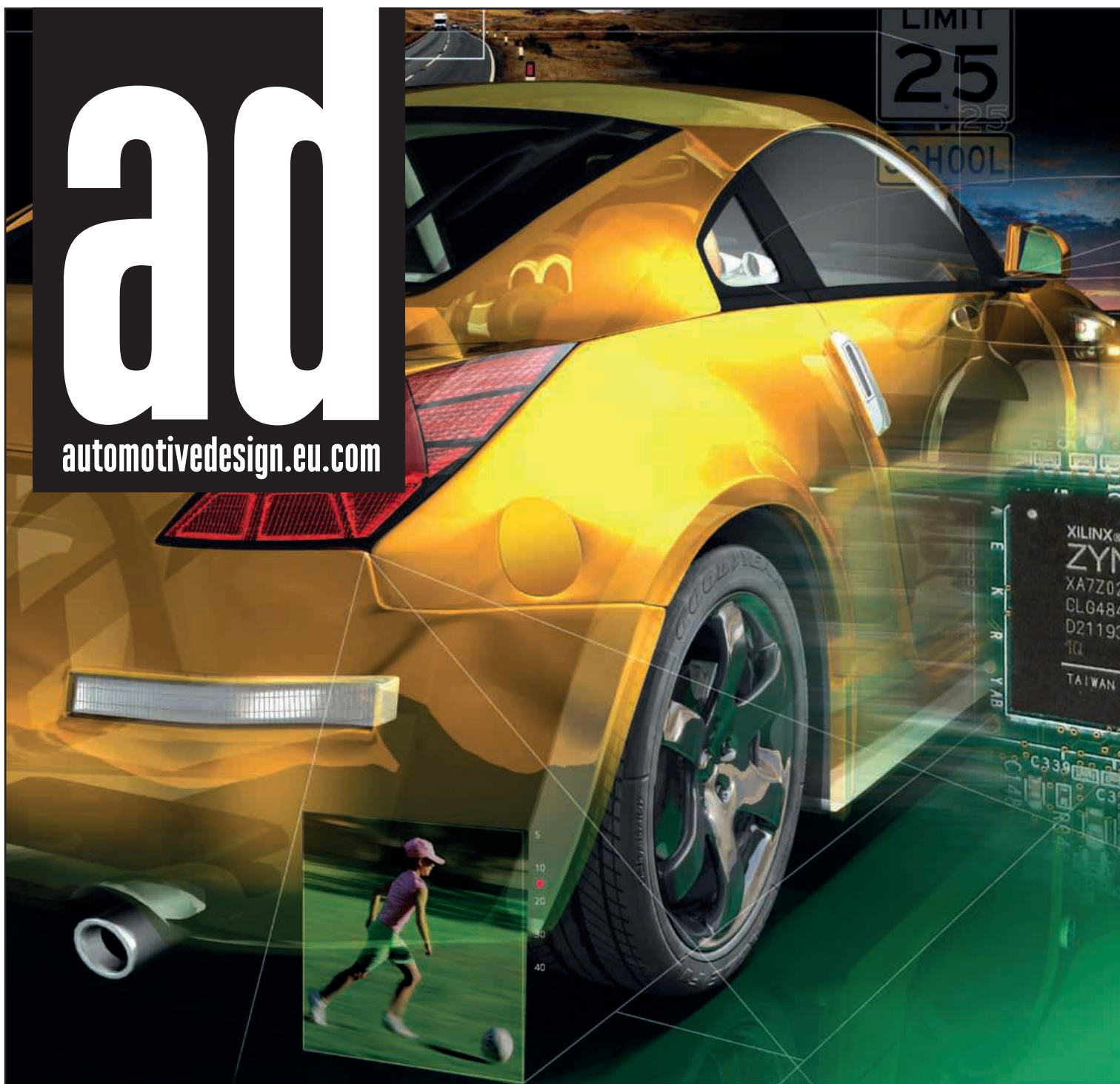


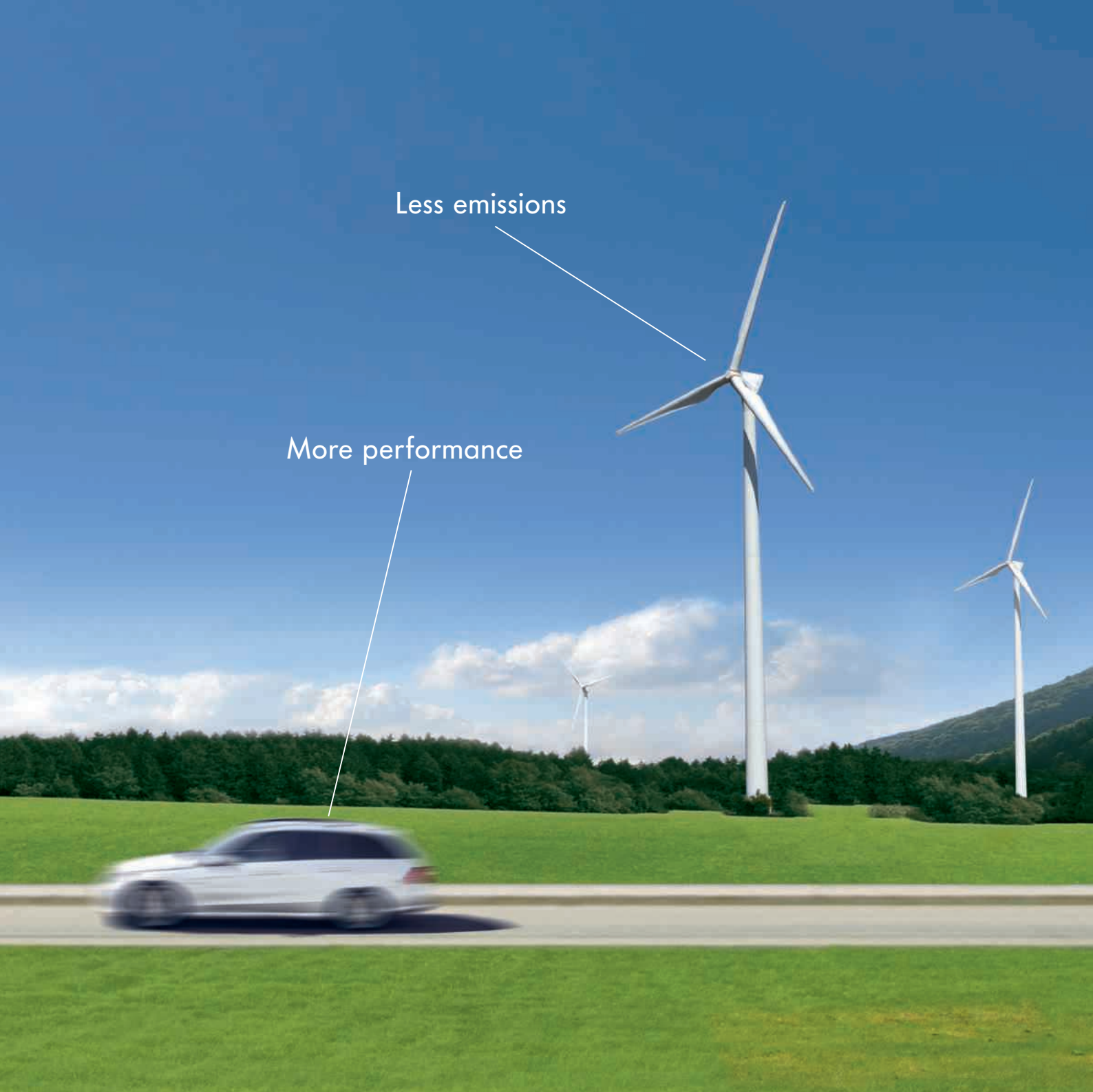
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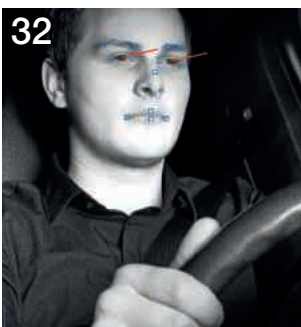
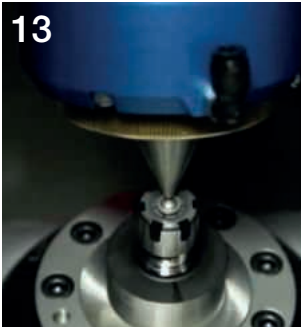
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Contents



13 SAE World Congress

Top tech talent

Spotlight on some of the technologies that have been judged worthy of an AEI SAE 2013 Tech Award

16 Automotive Design Interview

On the charge

New solutions for turbocharger hoses were revealed at a leading international conference. Ian Adcock reports

20 Cover Story

Gateway to electronic future

Chris Edwards asks if field-programmable gate array will be the next big step in automotive electronics

24 Exhaust & Emission Technology

Emissions mission: 2020 vision

Tony Lewin hears how next-generation engine control units will be key to hitting EU 2020 targets for CO₂

28 Instrumentation

Before your very eyes

Digital and multi-media technology are forcing a fundamental rethink on how the instrument panel can best support the driver, as Ian Adcock explains

30 Fuelling Systems

Under pressure

Fuel delivery and storage systems are being pushed hard to keep pace with demanding current and impending legislation. How well are they doing?

32 Question Time

Keeping you safe

Ryan Borroff reports on the 'eye' in the car that warns a driver of hazards or if his attention is elsewhere

5 Comment

6 News

- Peugeot hybrid breakthrough
- Door to greater weight-saving
- The sky's no limit
- New ways to slash bike-car accidents

19 The Columnist

Transformational times are with us

Kevin Jost, SAE International Editorial Director

34 60 second interview

