dazzled and allows the S-class's main beams to be left on virtually all the time.

Mercedes claims its LED units require 34 watts per vehicle to produce the same light output as that 120 watts of Halogen lighting or 84 watts of Xenon lighting, saving up to 0.05 litres of fuel per 100km. The S-class

uses three main single-chip lighting units at the front: a 10 LED low beam and cornering unit, a 4-LED high beam unit, 10 daylight running LEDs and six for each turn indicator. The infra-red night vision system uses its own LED light sources to 'light up' animals and humans when they have been identified at a long distance.

Lightweight design cuts CO_2

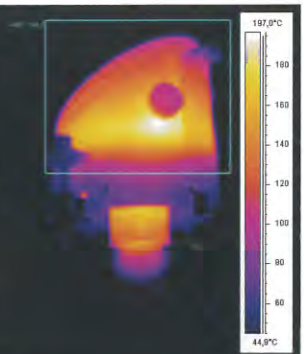
Schaeffler is offering two optimised mass solutions that can reduce the mass of its i² shift mass module by up to 70%, compared to conventional components, it states. However, the lower inertia level of the i² shift mass module is increased, using a gearbox. At the core of the gearshift module is a two-stage planetary gearbox that enables very high ratios.

A slipping clutch reduces the load on the plastic gear teeth during overloading, which helps to ensure a long operating life. Its lightweight shift mass also utilises a different approach, which improves the distribution of weight. Fitting the actual mass on the outer end of the lightweight carrier ensures optimum utilisation of the lever action provided. The lightweight carrier is made of aluminium or plastic, combined with a steel gearshift lever for transmitting the gearshift forces.

A 25% weight reduction can be achieved by making its new selector hub from sheet metal, instead of from solid sintered metal. The new two-part design comprises geometrically compatible sheet metal half shells, which, after the design optimisation process, can transmit higher torques than sintered components.

Schaeffler's new hybrid gearshift forks with aluminium bodies can replace traditional, conventional steel gearshift forks. The striker jaw is a high precision sheet metal blanked component. During assembly, the striker jaw is precisely aligned with the screw mounting axis and joined to the gearshift fork, compensating for single component tolerances. "These new lightweight concepts enable weight reductions of up to 1.2 kg for transmissions," explains Pascal Kohtes, product developer at Schaeffler.

Cool solution to hot issues



A new thermally conductive thermoplastic polyester from DSM provides automotive electronics developers and designers with an innovative solution in overcoming heat management issues in such components as foglamp housings, lens holders and AFL (Adaptive Forward Lighting) frames, while minimising additional vehicle weight and fuel consumption.

Arnite PET XL-T combines high heat resistance (HHR) with low out-gassing, offering a new alternative to metals and more exotic HHR materials often used in such applications. In use, it shows a performance approaching those of more expensive HHR thermoplastics, such as polyphenylene sulphide (PPS) and polyetherimides (PEI), it is claimed, and does not suffer from moisture absorption issues that commonly arise with polyphthalamides (PPA).

The new grade is a further development of Arnite PET-XL, which DSM introduced in 2009. Both products are based on polyethylene terephthalate (PET) and are highly suitable for engineering applications. Arnite PET XL-T also features a low coefficient of linear thermal expansion (CLTE).

Sounds good

Four new European electric vehicles (EVs) will feature Delphi Automotive's innovative Vehicle Sound Generator by the end of the year, with another vehicle in Asia featuring the technology during 2013. The system provides a frequency range of 300Hz to 10 KHz and can reproduce melodies that represent the identity of individual vehicle manufacturers. The single-box, fully integrated solution measures 10x10 centimetres and weighs less than 450 grams; it is about three times lighter than a conventional multi-box system and is said to use 90% less power.

A high-fidelity sound generator allows vehicle manufacturers to enable multiple warning features, using one sounder. Unique sounds can be designed to remind drivers that the vehicle battery should be charged.

A shift in the oil mix

Polyalkylene glycol oils promise to reduce friction, cut CO_2 emissions and promote biodegradability – so why haven't they been taken up? Tony Lewin speaks to Dr Mathias Woydt of Berlin's Federal Institute for Materials Research and Testing to find out

"The problem is that, on one side you have Exxon and friends, who know what an engine oil is and who have the automotive customers; on the other side, you have Dow Chemical and BASF – they have the polyglycol oils, but they don't know the customer and they have less experience in engine oils."

There's the smack of conspiracy theory behind Mathias Woydt's lament that the automobile world has not yet allowed his pet project – synthetic oils derived from the polyalkylene glycol (PAG) process – the recognition it deserves. The clear implication is that the interlocking business relationships between the carmakers, the oil companies and the additive formulators are making it impossible for other ideas to get a look in, no matter how attractive they might be.

Capability questioned

Yet, on the face of it, the time is absolutely right for a product that promises to cut fuel consumption, reduce emissions and improve sustainability. "The world has changed," declares Woydt. "Mineral oils work and they are cheap, but many more demands are being loaded onto our oils – biodegradation, ecotoxicological properties, chemical restrictions, in terms of phosphor, sulphur and ash content. The question is whether hydrocarbon oils can fulfil these – and I say they can't."

Improving fuel economy by changing the oil type is much cheaper than moving to a lightweight body architecture, argues Woydt; hydrocarbon oils are approaching their physical limits, when it comes to the proposed high viscosity indices above 200. "The evaporation of this very low-viscosity base oil is too high and the oil thickens. This might be acceptable in a region such as North America, where there are short drain intervals, but it would not work in Europe or Asia."

Low viscosity – without the drawbacks

PAG engine oils, by contrast, could offer even lower viscosities for still better efficiency, especially at idle speeds, while keeping volatility low and the loading of additives much

Dr Mathias Woydt CV

Dr-Ing Mathias Woydt is head of the Macrotribology and Wear Protection division of the Federal Institute for Materials Research and Testing in Berlin. In a long career as a specialist in tribology, he has had some 45 patent applications, including several in the fields of alternative engine oils and biolubes.

He has worked with a wide variety of industry partners, including BMW, Audi, MAN and Renault, where he was involved in the 2002 Ellypse concept car, which was designed to be maintenance-free for 100,000 km. He lists DOW, the provider of the PAG base oils for his current research, as a strategic customer.

lighter. Potentially, too, PAGs could be made free of metals, so they do not contaminate exhaust after-treatment systems, especially the costly units fitted to turbodiesels.

"All vehicles have emission issues, especially that of ash," he explains. "Ash build-up in the particulate filter means you need a big filter. Over time, the back pressure increases, but you can't clean a filter of its ash – only soot can be cleared."

This is especially relevant to trucks, reveals Woydt: Daimler's Euro VI trucks have to have a particulate filter holding 800 litres, so as to be able to guarantee the emissions level over extended periods of use. "Ash, zinc, molybdenum and other metals tend to degrade emissions performance over time, so you try to avoid them."

Carbon reduction benefits

Even so, it is the CO_2-reducing potential of the super-low viscosity PAG oils that is most likely to grab the industry's attention: tests carried out on the NEDC, using the best reference oils selected by European automakers, have shown a benefit of between 2.5-3% in CO_2 emissions, while truck fleet tests are showing cuts of up to 7%.

"You can have all the viscosity range you want," declares Woydt – but therein lies one of the big issues for PAG: because of its different temperature behaviour, it does not fit the SAE's familiar winter/summer classification template.

"If you look to the upcoming SAE 16, which some people are calling SAE 5W minus 5, it fits easily within these grades. With increasing temperature, the viscosity index increases – it doesn't remain constant, as with hydrocarbon oils." At cold temperatures, the PAG's viscosity is half or one third that of a conventional oil, he explains.

More power, longer drain intervals

Further plus points in PAG oils' lengthy list of advantages are extended drain intervals – up to 50,000 kms is possible, says Woydt – and the potential for extracting more power from the engine, something that encouraged Renault's F1 engineers to choose the oil for top-level racing. PAG oil's molecular backbone structure improves thermal conductivity, allowing more heat to be extracted from critical parts of the engine, thus allowing the motor to be pushed harder.

That same backbone – see panel – gives PAG the oxidation stability that allows it to run for extended mileages, though for marketing reasons automakers currently prefer to keep oil changes down to between 20,000 and 30,000 kms.

Is this the future?

Polyalkylene glycol (PAG) oils are fully synthetic in their make-up, but their molecular structure is modified to produce a higher density than conventional oils. "In each monomer, you have an oxygen atom," says Dr Mathias Woydt, head of the BAM Federal Institute for Materials Research and Testing in Berlin. "Each monomer is polar, whereas hydrocarbons are non-polar, which means they don't have any EP or anti-wear [properties] and need a lot of [extra] chemistry to make them function.

"The PAG's polar backbone structure gives lower volatility, wider viscosity indices and better absorption to surfaces and, in consequence, better lubricity and EP performance," he adds.

Due to their intrinsically better properties, PAG lubricants do not need as many additives as hydrocarbon oils, and they can also be made metal-free and meet the European standard for biodegradability of at least 60%.

What others think

"The low-viscosity concept is a good one," says Martin Mann, technical director of independent producer Miller's Oils. "We have explored and exploited this with our recent range of racing oils, and we have achieved similar figures to PAG, but with our technologies."

The principal issues, in Mann's view, are the claims to biodegradability and ash-free status. While the virgin base oil might comply, says Mann, as soon as additives are loaded in and engine combustion by-products absorbed, the used oil will always be classified as toxic.

Asked about the advantages of PAG oils, Ian Shannon, general manager of passenger car motor oil development at Shell, said that PAG's theoretical benefit of a low coefficient of friction would be especially useful for worm gears. "The loads that these gears are subjected to mean that PAG oils are able to provide very specific protective qualities, which could certainly be beneficial in certain areas of the modern combustion engine and beyond," he told Automotive Design.

Amongst the factors he identifies as weighing against the take-up of PAGs in the auto industry are their uncertain compatibility with current engine oils and additives, preventing mixing in the field, and the fact that they readily absorb water, a by-product of combustion.

Next steps

Despite his complaints of indifference from the auto industry establishment, Woydt's Berlin organisation is, in fact, working with a European automaker group (which he declines to name) on a programme targeting homologation of a PAG oil within four years. Maximum benefit is only likely to be shown when a new engine is configured around the performance of the new oil, he states, a comment which effectively rules out any aftermarket sales for several years.

"We will need an after-sales solution that makes the customer want to refill with this oil," he concedes. Yet, even at a price that's likely to be double that of current synthetics, which are themselves already expensive, Woydt reckons the extra cost of about €20 for a passenger car oil change will represent an attractive proposition when considered against future savings on fuel.

The argument he puts forward becomes even more convincing in the context of heavy trucks. Woydt's organisation is co-operating with two large US-managed truck fleets, running 200,000 vehicles worldwide. The advantage of this arrangement, he says, is that the operators own the vehicles and are therefore free to fill them with oils not necessarily on the manufacturers' approved lists.

"We may see some results in six months' time," he predicts. "The trial was an attractive one for these operators – and the value for them will be [a saving of] between €1,200 and €1,600 per vehicle."

The benefit works out at up to €31 million per year across the fleets on fuel costs alone. Quite impressive for no more than a switch of oil.

In the air – and in the factory

PAG oils may not be well known in the auto industry, but they are familiar to production engineers as machining lubricants. Aircraft enthusiasts know them, too: in World War II, the US Air Force used this type of lubricant in some of its piston-engined combat aircraft, valuing the oil's low viscosity at extremely cold temperatures. German chemical engineers also developed similar synthetic oils in WW2, prompted by shortages of hydrocarbon base oil stock, but the high costs of these processes meant that post-war industries quickly returned to cheap and plentiful hydrocarbon stocks.

Today, PAG oils are also used by model aircraft enthusiasts in miniature two-stroke engines, where the fuel-oil mix burns without smoke.

Wind cheater

As OEMs strive for greater vehicle efficiency, subtle changes in aerodynamics can deliver significant rewards, as Ian Adcock discovers

"I think we're going to enter an era where aerodynamics is going to become significantly more important. Aerodynamics are relatively cheap, wind tunnels are relatively inexpensive and most OEMs have their own."

So says Dr Jeff Howell, lead engineer aerodynamics TATA Motors European technical centre, and it increasingly seems to be a view held across the industry, as OEMs search for cost-effective solutions to the twin challenges of improving fuel economy and lowering emissions.

Howell continues: "There are two major areas where it has an impact – maximum speed and the power required to drive the car through the air. The rule of thumb is that, if you reduce drag 10%, you can increase speed by around 3%. That's a consequence of power being a function of V cubed, the main impact these days on fuel economy and CO_2, and that a 10% drag reduction will give 2% gain in fuel economy."

Thin on the ground

These are fairly thin improvements, but understandable, given the European drive cycle predominantly weighted towards urban, rather than faster highway, motoring. Otherwise, as Pininfarina's product development director Andrea Benedetto points out, Mercedes-Benz wouldn't have spent a claimed 2,500 hours in the wind tunnel for its new B-class.

He describes that investment as "a huge amount of hours for a shape that is not really aero friendly MPV – unless there were lots of hidden gains," before adding: "If you look at the B-class spats, its aero shape is extremely complex and its specific to that vehicle, so you have to dedicate simulation and testing hours to develop that small component just for that car, because the A-class design is different again. The principles you can develop across the line, but the fine tuning and shape is influenced by many surrounding parts."

Instant gain

As TotalSim's Rob Lewis states, modern cars "don't have flat underfloors. There are all sorts of lumps and bumps and things dangling down, so a flat floor is an instant gain of maybe 5% drag

Rob Lewis of TotalSim

reduction, but that adds cost, weight and complexity. But it will come as fuel prices rise."

And with MIRA's Martin Jones confidently predicting production car Cd figures of 0.22 or 0.23 within "five years or so" and 0.2 in "eight to 10 years," it's obvious that sleeker, more efficient cars, irrespective of their size and class – and the legislative demands placed on them, such as pedestrian impact requirements – will be the norm, rather than a concept fantasy. The challenge is: where will those gains come from?

The prominent aerodynamicist Wolf-Heinrich Hucho identified two routes to achieving better aerodynamics: constantly refining the car from where you started and, secondly, start with a more ideal aerodynamic shape, and then turn it into something more aesthetically pleasing and feasible.

"It's always an issue with the design team who want to maintain the car's aesthetics and brand identity," argues Howell, so add-ons such as wheel covers, while having a significant effect on drag reduction, might not sit easily with the designers.

"Some 30-35% of a vehicle's drag coefficient derives from the wheels and wheel arches," claims MIRA's Jones, adding: "There's a lot of work going on in this area. Ducting air through the cooling pack and into the wheel arches helps to reduce losses, as well as managing airflow at the front of the vehicle, so the effective yaw of the front wheels is minimised.

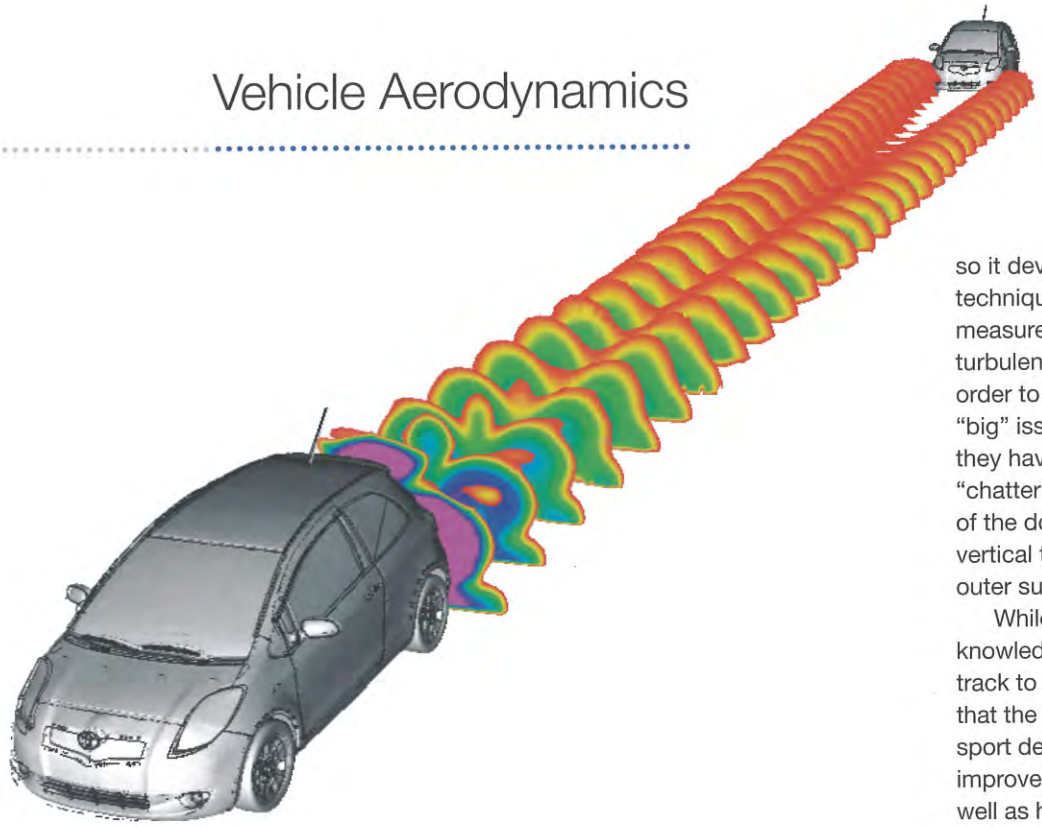
Guiding light

"If you have air hitting the wheels at a small yaw angle, the losses can be considerably higher than if you just guide the air actually along the vehicle and around the wheels. MIRA did some wind tunnel and computational fluid dynamic (CFD) work, blanking off the wheel arches, and it demonstrated some very useful benefits by controlling the airflow into and out of the wheel arches. We also carried out some wheel blanking and got useful gains, but came up against the styling demands. The other challenge is that you still need to keep an eye on your brake cooling requirements as well.

"Ducting air out of the rear wheel arches and into the wake's low pressure area, using simple ducts, also produced useful benefits, especially when combined with wheel blanking and wheel arch covers."

Rob Lewis believes that taking this concept further could result in huge gains in the region of 10-20%, which would result in significant fuel savings, as he explains.

"One radical idea for road cars is if you could design the car so that



the wake it leaves behind stays in the shape of the car. What happens with road cars is, because they create lift, the wake gets washed down into the ground, hits it and dissipates sideways. So that the following car doesn't drive through that much of the wake, it's feasible to engineer the car's shape without radical change to make the wake stay more in the car's shape. If that was the case, the car behind could save a fairly huge amount of drag, not just the 2-3% here and there for wing mirrors etc – it could be a 10-20% drag-saving."

Conquering the challenges

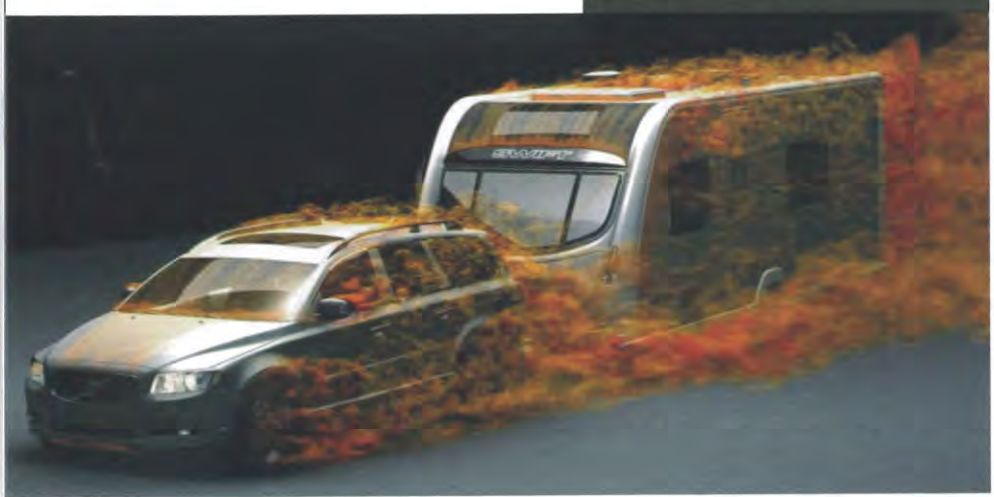
However, before long-term solutions like that are adopted, Benedetto is more concerned about challenges created by pedestrian legislation, as he explains: "The unforeseen effect of having hoods which became higher, thinner and lighter was an increase in dynamic vibrations." Pininfarina, says Benedetto, had many customers seeking a solution, so it developed a 3D dynamic technique for use in its wind tunnel to measure the laminar flow and turbulence generated by the hood, in order to solve the problems. Another "big" issue, says Benedetto, that they have now conquered, was "chattering" or longitudinal vibration of the door mirrors, caused by vertical turbulence created by the outer surface of the mirror itself.

While most agree that transferring knowledge learned from the race track to road cars is rare, all concede that the relentless pace set in motor sport development has driven rapid improvements in CFD software, as well as helping to develop engineering skills. However, both Benedetto and Lewis see some potential for technology transfer.

"Recently, we have seen semi-active aerodynamics in F1," says Benedetto, "which maybe, in a different way, will be part of road cars in the future. I am thinking of using guided airflows to influence the main airflow of the vehicle, taking air from some inlets and then redirecting airflows to other parts of the vehicle at certain speeds to solve transitions of aerodynamic issues."