Fabrice Gallo, LMS International's transmission solutions manager

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Vying for pole position



Headline grabbers from this year's Geneva Salon might well have been a flurry of hyper cars from McLaren, Ferrari, Lamborghini etc, plus Rolls-Royce's new coupé, that looked as if it had taken inspiration from Bentley's original Continental Type R around the rear window. But, beneath the surface, I detected a more upbeat attitude amongst the real-

world car manufacturers than I have done for some time. And that in spite of disappointing sales in mainland Europe and, especially, in the debt crises Mediterranean nations.

What was also significant was the eagerness of some OEMs to outline their future; usually Japanese executives are very reserved in interviews, guarded by a minder-cum-translator who will usually shrink lengthy answers down to a monosyllabic 'yes', 'no' or, if you're lucky, 'no comment'. This time, however, both Mazda and Nissan executives were far more forthcoming, as you can read in the news section on pages 9 and 6.

The drive towards improved emissions is concentrating everyone's minds – witness Kia joining the downsizing club with its own take on Ford's EcoBoost one-litre, three-cylinder engine. Not that I am suggesting it's in any way a copy, as it patently isn't; just that engineers, given the same problem, inevitably end up with more or less similar solutions.

And while we all thought that Ford's mini marvel was a game-changer, I would wager that Peugeot's intriguing and unique HYbrid Air could prove an even more significant breakthrough, sparking a race to develop hybrids not dependent on batteries.