Rob Lewis' radical drafting theory, above

Turbulent airflow caused by towing (below).



Untapped potential

As for Lewis, who is critical of what he calls "cooling by chaos", he sees "under-bonnet air management as untapped potential. You control the flow of air onto the radiator and control it off, where it goes and expands. So you catch the air in a high pressure place and release it in a low pressure area or, ideally, into the car's wake where it can save drag. Opportunities like that are fairly high on the effort, complexity and cost scale, with only moderate rewards. But, at some point, they will be viable".

Future cars might not have the slippery shapes seen on some concepts, but aerodynamic tweaks – some obvious and others not so – will be the norm and not just the provenance of the exotic supercars.

CAFE Racers

The race is on to create the 54.5-US mpg (4.3 l/100kms) car. The new US Corporate Average Fuel Economy (CAFE) regulations are now in place to raise the auto industry's overall fleet fuel-economy requirement from 25.3 US mpg (9.2 l/100kms) in 2010 to that 54.5-mpg fleet-average fuel economy ultimately set for the 2025 model year. The rules are projected to save about 4 billion barrels of oil and 2 billion metric tons of greenhouse gas emissions (GHG) over the lifetime of the 2017-25 rules, according to the US EPA.

The kicker with the new CAFE, however, is how to do it without constricting consumer choice and (most importantly) without pricing most buyers out of the new-car market.

Wide debate

The Obama administration estimates the retail-price burden of CAFE to be about $1,800 (€1,400) a vehicle by 2025. That figure has been widely debated by industry analysts, non-governmental organisations and academics, some of whom believe it underestimates the cost and readiness of some technologies or misses others entirely.

Consumers who buy 2025 models can expect to save more than $8,000 (€6,250) over the life of a car in greater fuel efficiency, compared to 2011 models, the administration calculates, more than offsetting higher purchase costs.

Under CAFE, light trucks can improve at a slower annual rate until 2021, when the plan calls for trucks to improve at a rate of 5% a year to catch up.

The ultimate test of the CAFE rules will come in the marketplace with consumers. New analysis from the Consumer Federation of America (CFA) shows that the regulations align with consumer demands and needs.

"The 54.5 mpg by 2025 standard will be one of the most important consumer protection measures to be adopted in decades," said Dr Mark Cooper, director of research for CFA, an association of nearly 300 non-profit consumer advocacy organisations across the nation.

Lower oil consumption

Top findings of the telephone poll of 1,000 adults, conducted in May 2012, include 88% of those surveyed who said that the US should reduce oil consumption. CFA found that the belief that the US should cut back on oil consumption is associated with the desire for higher fuel economy. Respondents who said cutting oil consumption is very important want to get 5 mpg (8 kms) more with their next vehicle purchase. In addition, 74% of those polled said the new fuel-economy standards are a good idea, 66% said they would still support the standard, even if it creates higher sticker prices for vehicles, and 86% said cutting consumer costs is an important reason to cut oil consumption.

Top findings of the telephone poll of 1,000 adults, conducted in May 2012, include 88% of those surveyed who said that the US should reduce oil consumption.

Though the CFA data sounds promising, the proof will be found in actual consumer behaviour. The industry and government will have to show that spending less on fuel will far outweigh the additional cost of buying a more fuel-efficient vehicle.

SAE International will work diligently to ensure that we protect that IP – that knowledge – so we, as a profession, can keep moving forward.

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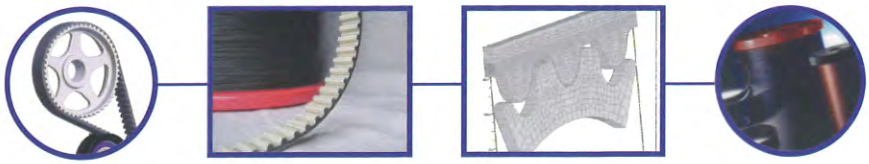


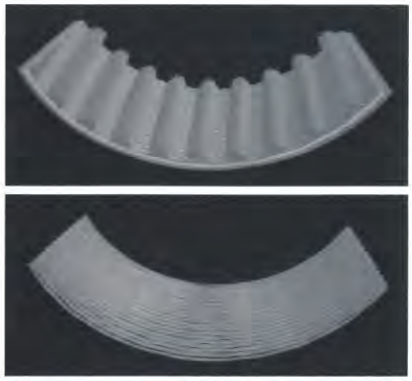
Timing belts for lower friction: better, longer, in oil

The days of changing timing belts are over.

The modern automotive engine has strong requirements for high fuel economy and low CO_2 emissions. The timing of the combustion process is perhaps taken for granted – but the valves are required to be opened and closed from the rotation of the cam shaft at the right speed and in phase with the crank shaft. Commonly, a steel timing chain, or a glass fibre cord reinforced rubber timing belt, is used. For the timing to be as precise as possible, the stiffness needs to be high (for low stretch when load is applied), the creep needs to be low (for low, permanent extension under load – a maximum of 0.1% is allowed), and the durability needs to be long (to prevent in-service failures). The stiffness and creep resistance of the belt is provided by a flexible matrix of many thousands of precisely twisted glass fibres. The glass filaments are encapsulated in rubber latex to provide abrasion resistance during dynamic fatigue of the glass.

Until recently, life-of-engine durability was the sole domain of the timing chain. In the previous decade, a change of glass formulation came to the market for the reinforcing cord for belts. The standard E glass could be replaced by the high-strength glasses K and U. The tensile strength of a U glass cord is about 1500 MPa, as opposed to 1100 MPa for an E glass cord. The high-strength glass cords provided life-of-engine belt durability for gasoline engines.

In 2008, FEV in Aachen took a 1.6 litre gasoline engine and characterised the friction losses and noise of the system with a timing



Ford EcoBoost 1.0 litre gasoline engine, with timing belt running in oil.
Source: Ford youtube.com video.

chain. The chain and sprockets were removed, and the engine modified to take a timing belt. The engine was re-characterised. Lower friction was measured for the belt system, which would deliver 0.48 to 1.13% higher fuel efficiency and lower CO_2 emissions by 1.45 g/km. It was impressive, as this was a lab system, not a highly optimised and developed arrangement.

In contrast, a recent paper by Hyundai/Kia and Borg Warner optimised the timing chain for low friction, and were able to improve fuel efficiency by only 0.4%. FEV also found that the noise emitted by the chain or belt meshing with the cam sprocket/pulley was over 15 dB higher at 2000 rpm for the chain than the belt. The overall engine noise was up to 5 dB quieter with the timing belt.

2008 saw the introduction of the first timing belt running in oil, installed on the Ford Lynx 1.8 litre common rail diesel engine. The past year has seen the launch of the 1.0 litre gasoline Ford EcoBoost engine, also with a timing belt, running in oil, with the durability to last the life of the engine. The reinforcing cord for the belt in oil was made possible by developments in rubber (HNBR polymer for very good oil and temperature resistance) and novel chemical crosslinking systems. The design where the cams are driven by a belt immersed in oil was pioneered by Ford on its 1.8 l diesel Lynx engine. The Ford powertrain development manager Andrew Fraser told Automotive Design, "We think it's the best of both worlds: the longevity of a chain, but with the quietness and low friction of a belt!"

The drive to reduce engine friction has been emphasised by other car makers. In their launch of the EA211 gasoline engine, the use of the toothed belt for valve actuation was described as a "renaissance… Volkswagen has significantly reduced internal friction in its new generation of engines. Take the example of overhead camshafts (DOHC): the camshafts are not driven by chain here, rather by a single stage, low-friction, toothed belt design with a 20 mm wide belt and load-reducing profiled belt wheels. Thanks to its high-end material specification, this toothed belt's service life reliably spans the life of the entire vehicle!"

A toothed timing belt is also used on the 2.0 TDI engine with "a positive effect on acoustic comfort"

The development of better materials and high strength reinforcing glass cord provides modern timing belts with the ability to last the life of the engine.

Improved material systems have allowed the introduction of timing belts that can now run inside the engine, in oil, again lasting for the life of the engine.

Current developments are aimed at extending the operating range of the timing belt, to be able to carry higher loads with current durability levels, and provide enhanced fuel economy and lower CO_2 emissions vs chain.

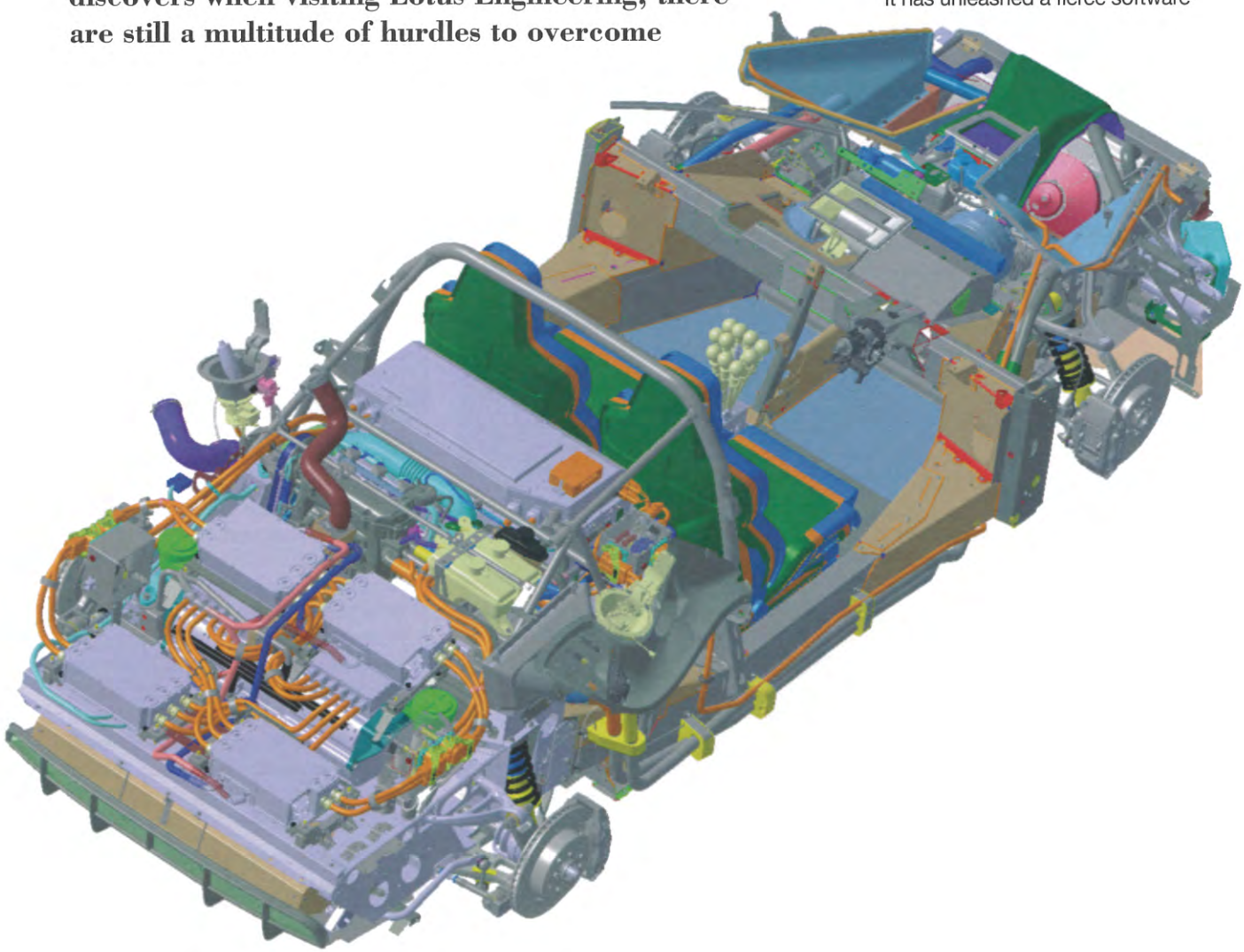
Hethel bred and ready

Hybrids are the way forward, but as Ian Adcock discovers when visiting Lotus Engineering, there are still a multitude of hurdles to overcome

A two-seater with a top speed of 133mph (214Km/h) and zero to 60mph (96Km/h) in 4.4secs doesn't read much like a practical application of hybrid technology, especially when its clothed in the svelte lines of a Lotus Evora. Even director of engineering Mark James concedes: "One could argue the Evora isn't the right vehicle for this technology," before adding tellingly, "but it's one we know and it's great for PR."

However, the Evora 414E – so called, because the power developed by the twin 150kW electric motors driving the rear wheels equates to 414PS – is much more than just a test bed and demonstrator for Lotus's hybrid technology.

It has unleashed a fierce software



It's clear, from the comparative lack of sales and their high cost, that EVs aren't the answer everyone thought they were going to be. But there's still a need for OEMs to drive down their emissions.

development race at Lotus Engineering's Hethel base, especially in virtual reality test suites, as well as resulting in some novel, patented, control software.

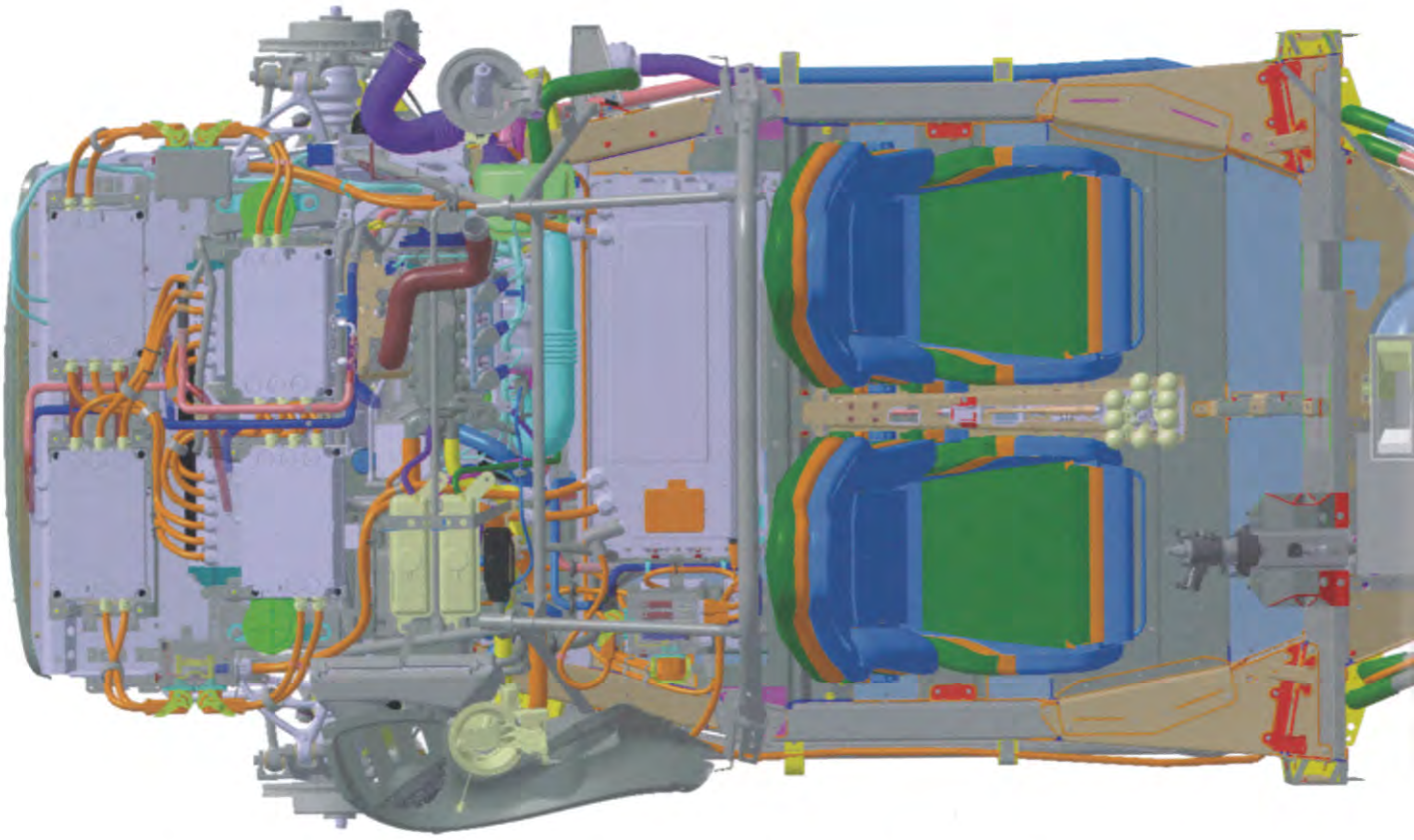
Lotus Engineering, explains James, sees range extender hybrids as "the transitional step" between parallel hybrids and full electric vehicles (EVs), adding: "In recent years, we have built parallel hybrids, series hybrids, full EVs and range extender hydrogen fuel cell vehicles." But the challenge for the OEMs, he maintains, is that "they don't know what the buying public wants and purchasers don't know what to buy".

It's clear from the comparative lack of sales and their high cost that EVs aren't the answer everyone thought they were going to be, but there's still a need for OEMs to drive down their emissions. Lotus contends that, if the combined cost of a range extender engine and a smaller battery pack is at least equal to, and preferably less than, a full EV, then you have all the advantages of reduced emissions, without range anxiety.

First things first

And yet even this strategy has not been without its problems. Production of the range extender engine has hit a hiatus, says James, because Lotus industrial partner Fagor Ederlan is still uncertain as to which engine variant to put into production first. "Initially, the OEMs said they wanted a three-cylinder 35kW range extender, naturally aspirated; next, they wanted 50kW, three-cylinder supercharged. So we changed direction, as were asked to. Now the market is saying a two-cylinder 20kW is what it wants. We think the market will support all those engines. The question is: which comes first and that's what Fagor Ederlan is trying to resolve."

In this first iteration, the 414E uses a 35kW normally aspirated range extender – chosen because it is the minimum amount of power needed to drive the Evora, or an equivalent 'C' segment car, at 70mph (112Km/h) motorway speeds. The twin electric motors, mated directly to the rear wheels that produce 300kW and the 35 kW generator, have been developed by Evo Electric, while Amberjac supply the 14.9kWh Lithium iron phosphate liquid-cooled battery pack, comprising of 112 cells



in series and 60 in parallel.

The 250Kgs pack replaces the Evora's vestigial rear seats, but, according to programme's chief engineer Phil Barker, does little to affect the car's overall weight distribution. Other partners in the £19 million (€23.5m) government-funded project are Nissan, Jaguar Land Rover and Xtrac. The car was developed using ISO 26262 safety-critical guidelines to identify risks and hazards in functions such as the electric power-assisted steering (EPAS) and self-parking systems, as Barker explains. "You need to ascertain what levels of multiple redundancy do you build in – for instance, two chip sets making the same calculation – and something monitoring both; so, if it sees a discrepancy, it flags it up or how many levels of redundancy is built into the software.

"We used the 414 project to apply those guidelines and come up with safety tests we wanted to perform. A lot was carried out in the virtual world and, if we can simulate them and see what happens to the cars behaviour, it's a safe environment in which to do that. If you were to write a fault code in the software and put it in the vehicle, you could be putting the driver and vehicle in danger. We've been able to use the virtual world with all the control algorithms and coding to prove out the safety case. Once we're happy with that, we can put the car on a rolling road and go through them before putting the car on the test track."

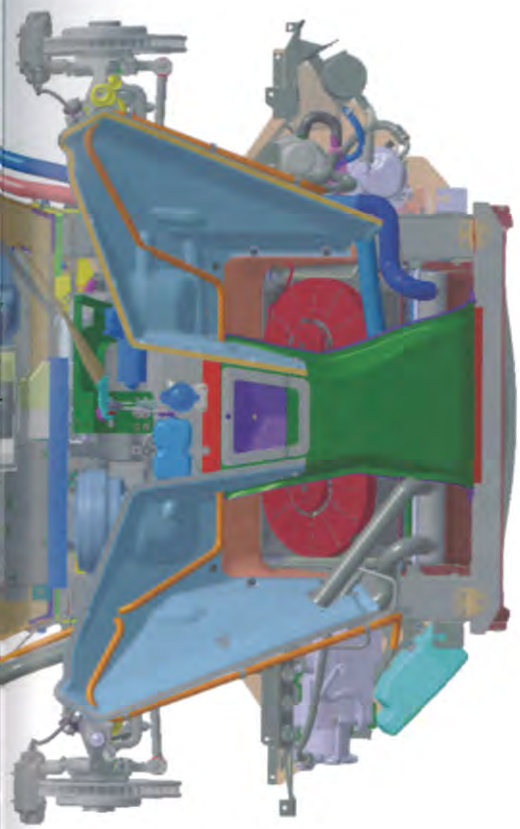
Powerful testing

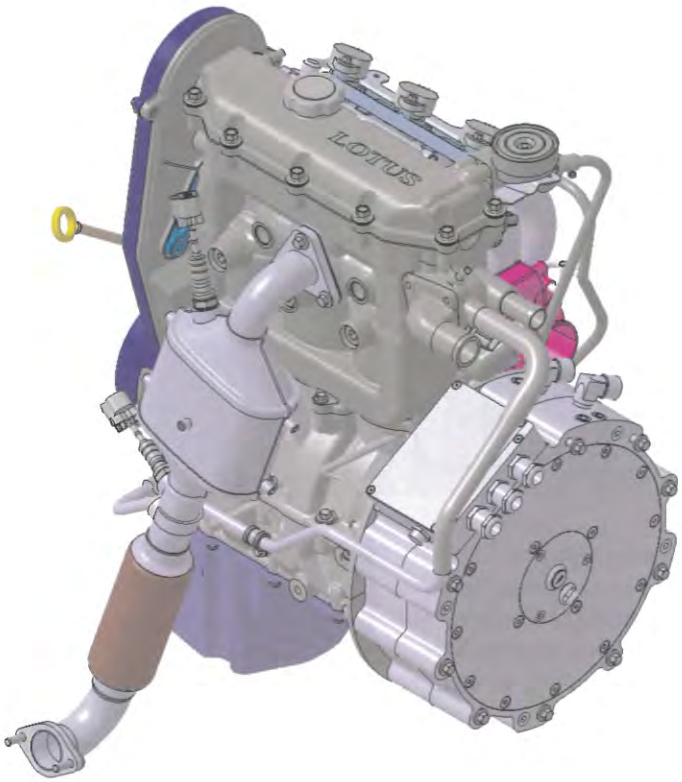
Lotus, says Barker, also used Motor Industry Software Reliability Association (MISRA) codes to develop in the loop testing capabilities. "We can build mathematical models of the car in our simulation environment and then connect it to the vehicle controller to run a lot of the strategies on a test bench, rather than on the vehicle.