Meanwhile, Chris Edwards takes a critical look at vehicle electrical architecture and how this is managed on page 20, while pondering what the future may hold for field-programmable gate array (FPGA)

Ian Adcock, Editor in Chief

Peugeot hybrid breakthrough

They say there's nothing new under the sun and Peugeot's HYbrid Air technology – that has delivered a figure of 2.9l/100Kms and CO₂ levels of just 69g/km during homologation and is talked of being capable of just 2.01l/100Kms – is a case in point, according to Karim Mokaddem, Peugeot's director hybrid project, as he explained to Automotive Design.

"Paul Magès, who was responsible for developing Citroën's hydraulic suspension back in 1958, came up with this concept at that time, using a 2CV, but stopped development, because he couldn't control the system."

The technology, which uses a combination of internal combustion engine – petrol or diesel – and compressed air to drive the car lay dormant until 2011 when Mokaddem and his team revived the idea. Two years and 80 patents later, Mokaddem is predicting that it will go into series production in 2016. "The main hurdle we have to overcome is the

industrialisation of the hydraulic components. Currently, they are used for aeronautical applications, not automotive, and, with our partner Bosch, we need to industrialise them to bring them down to a realistic price for more mass production in the automotive sector."

Mokaddem wanted to have a "worldwide technology" that would be cost competitive with a 'D' segment diesel with automatic transmission, at "half the cost of an electric hybrid."

Although currently installed in a Peugeot 2008, the production version will first appear in PSA's new Efficient Modular Platform 2 (EMP2) that underpinned the Citroën Technospace concept unveiled at Geneva. Unusually for a project of this nature, the development team, as well as consisting of dedicated engineers, included marketing and product strategy specialists to jointly determine if this was a viable technology, with Eric Lalliard, chief engineer HYbrid Air, explaining that each of the four prototypes built since 2011 proving that there was "no key show-stopper technology", adding: "All the innovation is around how we manage the transmission, and control the energy flux from the ICE and the



compressed air. When it goes into production, we will use the same type of ECU as found in a diesel engine, but with our own unique, in-house developed, algorithms."

BLENDED POWER

In addition to the latest generation three-cylinder Peugeot 1.2-litre VTi 61kW petrol engine, HYbrid Air has an air tank pressurised at 250bar, located in the centre tunnel, with a low pressure tank acting as an expansion bottle at the rear (similar to a SCUBA tank, notes Lalliard); an hydraulic unit consisting of a motor and a pump installed under the bonnet on the Electronic Gearbox Control (EGC) automatic transmission, which blends the power from the



Enlightened thinking behind new lightweight strategy

Nissan is actively pursuing a lightweight engineering strategy for its future product portfolio, according to its corporate VP, global product strategy and product planning division, Keno Kato – pictured, far right. "Lightweight engineering is really core of our future technology. We focus on body structure to make it lighter, but other parts of the car as well. In this context, we have lots of room to reduce the weight of components, engine, chassis, heating, ventilation and air-conditioning (HVAC), as well as steering systems, instrument panels etc, using carbon fibre reinforced plastic (CFRP) and aluminium." The key to this strategy, he explained to

Automotive Design, is "co-operation and teamwork across line engineering – who is in charge of HVAC, engines etc and the chief engineer – and this collaboration is improving daily." Kato conceded that the clear targets for reducing each vehicle's weight was "into double figures", although this would be spread across the components, "with strict targets for each".

These, he said, "must tie in with forthcoming emissions legislation in 2015, 2020 and 2025. Weight reduction is one solution to meet these, but combustion improvement, electrical devices etc, as well – there are lots of ideas to package in the car".

He described Nissan's engineering strategy

as based on 'function axis' and 'regional axis'. "I am head of product planning and not engineering; we can approach engineering with a dense message and make a request, and then engineering will ask each region to work accordingly. So, you have lead engineers for a global vehicle who could be the USA, Japan or the UK." The 'function axis' would then slot into the product development programme, wherever it's based.

Increasingly, Nissan products will be based on common architectures and components, clothed in a multitude of styles and designs, both interior and exterior, "We want to emphasise the car's character, which is why



Home, James!

Autonomous driving has taken a step closer with the announcement that BMW and Continental are pooling their development capacities to define the long-term prerequisites for series introduction of highly automated driving on European highways beyond 2020.

The cooperative project between the BMW Group and Continental runs through to the end of 2014 during which time several prototype

vehicles will be built.

The research prototypes will then be made available to a select team of trained test participants. Employing close-to-production technology, testing will involve analysing highly automated driving functions not only on German highways but on roads throughout Europe as well. The tests will cover all the challenges this poses, such as interchanges, toll plazas and road works.



two sources. In the zero emission vehicle (ZEV) mode, the car is powered by compressed air stored in the tank, sufficient for 2-3 Kms commuting speeds, he claims.

Under braking, 95% of the energy that would otherwise be lost is harvested to replenish the accumulator in 10 seconds, says HYbrid Air's Lalliard. At higher speeds, out of urban areas or on highways, the conventional ICE takes over, Mokaddem states.

The two motive powers can be proportionally combined, according to the vehicle's performance demands, so the compressed can enhance acceleration or when moving off from standstill.

Mokaddem is confident that the car will reap as much as 45% fuel savings in urban cycles, but what he is most proud of is this: "We can demonstrate today that there are other options when it comes to hybrids and open the door for other solutions."



I love to commonise the things buyers don't see." Nissan was on a "massive" learning curve, he accepted, with its relatively new relationships with Daimler and Mitsubishi, but believes the deeper understanding it has with Renault can be a template for the future with its German and Japanese partners.