So, a good deal of the early design was done in a virtual environment and then brought into hardware, such as the controller, or additional hardware, like the range extender on its test bed, and run through scenarios at a test bench level.

"Additionally, we didn't have any downtime for charging the battery, because we could programme a battery simulator to mimic the battery pack characteristics to run the electric motors on the test bench for 24 hours a day."

One of the most important breakthroughs developed using this process was matching the inverters and motors. Working with Evo Electric, a 3D dynamic mapping process was developed to match the torque output of the motors. "Essentially, the torque you get out of a motor is proportional to the current you put in. But when you put in the current, you get current losses and understanding that is where we've got a significant gain. When we started, the percentage error between sending in the current and getting the torque output was about 24%. You can't live with that





percentage error in torque management, if you have a two motor set-up independently driving the wheels. By characterising the motors, and bringing in these 3D maps and including different parameters, we've brought that percentage error down to 2%. That's quite a significant result."

Optimal power split

Lotus has also developed and patented an Adaptive Energy Management System that monitors driving behaviour in 20-second cycles and then uses that knowledge on a continuous basis to predict how the car will be driven over the next 20 seconds, with the algorithm adaptively selecting the optimal power split between the battery and range extender. Although still only at the simulation stage, Barker maintains it has already outperformed both load following software and stop-start, in terms of CO2 reduction and could increase the vehicle's current range of 300 miles (483Kms) by up to 15%.

Having got the Evora to a base level of calibration, the Lotus team is now moving into the second phase of development, including noise, vibration and harshness (NVH) improvement, as well as damper settings. The NVH work, starting early next year, will include active noise cancellation within the cabin that will also integrate a virtual seven-speed, paddle-operated transmission, with artificial torque reduction between gear changes. "This might not be the most economical way of doing it, but, when the driver goes back down through the 'box, we can increase the level of regenerative braking, so that, as he changes gear, more energy is put back into the battery," comments Barker, adding that Halsonic external noise creation will be added to warn other road users of the car's presence.

Torque vectoring is also on the cards whereby the time lag between turning the steering wheel and instigating the turn is minimised, so that, immediately the sensor detects the steering wheel has turned, it can add torque to the outer wheel and reduce it to the inner wheel or a combination of the two during cornering.

With the electric motors delivering instant torque, the equivalent of 2000Nm per wheel when geared up through the 4.58:1 ratio, from standstill it springs silently off the line under rapid acceleration, the range-extender coming to life above about 50mph when it can be heard, but not felt, through the chassis as it blends into and out of the powertrain. With 250Kgs of batteries behind the front seats, handling is marginally inferior to a standard Evora, with increased understeer, but it's still impressive for a development car that has had little chassis development work.

If this is a glimpse into the future of cars, then it's reassuring to know that motorists won't have to wear a hair shirt to be green.

If everything you do in the automobile is 'by wire' – be that steering, driving, braking – how exactly should those controls respond to driver inputs? Andrew English reports

ALL WIRED UP

The electrification of the automobile has had some unexpected results and the debate is divisive. Take electronic power assisted steering (EPAS), for example. "Steering feel is a subject most shrouded in disagreement that I have ever come across," says Matt Taylor, head of vehicle dynamics at Prodrive.

Control feedback lies on one side of the equation, but what about control response? Take an old-school throttle system; while this sort of arrangement is celebrated as the acme of driver-oriented control, it's also the zenith of non-linear pedal response, with lost movement, erratic weighting, variable pedal-to-throttle response ratios and loads of 'stiction'. Is this really a model of how we want a modern digital throttle pedal to respond?

A modern throttle-by-wire system tends to be based on torque demand. It's a slightly more logical approach to driveability and, in theory, leads to a more linear control response. But car makers get sneaky when they start to try to avoid certain high noise and vibration periods in an engine's rev range, or dampen throttle response for emissions or fuel consumption. You can end up with a throttle pedal with all the feel and response of a door bell.

For some engineering teams, however, feedback simply doesn't feature. Dan Milot is chief engineer on braking development for TRW. "We use a mechanical pedal," he says, "which simulates force build-up and feel, but we don't allow a feedback loop in the system – we keep an independent regime. Controlling 'feel' electronically is pretty tricky stuff."

While full brake-by-wire systems are not permitted by legislation, plenty of hybrid brake-by-wire systems use a digital retardation map to mix regeneration braking from an electric motor, with friction braking. Only last month, Frank-Steffen Walliser, chief engineer on Porsche's 918 hybrid supercar, dismissed these systems as "horrible... [and] unacceptable for a super sports car".

Steering is at the cutting edge of this response/feedback research, but measuring the quantity and quality of steering 'feel' is like fishing for smoke and that's presuming you wanted to measure it at all. There are those who claim that, if the steering is affected by the road surface, it is fatally corrupted.

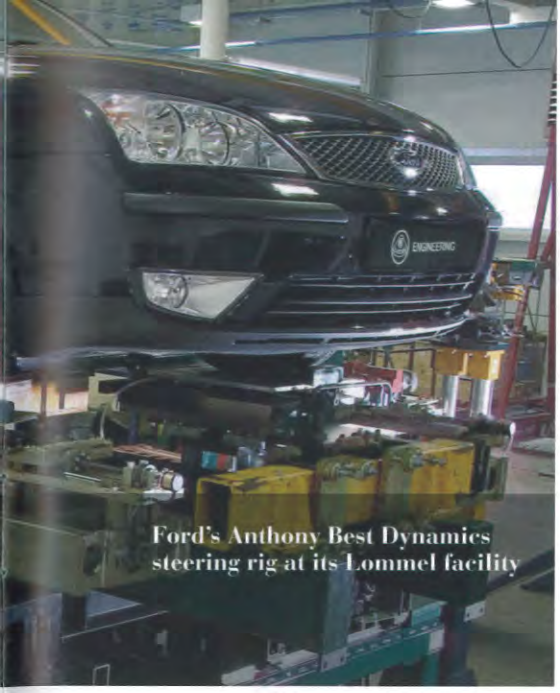
Another Matthew (Becker this time), chief engineer of vehicle dynamics at Lotus Cars, describes what he is seeking in Lotus steering systems. "Nothing should happen too quickly," he says, "where input gives an expected output." Elegantly stated, but what does it mean in engineering terms? Prodrive's Taylor says that one problem in getting

Becker: "Nothing should happen too quickly, where input gives an expected output."

good control feedback is the strategies that come from control engineers, who have seldom driven a vehicle near its limits.

"It's control strategies thought up by control engineers, versus artisanal dynamisists who know what they are looking for and they simply can't communicate with each other," he says.

Ford tried to measure steering response and feel with the last Focus model. It purchased (jointly with Jaguar) a very special steering rig from Anthony Best Dynamics. "The [machine] was built to a requirement



Ford's Anthony Best Dynamics steering rig at its Lommel facility

that came from the R&D teams at Jaguar and Ford," says Steve Neads, director of steering and suspension test systems at Anthony Best Dynamics. It wasn't a cheap machine to build, he states, partly because of the high-resolution position and force sensors. Ford measured whole system response, the effect of changes and loop simulations to develop strategies for issues like steering nibble.

Keith Saunders, principle engineer on vehicle dynamics with Lotus Engineering, credits the blue oval with attempting to bring together the subjective and objective on steering analysis. However, like Prodrive's Taylor, Saunders reckons the first-generation EPAS systems were merely directing the helm back to centre, and that the low steering efforts and reduced torque effort build-up in corners resulted in a 'Play Station' feedback loop.

Talk to Saunders and you quickly realise how difficult it is to get good steering response/feedback with hydraulics, let along electronics. Geometry, caster, camber, king-pin offset and scrub radius all play a part, while steering rack location, tyres, springs and dampers are significant variables. "Rear suspension design is very important as well," says Matthew Becker.

"Power availability is a big one for

Saunders: "A lot of early systems had a false effect," he says. "They were simply driving the system back the other way, with a false on-centre feel."