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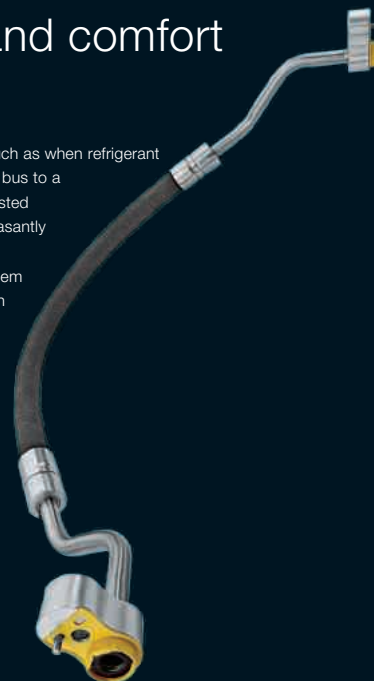
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Land Rover has built a fleet of electric-powered Defenders to gain experience with lithium iron phosphate batteries and switch reluctance motors, says Tony Harper, chief engineer research & advanced engineering for Jaguar Land Rover. The 110 Defenders are powered by 300v, 27kW battery packs, supplied by Axiom, driving a 70kW SR Drive electric motor.

The transmission comprises a single speed, 2.7:1 reduction gearbox, combined with the existing Defender four-wheel drive system. A modified version of Land Rover's Terrain Response System has also been incorporated.

"It's a gradual process of learning how the components behave, where they go wrong, how to make them more robust, how they work with other components and what are the electro-magnetic interference issues," commented Harper. "The learning and data gathering become part of the corporate knowledge for all our electric work."



Capturing the right effect

Renault's Captur, a compact crossover that replaces the Modus, passes twice through the paint shop at the Valladolid factory in Spain to achieve its two-tone paintwork. "We have the capacity there, so it makes commercial sense to do that," said Ali Kassai, head of small cars. Other carmakers that want the two-tone look, notably Land Rover with the Range Rover Evoque, have added loops into the paint shop to facilitate painting the contrasting colour.

But the two innovations on the Captur that most please Kassai are the unzippable seat covers and 'magic drawer' – a glovebox with an 11-litre capacity that is big enough to hide a laptop, as well as several bottles of water. It will only be available on left-hand drive models; to include it in right-hand drive versions would mean substantial re-engineering.

The unzippable seat covers will allow owners to clean or replace them, if they want a new look for the interior. Even the steering wheel can be personalised with coloured insets.

The door to greater weight-saving

Honda is claiming a significant breakthrough in joining steel and aluminium in the doors of its North American version of the all-new Acura RLX, reducing vehicle weight by 17% or 11Kgs per car.

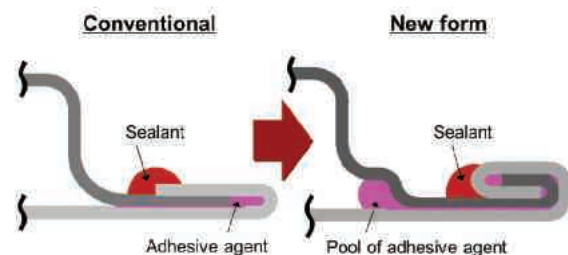
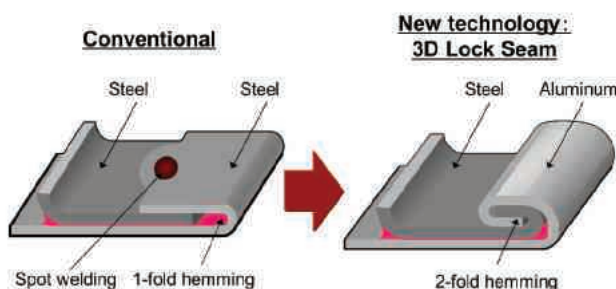
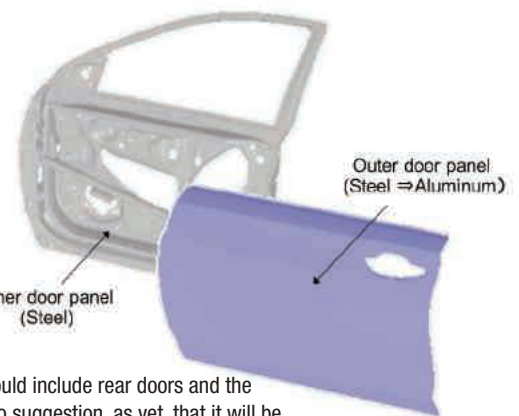
Developed in Tochigi, Japan, Honda had to overcome electrolytic corrosion and thermal deformation caused by the different expansion rates of steel and aluminium. To achieve this, the company developed three new technologies that allow the door's outer aluminium skin to be attached to the steel inner.

It adopted a '3d lock Seam' structure (below, left) where the steel and aluminium panels are layered and hemmed together twice – using a highly anti-corrosive steel for the inner panel and a new form that ensures complete filling of the gap with an adhesive agent (below, right) with a

low elastic modulus and optimised position of the 3D lock seam.

Combined, these techniques eliminated the need for spot welding, although the existing assembly lines can be employed.

Future applications could include rear doors and the bonnet, although there's no suggestion, as yet, that it will be applied to European Hondas manufactured at Swindon, UK.



The sky's no limit

"We're continually trying to improve the internal combustion engine (ICE) to get the ideal combustion system," explains Mazda's vice president of European research and design, Ichiro Hirose, pictured right, adding that 80% or so of all Mazda products will feature its novel SkyActiv technology by 2015.

"The current SkyActiv engine technology is only the first steps; we're looking to make even more efficient combustion and probably beyond 2015 we will implement those technologies.

"Cylinder deactivation is part of the alternatives we're considering, but it's likely to get even more sophisticated combustion. We have to achieve several factors to reach the ideal combustion system and, for some of them, we are very close to the ideal state with today's SkyActiv technology.