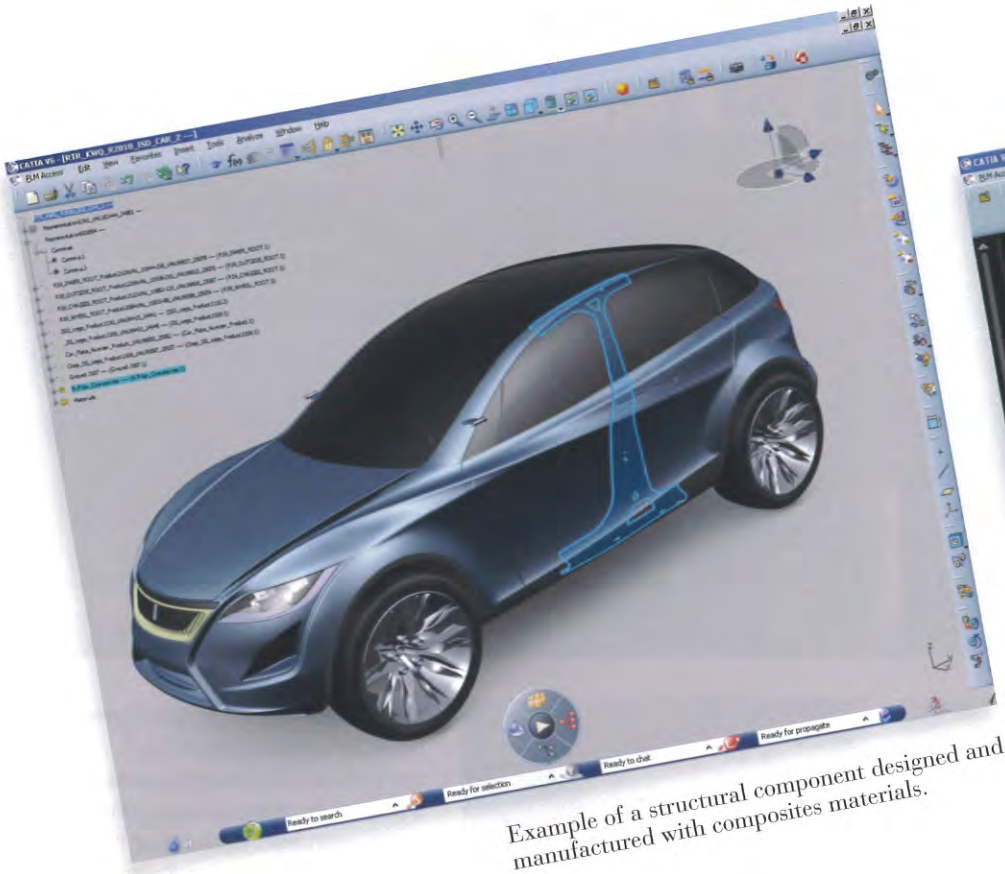
EPAS systems," says Matthew Taylor. "You need more power at low speeds just to move the wheels and it's not uncommon to find that rack return speeds are faster than their steering speeds, which inhibits you from making steering corrections." Taylor says the high-power demands of EPAS is why high-powered cars often retain a traditional hydraulic system. TRW's Dan Milot agrees that the power demands of a full brake-by-wire system mean it is unlikely to be feasible without on-board 42-volt electrics.

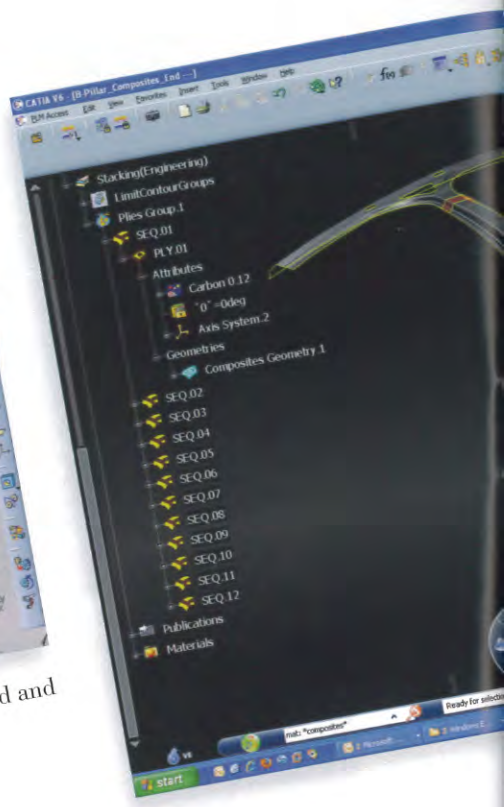
Motors are a research area where steering, throttle and brake engineers might learn from each other. "They are improving vastly," says Keith Saunders. "To improve the [steering] response, you can change to an AC motor and then add more phases to reduce the magnetic 'cog' effect'; but they all add money."

Budget conflicts

And the right funding and time are essential. "There are a bewildering number of parameters for control engineers to refine steering," says Prodrive's Taylor. "The trouble is, the budget gets sucked up tuning those parameters and not improving the system. I doubt I've been involved with any EPAS development where they've signed off the steering because it's as good as it could be; they've just run out of time."

The 'voodoo' engineering aspect of control response and feedback means it's likely to be a heated debate, particularly in the fields of hybrid braking and steering feel. Engineering has a problem with things it can't really measure, yet control response and feedback are at the heart of the value proposition from premium car makers. So the race is on to fully understand and exploit these ghosts in the machines.





Example of a structural component designed and manufactured with composites materials.

Mass production of

Rani Richardson, product specialist at Dassault Systèmes, reports on a potential key to unlocking carbon fibre's assembly potential

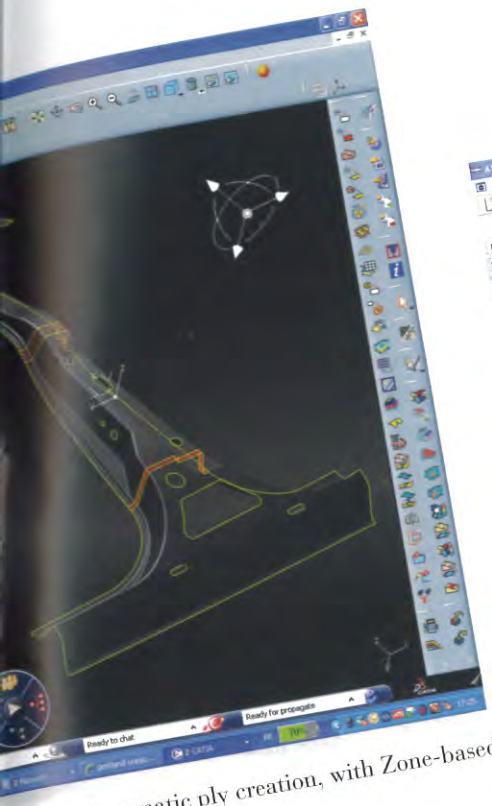
Successfully utilising composites structures in producing composite vehicles requires substantial improvements in the tools used for end-to-end product development. Most existing CAD solutions are intended for use with metal and plastic parts of less complexity, and offer no way to track laminate and composites properties, other than manually via spreadsheets.

From a simulation perspective, evaluating the mechanical performance of the proposed design is challenging, because ply and composites parameters must normally be manually re-entered in the FEA software—a time-consuming and error-prone process. Additionally, most of today's FEA software is designed for metallic materials that yield, bend and fold when they fail, whereas composites crack, fracture and delaminate.

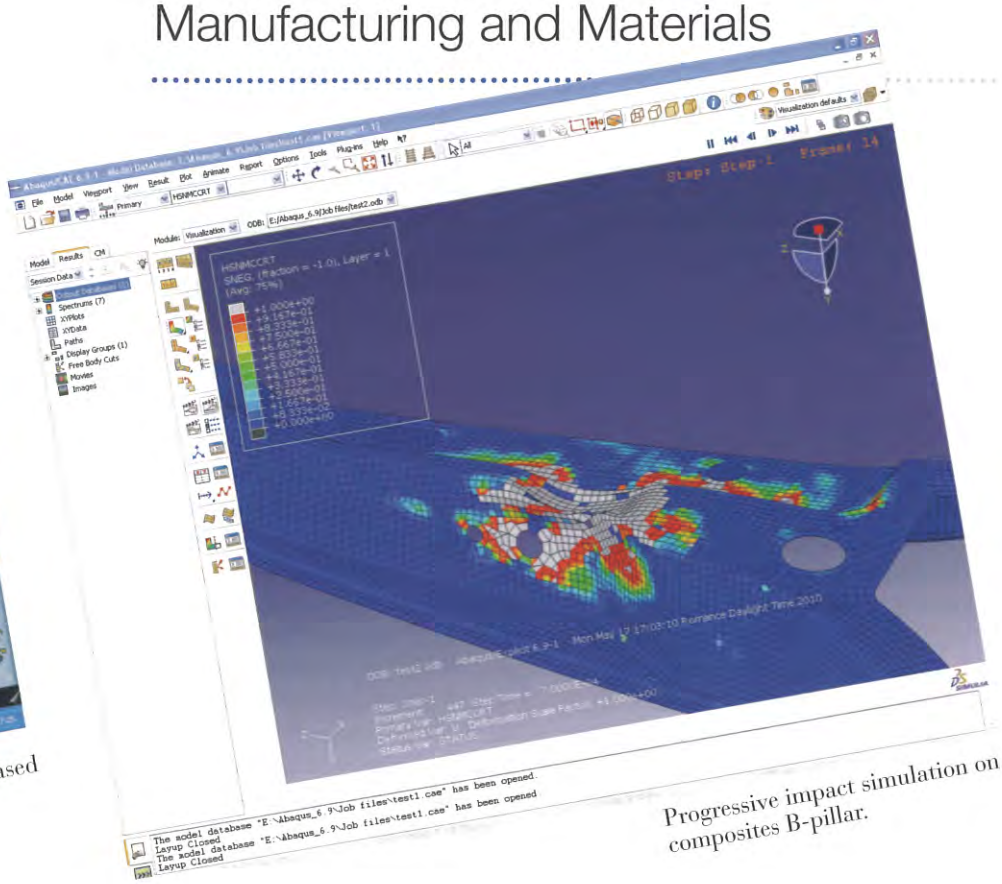
In manufacturing, the complex shape of automotive body geometries makes it difficult to predict how composite materials will conform to the mould's complex surface. A major hurdle lies in developing flat patterns that will meet the ply guidelines, without fabric distortion. The prevalent procedure is to cut fabric plies by hand and try to fit them on the mould tool. This process is time-consuming and can lead to costly errors in the positioning of the plies on the mould.

Currently, composites process planning does not take advantage of the product definition embedded in the 3-D model. Typically, composites process plans are created using manual entry or finite-element mesh defining plies that do not match the as-built models. While traditional software solutions cover the design, analysis and manufacturing of composites parts, they do not do so using a collaborative process. This inability to quickly analyse the impact of design changes on manufacturing further extends the time needed to deliver product.

To meet these challenges, Dassault Systèmes (DS) has worked in close collaboration with industry



Automatic ply creation, with Zone-based approach.



Progressive impact simulation on composites B-pillar.

composites solved

leaders to develop end-to-end PLM solutions to design, simulate and manufacture composites structures on a single virtual platform. At the heart of this solution, CATIA provides a dedicated environment for design of composite parts, SIMULIA provides advanced simulation tools and composites-specific methodologies to improve the design, and DELMIA supplies digital manufacturing capabilities, from planning to actual delivery to the shop floor.

Complex design process

Composites' numerical definition is complex and involves many different parameters, as compared to metals, which are isotropic. As a result, it's a challenge when modelling composites to find the right balance between the number of parameters necessary and the computation time needed. The CATIA Composites (CPD) solution provides accurate characterisation, based on material property data that allows engineers to quickly define a detailed composite lay-up.

Another challenge is the necessity to quickly explore and test many variants in the preliminary design phase. Critical at this stage is the ability to create and update the composites models within hours of a design change. CPD offers various methods for the automatic creation of plies and provides associativity between surface and composites parameters. When surfaces change, the model is automatically updated based on the new surfaces, enabling significant time savings. This approach also offers improved accuracy, reducing the number of physical prototypes needed.