"There's combustion period, combustion timing and exhaust loss reduction, pumping losses and reduced mechanical friction losses. We already implement combustion ratio improvement, and also part of the pumping losses we have already implemented and exhaust loss reduction mean more expansion, with increased combustion ratio.

"There is still much to do with reducing pumping losses. For example, if we introduce re-combustion technologies with HCCI type



combustion, or similar to that, we still have those opportunities and we can also reduce mechanical friction losses a lot more."

Mazda has combined both its petrol and diesel engine development departments to encourage cross-fertilisation of ideas, one result of which has been the common 14:1 compression ratio shared by SkyActiv petrol and diesel engines. Hirose predicts that the nine injection sequences used in diesel engines will influence work on petrol engines, especially as Mazda continues to develop Piezo injectors. This will be in conjunction with further developments of spark plug ignition technology, and even more radical design of piston crowns to promote improved mixture and light-off.

While he concedes Mazda is investigating

even higher compression ratios for its petrol engines, he admits to concerns over low engine speed behaviour and the threat of residue build up on the piston crown over extended mileage. "The challenge is for injector technology to create finer air/fuel mixture, combined with higher line pressures," but he warns that this can lead to an increase in mechanical friction.

Rather than follow the trend for high-boosted downsized engines, Mazda's approach, he says, "is to expand the fuel efficiency areas wider and wider, so that doesn't require more gear ratios to keep the engine in its sweet spot.

"Those improvements are driven mainly by the combustion process and it's a philosophy we can apply from small to large displacement engines," he adds.

Rag top to riches

Magna Steyr showed off the latest version of its View Top cloth and glass sliding roof concept on a Peugeot RCZ coupe. First seen at last year's Geneva Salon as the MILA Coupic concept, this latest version achieves a maximum opening of 850-900mm, said Berthold Klein, director advanced engineering, Magna Steyr. The roof profile cleverly mimics the Peugeot's double bubble roof, but with 13 glass elements incorporated in the cloth roof. It takes just 12 seconds, said Klein, to open or close, adding that they were working on a stop-start system that would allow the roof to be only partially opened, if it needs to be.

Although it adds 28Kgs to the car's overall weight, it will fold down to a stacking height of only 200mm, without intruding on boot capacity.

"We're discussing development with several OEMs and would hope to have it in series production in two years," added Klein.



News in brief

Kia's lightweight three-pot

Kia is the latest manufacturer to join a growing list of OEMs offering a one-litre three-cylinder petrol engine. Turbocharged and with a lightweight aluminium block, the engine was jointly developed in Europe and Korea. It features reciprocating masses that are 25% lighter than standard, according to Dr Joachim Hahn, Kia powertrain manager, in an effort to ensure that a three-cylinder's inherent imbalance doesn't adversely affect quality. Kia worked with Korean supplier DongYang to develop the components.

Memories are made of this

The latest Chevrolet Corvette sees the first ever application of shape memory metals to replace electric motors. It's used to open and close a venetian blind-like flap in the boot space to relieve cabin pressure, making closing the coupé's doors easier for occupants. According to Corvette chief engineer Tadge Juechter, there's potential to use the materials in place of electric motors in seats or even for flaps in active aerodynamics.

Active sound

ASD Technology from Genesis uses the existing infotainment system of the vehicle and a patented algorithm to generate sound components according to the driving conditions. As a software-only solution requiring resources as low as 10 DMips, it shows a low cost in production and may be ported in most of the current audio systems.

Active Light Sensor

The MLX75030 from Melexis is a universal active light sensor interface that has been designed to allow easy implementation of robust multi-channel, close-range optical sensing systems into difficult operational environments. It incorporates four independent simultaneously operating light measurement channels: two taking care of reflection and the other two for ambient light measurement. This makes the device highly optimised for inclusion in human-machine interfaces (HMI) requiring proximity detection or touch-less gesture recognition in environments that are subject to wide variation in background lighting levels, especially automotive infotainment systems.

Slashing bike-car accidents

According to accident data, about half of all cyclists killed in European traffic have collided with a car – a number that could be mitigated by Volvo's new Pedestrian and Cyclist Detection technology.

New advanced software, including more rapid vision processing, has made it possible to extend the present detection and auto brake technology to cover certain cyclist situations.

The advanced sensor system scans the area ahead. If a cyclist heading in the same direction as the car suddenly swerves out in front of the car as it approaches from behind and a collision is imminent, there is an instant warning and full braking power is applied.

Pedestrian and Cyclist Detection, with full auto brake, consists of a radar unit integrated into the car's grille, a camera fitted in front of the

interior rear-view mirror and a central control unit. The radar's task is to detect objects in front of the car and determine the distance to them. The camera determines the type of the objects. Thanks to the dual-mode radar's wide field of vision, pedestrians and cyclists can be detected early on. The high-resolution camera makes it possible to spot the moving pattern of pedestrians and cyclists, while the central control unit continuously monitors and evaluates the traffic situation.

The auto brake system requires both the radar and the camera to confirm the object. With the advanced sensor technology, it is then possible to apply full braking power immediately when necessary. The technology also covers vehicles driving in the same lane.



Volvo's detection technology helps to improve pedestrian-cyclist avoidance

Webbing catcher belt concept

TRW revealed a new seat belt concept, in collaboration with Rinspeed, at the Geneva Motor Show.

Instead of a seat belt buckle and tongue, the technology features a 'webbing catcher' that enables semi-automatic buckling and unbuckling. The system is being introduced on the microMAX commuter vehicle concept, designed to travel short distances in urban environments. It features unconventional upright seats.

Sven Schaub, senior manager, engineering strategy and communication, said: "Our new seat belt concept is another example of how TRW continues to develop innovative technology, and enhance the safety of passengers beyond conventional passenger and commercial vehicles.

"The concept is based on proven seat belt restraint functionality. The semi-automatic buckling offers convenience, and ease of entering and exiting for new and conventional vehicle concepts – helping to increase belt usage rates over short distances."



Seat – pushing the limits in the lightweight race

Seat, the Spanish arm of automotive giant VAG, sees body-in-white (B-in-W) engineering, as well as sophisticated and dramatic lighting systems for both the exterior and interior of its products, as its signature engineering competences. That's according to Dr.-Ing. Matthias Rabe, the marque's executive vice-president of research and design.

Although based on the MQB platform as used by sister brands VW, Audi and Skoda, Seat's Leon is the lightest in its class, claims Rabe, with as much as 100 Kgs being shaved off the car's weight, depending on engine application.

"B-in-W engineering is very important to us. If you look at the window sealings on the new Leon, they are the smallest cuts in the group and



set a new benchmark. We also optimised all the door flanges to gain as much space as possible for easy ingress and egress from the back seats."

But it is Seat's lighting prowess of which Rabe is most proud. "Our lighting technology is unique within the group, outstanding in this class. Lighting development has to be done by

both the tier one and the OEM. We wanted six LEDs with a parabolic mirror, but you must have all the design and performance, as well as minimising the humidity inside the headlight itself," he commented.

"Design and engineering have to work very closely together to achieve the function. You have to define the volume, height, width and also the ventilation inside the light to get the best design," he explained.

"Lighting is extremely important and you will see more from us – not just exterior, but interior lighting in future cars. You don't need the most light inside the car, but need to have it in the right place, fitting to the design; not bold, but very fine lighting," he added.

Combined combustion creeps ever closer

Mercedes-Benz's Diesotto combined combustion system is potentially two years from full development, but it might take another year to prepare that market, advises Professor Herbert Kohler, head of e-drive and future mobility. "From an engineering standpoint, it's two years from the market," he said, adding that neither a market, nor customers, nor an application has yet been decided and this "could take another year".

Diesotto first debuted in the F700 experimental vehicle at the Frankfurt show six years ago, although the idea of a petrol spark-ignition engine that runs as a diesel compression-ignition engine for certain periods is a hot topic of research for most car companies. Fuel savings of up to 10% have been mooted, but in the past Kohler has said that figure is more likely to be between 6-8%.

Mercedes, Volkswagen and General Motors have revealed that they are working on the technology, but Mercedes has the best name – a portmanteau word that combines the names of the inventors of the diesel and the petrol engine.

"We have engines running on a test bench, and it is attractive and fun," says Kohler. "We are looking for the right slot and working with Renault Nissan on a four-cylinder engine... The 'where' and the 'when' of it have not been decided."

The experimental F700 Diesotto model had a Newton metre torque peak figure for its 1.8-litre four-cylinder engine that was higher than the power output, which made for an effortless and rather charming engine to drive. Kohler agrees and says the attractions of combined combustion aren't just in fuel savings, but in driving pleasure as well.

Are you sitting comfortably?

Johnson Controls has developed a hip-point mannequin that complies with all three existing international standards that define the characteristics and dimensions of these mannequins.

The new hip-point mannequin meets standards set by the Society of Automotive Engineers (standard SAE J 826), the central specification for hip-point mannequins worldwide and the GLORIA standard for EuroNCAP tests. It also satisfies the recommendations of the German Association of the Automotive Industry VDA (recommendation VDA 304).

The measuring mannequin, with its carbon torso, can also be fitted with a head restraint measurement device (HRMD). This determines the position of the head in relation to the head restraints.

Johnson Controls has also developed a procedure for calibrating the hip-point mannequin and head restraint measurement device. The mannequin is clamped into a calibration device and measured with a 3D coordinate measuring machine. An optical 3D scanning system is used to test that the carbon torso shell fully meets all standards after production as well. This method ensures an especially high degree of measurement accuracy and precise reproducibility of the process.

The engineers have also defined a detailed, but user-friendly, calibration log. This allows users of the mannequin and head restraint measurement device to easily check adherence to the detailed specifications contained in the three standards.



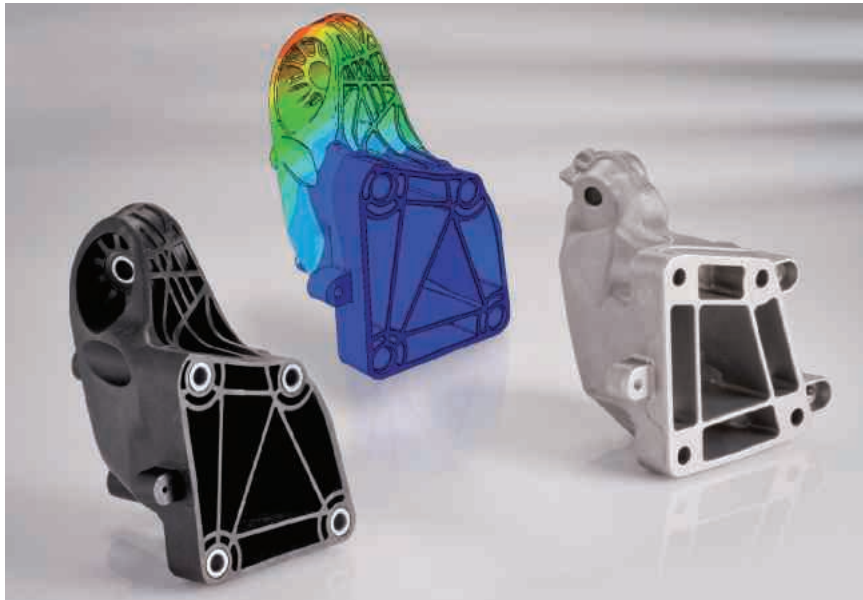
Daimler unveils first plastic engine mount

Daimler is installing the world's first plastic engine support for a six-cylinder diesel engine in the new GL Class. Compared to the previous aluminium support, the plastic part offers improved acoustical properties, better thermal insulating characteristics and a definite weight advantage, while being able to withstand the same load.