Designers also need to perform analysis on the composites parts early in the process, in order to understand the behaviour of the various materials and their mutual interaction. CPD delivers a comprehensive set of inspection tools to review the composites structure in detail.

To achieve design weight and strength optimisation, as well as ensure the final product performs as designed, it is necessary to integrate the design, analysis and manufacturing process on a single platform. Metal components are joined either by welding, rivets, bolts or bonding. For composites, the assembly process can be quite different. Designers need to understand the composites material properties and the manufacturing assembly process, as well as the potential impact on the parts they are modelling. With CATIA Composites,

productive features are provided, so the designer can take them into account early in the design phase, helping to reduce the design lifecycle and allow manufacturers to go to market faster.

Additionally, designers need to simulate the manufacturing process, in order to visualise the fibre orientation of the material on the shop floor, to ensure that the final product adheres to the original design intent. DS works with technology partners to provide advanced specialised applications that fully integrate with the CATIA environment to improve part quality and prevent delays in production. Engineers can visualise the ply stacking and tweak the laminate structure before the design is sent to manufacturing.

Properties and crash simulation

Composite materials behaviour is complex and more difficult to predict than metals, so reliable simulation applications are key in understanding part behaviour.

Additionally, raw materials manufacturers constantly introduce new materials and parameters need to be established. Relying on fully integrated partner products, this solution allows users to quickly define the complete properties of a new material and drape it on the mould.

The loss of information and time required to transfer composites data between CAD and CAE applications often requires data translation. The integration of CATIA information with SIMULIA CAE FEA software overcomes this issue. The ability to directly transfer accurate fibre angles and ply thicknesses from the design to the analysis environment improves simulation accuracy.

Transferring updated design information from analysis seamlessly back to design enables designers and analysts to work collaboratively to ensure the analysed model matches the final structure, and to prevent specifying plies and structures that cannot be manufactured. Composites assemblies' failure analysis requires a comprehensive analysis of crash worthiness and other severe events inherent to composites, which are all addressed by this solution.

From manual to automated manufacturing processes

Shifting from high-volume metal parts to composite structures is a challenge for OEMs and Tier suppliers. The high cost of raw material, as well as the lack of automated and repeatable manufacturing processes, is preventing composites from being widely used in mass production. DS DELMIA Composites Planning takes advantage of ply stacking and composites properties from the CATIA model to deliver process planning capabilities needed to automate manufacturing processes.

With low volumes, a manual process is recommended; for medium to high volumes, an automated process is more suitable. With manual lay-up, automotive manufacturers are reaching a quality limit, because it's difficult to predict the exact final finish of a part on the shop floor. The operator may not deposit the ply consistently at the same position, jeopardising the precise initial design.

Utmost accuracy

To help the operator accurately lay the fabrics on the mould, best-in-class industry solutions are fully integrated in the design environment for nesting, cutting and laser projection systems, optimising the ply lay-up of a composites model with the highest degree of accuracy.

With automakers able to implement an end-to-end solution for composites, the industry is increasing its use of fibre-reinforced composites for a wide range of applications, which allows them to reduce their time to market and avoid costly errors, while minimising vehicle weight and cost and preventing overdesign. And that has to be beneficial.

General Motors is preparing to increase its use of aluminium in vehicle body structures significantly, with a new twist on an old joining technology: resistance spot welding. The automaker is expanding use of what GM engineers claim is an industry-first aluminium spot-welding process that features a new type of electrode developed and patented by GM research and development (R&D).

The technology is designed for much higher production rates than are currently employed in automotive aluminium-structures manufacturing. It centres on a new electrode-tip design that will enable GM's global body shops to spot-weld virtually any combination of aluminium sheet, extrusions and castings, according to Blair Carlson, lab group manager, Lightweight Materials Processing Group, GM R&D.

"No other automaker is spot-welding aluminium body structures to the extent we are planning to and this technology will allow us to do so at low cost," he says.

By increasing its use of aluminium spot welds per vehicle, GM expects to eliminate nearly 900grams of self-piercing rivets from aluminium body assemblies including doors, bonnets and tailgates.

Using rivets to join aluminium pieces adds up-front cost, while complicating end-of-life recycling efforts. Rivet-gun operating limitations also restrict the joint configurations that can be employed in a structure.

GM also aims to commercialise the welding technology. "We've got a good handle on it in our internal production and we've licensed it to the GM suppliers for upcoming programmes," Carlson told Automotive Design. "Now we're taking the next step to license it externally for non-GM production," which he expects to include heavy truck, railroad and aerospace applications.

GM owns a suite of intellectual

Light weight future

Lindsey Brookes reports on a GM breakthrough that challenges aluminium manufacturing techniques

property around three concepts: the electrode design, the controls for the electrical current, and the technology for dressing (cleaning) the electrode tip intermittently, Carlson said.

The resistance-welding technology has been in use on select bonnet (Cadillac CTS-V) and tailgate (hybrid versions of Chevrolet Tahoe and GMC Yukon) applications since 2008. GM's invention is the unique design of the electrode tip. Its concentric domed rings (see image, below right) break through the aluminium oxide layer contained on all aluminium parts.

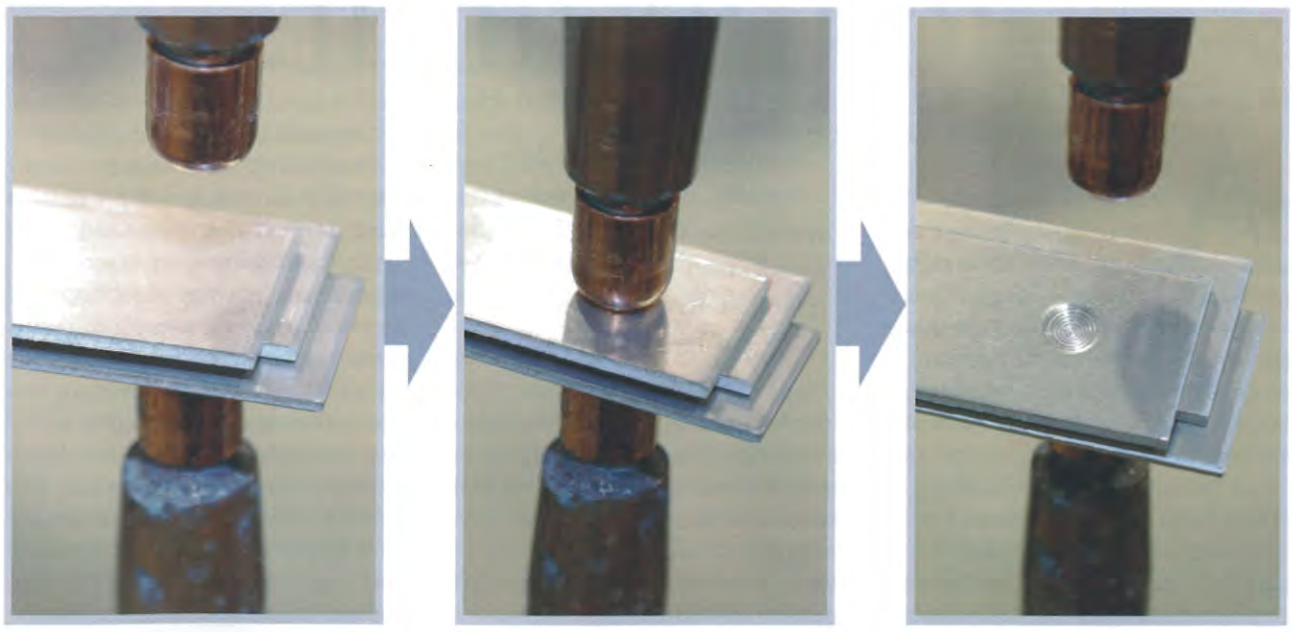
"That layer is the bane of aluminium welding," Carlson explains. "The rings allow the electrode to engage the surface of the material, so that current passes more easily and generates a weld nugget in the middle, centred between the two parts," he said.

The process is not affected by material gauge and has demonstrated improvements in process consistency and electrode life since it entered volume production. Carlson recalls GM's implementation: "Basically, the ME [manufacturing engineering] guys wanted us to do due diligence, so we took the recommended practices of The Aluminum Association for weld schedules and electrodes, and did process windows versus our technology. We published this in an earlier sheet-metal conference paper."

The new electrode tip design gives a larger and more robust weld process window, with much tighter consistency than with conventional aluminium spot welding, Carlson notes. "We don't have traditional issues such as the sheet metal sticking to the electrode, which usually means the welding cell will stop, and the operator has to go in and check it out. We avoid all of those interruptions in production." GM uses MFDC (mid-frequency direct current) in its aluminium fabrication operations.

Jon Lauckner, GM's chief technology officer, views the technology as a strategic asset. "The ability to weld aluminium body structures and closures in such a robust fashion will give GM a unique manufacturing advantage," he said in a statement. "It is an important step forward that will grow in importance."

Concentric rings on the domed electrode tip (image at right) are key to the effectiveness of the aluminum resistance-welding technology. GM owns IP around three concepts: the electrode design, the controls for the electrical current, and the technology for dressing the tip intermittently.



The targets and tolerances used in these images are for illustrative purposes only and do not represent the real targets used by the OEM

Pushing tolerances to the limit...