The part, which supports the engine with the aid of the engine mounts, is moulded from Ultramid A3WG10 CR, a highly reinforced specialty polyamide from BASF that has been optimised for high mechanical loads.

The torque supports that are already used by various vehicle makers in versions of Ultramid transmit only the tilting moment of the engine. In contrast, engine supports are subject to a permanent load – the engine's weight – while also absorbing the entire engine torque.

To date, they have always been made from aluminium. To replace it in this challenging and



also crash-relevant application, the plastic must fulfill demanding mechanical requirements: while Ultramid A3WG10 CR is very rigid; it was also necessary to demonstrate that it exhibited sufficiently low tendency to creep in the confined space of the engine compartment when subjected to a continuous load.

Furthermore, depending on the installation conditions in the engine compartment, the plastic engine support must also withstand high

bending moments. The good acoustic characteristics are the primary benefit of the Ultramid engine support over its aluminium counterpart. Thanks to the damping behaviour specific to plastic, the new engine support contributes to a more balanced sound.

A further benefit is that the heat conduction of the plastic is considerably less than that of aluminium. As a consequence, the Ultramid engine support provides better protection from the engine's heat for the natural rubber engine mounts connected to it, increasing their service life. Moreover, in the context of the CO₂ debate, a weight-saving of more than 30% for the plastic part versus the aluminum version is an additional payoff.

The multitude of tests that the plastic part must pass successfully includes the so-called repair crash, which replicates smaller crashes, and the massive offset crash (offset head-on

crash). In the first case, the support must remain undamaged; in the second case, it must fail quickly and in a specific manner to prevent the engine entering the passenger compartment.

Along with checking these requirements in crash tests, BASF already incorporated both cases into the very early development phase of the complex-shaped engine support through use of its Ultrasim universal simulation tool and predicted the part's behaviour: Ultimate (breaking) loads, strength values under dynamic pulsed loads and crash loads were in accordance with the results of testing, and achieved the values required for the aluminium predecessor. It was thus possible to incorporate ribbing to withstand the high loads and satisfy acoustic requirements early on, and reduce the number of prototypes usually required during the development programme.

Latest bearings saves CO₂

SKF has launched its latest low friction hub bearing unit, an energy efficient wheel end for cars. The product reduces friction by more than 20% compared to previous generations of SKF standard hub units, and provides CO₂ savings of up to 0.6 g/Km. When based on an annual mileage of 14,500Kms, the saving is 9 kg CO₂ per year. This equates to a reduction of 9000 tonnes of CO₂ per year if one million cars were equipped with the SKF solution; it is included in the SKF BeyondZero portfolio.

"In SKF we are dedicated to develop and deliver energy efficient solutions to our customers, and with this new hub unit we have used our broad experience and knowledge to develop a product that reduces friction even more than previous hub units, therefore continuing to reduce CO₂ and fuel consumption", says Aurelio Nervo, director car chassis, SKF.

The bearing's internal geometry has been carefully

analysed and re-designed. This re-design, as well as the development of a better, high performance grease, gives a significant friction reduction. A further characteristic of the new grease is to provide longer life and a better resistance to micro-movements.

The SKF low friction hub bearing unit can be used for different sizes and configurations to fit different car models. It can be used in existing as well as future new hub unit designs.



Top tech talent

The editors of Automotive Engineering International annually select, from among SAE World Congress exhibitors, the technologies they judge worthy of an AEI SAE 2013 Tech Award. Judging is based on level of design and engineering innovation, uniqueness, potential for 'real world' production application, and potential benefit for industry customers and end users.

Some of the highlights of the winning technologies are described here. Coverage of additional exhibitor technologies and other aspects of the SAE 2013 World Congress (16-18 April in Detroit) is viewable online at www.sae.org/mags/aei/saewc

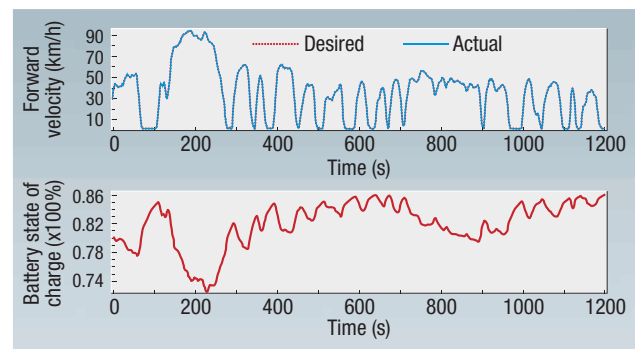
New methods for modelling physical systems

Maplesoft and its partners – the University of Waterloo, the Natural Sciences and Engineering Research Council (NSERC), and Toyota – are researching ways to develop the theory and computer algorithms necessary to automatically create engineering models in a mathematical form.