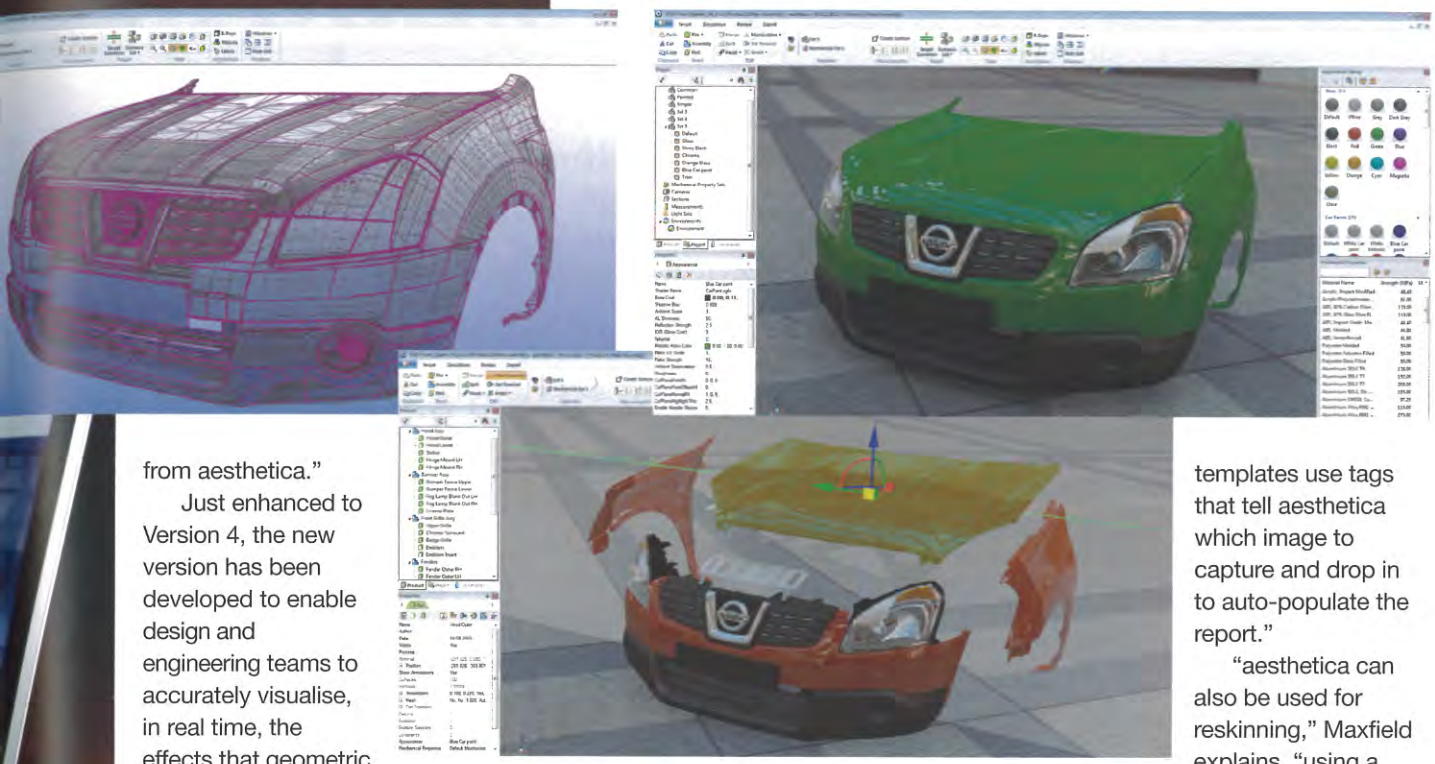
Photo: Dean Smith, Camera Crew

...to capture real-life results. Mark Fletcher speaks to the man behind aesthetica and its crucial part in streamlining the design process

Arguably one of the most important steps of the automotive design process is to iron out any potential issues as early as humanly possible. By designing out such issues before they become major problems, not only can the design process be significantly streamlined, but it can also save huge amounts of expenditure.

Dr John Maxfield, technical director and founder of Icona Solutions, explains: "Typically, perceived quality is all about looking at product, using renders. But the issue here is that renders produce a perfect nominal model. Although you can vary the environment, the reality is that the product will not look like that. What aesthetica allows designers to do is introduce the common imperfections that can appear in both the design and manufacturing processes.

"aesthetica doesn't just simulate the movements," he continues. "Instead, it can simulate all possible tolerance conditions (shape and position) and combine them with any deformations that may occur during assembly. Using this approach, a solution can be found very quickly... but not by aesthetica. aesthetica knows the measurement targets and what is causing the issues – ie, which tolerances are having the biggest impact and how many are in target or not in target – but it does not know what would be a cost-effective solution. That is up to the designers, based on the knowledge exported



from aesthetica."

Just enhanced to Version 4, the new version has been developed to enable design and engineering teams to accurately visualise, in real time, the effects that geometric variation caused by manufacturing processes will have on the aesthetics of a new product much earlier in the development process. "The software is unique, in that it combines tolerance analysis with high-end, real-time 3D visualisation," explains Maxfield.

"Unlike other software products, it enables the user to dynamically visualise the effects of manufacturing variation – gap-and-flush, buckling, twisting etc – anywhere on the 3D CAD model of the exterior and/or interior of a new or redesigned vehicle and to show not just the extremes of variation, but all states in between the extremes. Importantly, it enables this as early as the concept design phase."

Amongst the new features introduced with aesthetica Version 4 is a new 3D visualisation system, which supports HDR environments, lighting and shadows, and a new material library, with accurate representations of car materials. V4 also includes a new geometry-based measurement system, which enables gap and flush to be defined relative to the CAD geometry within the section; point and point-to-point measurements; relative difference measurements that can be used to assess taper and parallelism; and closest point, to measure the minimum distance between two geometric objects.

A new user interface utilising an intuitive ribbon and context-sensitive menu system replaces the older-style menus and tool bars in previous versions. All functions for a specific perceived quality process activity are launched from the appropriate tab – Target, Tolerance, Review, Output – on the ribbon and most common functions are now immediately accessible through the context menus. Interacting with the 3D model is also easier and more intuitive, with selection and navigation performed directly on the 3D model, without the need to switch interaction modes.

"Engineers can also exploit the export tool," Maxfield elaborates, "which can generate PowerPoint or Excel files, based on predetermined templates for target-setting reports. Each page of the report can highlight a measurement, show maximum and minimum conditions, and then illustrate them with an animation.

A second slide could then show parallelism or taper. Predetermined templates use tags that tell aesthetica which image to capture and drop in to auto-populate the report."

"aesthetica can also be used for reskinning," Maxfield explains, "using a locator scheme from a previous vehicle that details 'A' surface fastening points. A Monte Carlo analysis can be run, where each individual locator has a tolerance. aesthetica then randomly positions locator points, based on their tolerances, and takes into account any form variations of the parts. It takes imperfect parts and attaches them to imperfect locators, and builds what is classed as a random vehicle, based on the available tolerances.

"This analysis will then be repeated thousands of times, with thousands of randomly varied parts, to simulate what could happen on a manufacturing line. The more times you repeat the process, the better the overall distribution of variation will be. At the end of the process, you can then look at the result and, in some instances, aesthetica will highlight issues that may not appear, using nominal tolerance analysis.

"aesthetica will also highlight what can be causing the problem, such as which tolerances and features are directly involved in the variation of a particular point. This then guides the designer or engineer to a solution."

Marc Michelsen, director, AkzoNobel Automotive and Aerospace Coatings

Paint your wagon

"McLaren wanted best in class, with respect to gloss and general appearance, for its new P1 supercar that was unveiled at the Paris motorshow. Particularly, they wanted high levels of hardness, processing and damage resistance, with a unique colour range. Added to that was the challenge of developing paint that would be compatible to metal, plastic and carbon fibre substrates that was as light as possible.

"It's not so difficult to make hard paint or one that looks good; the challenge is combining both sets of properties. We use a special process in the application phase when the paint flows out very evenly and then the stoving process is very fast, so it ends up with a very high level of hardness that can be easily and quickly polished, without waiting for it to be cured.

"We've also been able to save 15-20% in weight over normal paint; it's all about optimising each colour, so you have fewer layers that lead to the weight reduction, rather than the composition of the paint.

"The car consists of a number of parts that are assembled after painting, so colour consistency is really important. We supply different primer colours, so all the components start with a similar shade, and then we strive for what we call 'optimal hiding' of our base colour, which gives very consistent lay-down, making sure all the special effects are similar.

"Carbon fibre has two challenges: it's rougher than other substrates, so it has to be really well covered to get a nice, smooth appearance; and, secondly, the epoxy matrix isn't light stable, so you need a protective layer with sufficient UV stabilisation in it.

"Carbon fibre has two challenges: it's rougher than other substrates, so it has to be really well covered to get a nice, smooth appearance"

"Because we use fewer layers, it's a quicker painting process and the other time-saver is our unique clear coat, which hardens directly after the stoving process; whereas, with other clear coats, you need to wait a few hours before they harden off. That's quite attractive for a company that comes from Formula 1.

"The usual baking temperature range for auto paints is between 120-150°C, but, as the McLarens are mainly hand-built, our system cures between 60 and 80°C.

"McLaren has a range of 17 colours, including the 'Volcano' range, which are very, very difficult to match, as well as bespoke one-off colours. The problem is, you want to get depth and brightness at the same time, and we've been able to achieve that."

The Propulsion Evolution

SAE J1772 ™ EV Conductive Charge Coupler

Helping make electromobility a global reality.

Standards & Resources from SAE International

Many say the automotive industry could well be standing before a paradigm shift with respect to propulsion. If so, a future that uses environmentally friendly motors partially or entirely powered by electricity represents one of the most challenging and profound technological transformations of our time.

In the 1900's, early automobile manufacturers came to SAE to freely exchange ideas and expand their knowledge on the "new form of transportation" at that time. It was the go-to forum for solving common design challenges, reducing costs and increasing safety, reliability, and comfort of the "horseless carriage."

Today, as then, SAE is at the forefront of advancing new forms of transportation by addressing the challenges associated with vehicle electrification and connectivity through its global, market-driven, voluntary consensus standards program and its library of mobility engineering information -- the largest of its kind.

SAE: Advancing the Advanced Vehicle

- Lead standards development organization by the Smart Grid Interoperability Panel
- SmartGrid standards harmonization activities with ISO, IEC, utilities, IEEE, EPRI, ZigBee Alliance, & HomePlug Power Alliance
- Rechargeable Energy Storage System (RESS) safety efforts through US DoT's NHSTA cooperative research project
- 29 standards development committees and 774 members involved in Vehicle Electrification
- 260 representatives from 150 organizations participate on the SAE Battery Standards Steering Committee

Charging, Batteries, Interoperability

- SAE J2954 ™ Wireless Charging of Electric and Plug-in Hybrid Vehicles
- HEV and EV Battery Technology SAE Standards Subscription
- SAE 2012 Convergence ®, The premier transportation electronics event

Safety

- SAE J2344 ™ Guidelines for Electric Vehicle Safety
- Fire Safety; 2007 and 2008 Book
- Basic Hybrid and Electric Vehicle Safety Webinar

Smart Grid, Energy Conversion/ Consumption, Energy Sources

- SAE J2847/3 ™ Communication between Plug-in Vehicles and the Utility Grid for Reverse Power Flow
- Electric Vehicle Technology-Smart Grid & Infrastracture 2011 SAE Technical Paper Collection
- Braking for Electric/Hybrid Vehicles; session, SAE 2012 Brake Colloquium & Exhibition

Advanced Vehicle Drivetrains & Engines

- SAE J1711™ Recommended Practice for Measuring the Exhaust Emissions & Fuel Economy of Hybrid-Electric Vehicles; Including Plug-in Hybrid Vehicles
- Modern Electric, Hybrid Electric, and Fuel Cell Vehicles Book
- SAE 2012 Competition for the Transmission of the Future Symposium

Electric, Fuel Cell, & Hybrid Vehicles

- Alternative Cars in the 21st Century, Second Edition-A New Personal Transportation Paradigm
- Vehicle Electrification—SAE Online Magazine evsae.com
- SAE 2013 Electric Vehicle / Hybrid Vehicle Technologies Symposia

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