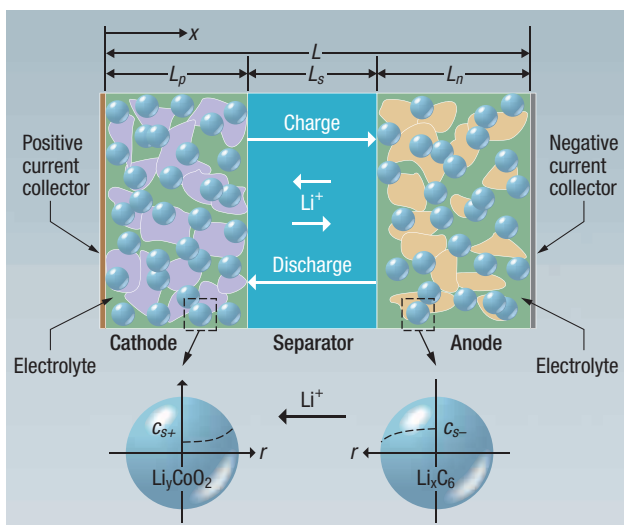
In collaboration with experts from Maplesoft and Toyota, Dr John McPhee, executive director for the Waterloo Centre for

Automotive Research (WatCAR), and his research team have used MapleSim to create a number of multi-domain system models, comprising mechanical, electrical, hydraulic and other components.

McPhee and team member Dr Sam Dao modelled a power-split HEV in MapleSim, with simple and advanced controllers created for the driver, power distribution and electronic control. The driver model looks at the desired federal



A schematic representation of a lithium-ion battery model is shown. Using the hybrid vehicle model to simulate an FTP drive cycle, the desired and actual speed of the vehicle versus time are shown at the top. The state of charge of the battery can be seen in the diagram below, left.



test procedure (FTP) drive cycle, compares it to the actual vehicle velocity, and adjusts the power until the actual and desired velocity overlap.

Many of the power-split HEV model's components were taken from the built-in MapleSim library, including all the components necessary to build a full multi-body dynamic model of the vehicle, with Pacejka tyres for asphalt roads, power-split device transmission, electric motors and generators.

"If we want to look at the underlying equations for any of

these components, we can easily do so," McPhee points out. "On the other hand, we don't need to take the time to assemble any of the component-level equations into the system-level equations."

COMPLEX CHALLENGES

Due to their complexity, the battery and the internal combustion engine (ICE) models were developed directly using MapleSim's Custom Component capabilities. 2D models of the battery were created, where the response of the system was governed by partial differential

equations that model the concentration of solid and liquid ions within the battery.

The completely chemistry-based battery model was then converted into a MapleSim Custom Component by taking the mathematical models and directly entering them into a Maple worksheet to define the governing equations for the component.

When compared with existing physical experiment results for the discharge/charge of a battery, the results of the chemistry-based battery model matched very well.

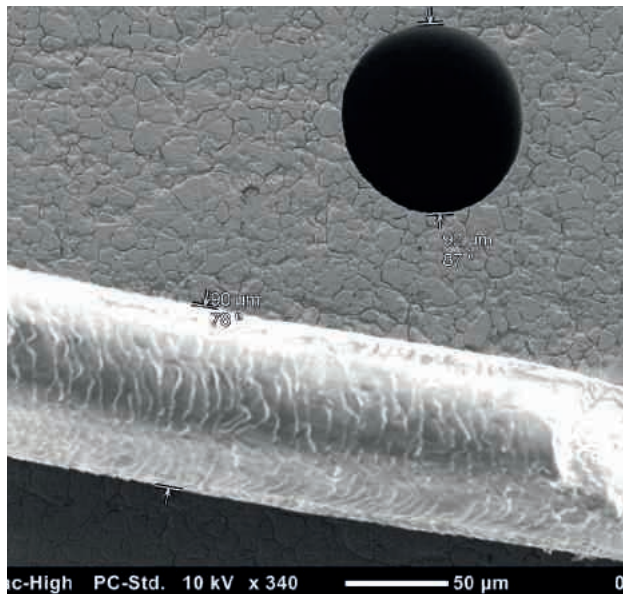
A mean-value ICE model was developed, using equations available in standard engineering textbooks. The engine model includes a throttle body, where the input is a throttle valve angle, connected to an intake manifold, which connects to the engine itself where the combustion takes place, followed by a driveshaft.

REGENERATIVE BRAKING

In the full HEV model, the mean-value engine model connects to the power-split planetary gear set, as do two motor/generators that are powered by the lithium-ion battery pack and controlled by an electrical controller. The output then drives the vehicle model.

When the hybrid vehicle model is used to simulate an FTP drive cycle, the desired and actual speed of the vehicle versus time are compared, and state of charge of the battery is also plotted. Results showed that, during heavy braking manoeuvres, the state of charge of the battery increased as a result of energy being recovered from regenerative braking.

"With MapleSim, the model development and analysis time of our power-split HEV model was drastically reduced," says McPhee. "MapleSim gives you complete flexibility and openness for complex multi-domain models, letting you create, analyse and run system-level models in a fraction of the time it takes with other tools."



Delivering precise micro hole drilling for next-gen fuel injectors

The R-Drill 200 from Raydiance is a laser-based micro hole drilling solution suitable for fuel-injector manufacturers, including those for gasoline direct injection (GDI) spray nozzles.

The Petaluma, CA-based company reports that the technology is the result of years of science and engineering innovation (27 patents to date), taking femtosecond laser pulses – pulse duration in the range of a few quadrillionths of a second – and applying it to solve real-world manufacturing challenges.

WORLD-FIRST CLAIM

In fact, Raydiance lays claims to being the world's first industrial-grade femtosecond laser based upon a fibre optic architecture.

Essentially, what the R-Drill 200 does is address the simultaneous challenges of greater machining precision, broader flexibility in feature shape and more cost-effective means of manufacturing next-generation fuel injectors.

The geometries and surface finishes achieved by the R-Drill 200 were not practical with other fabrication technologies, such as

electrical discharge machining (EDM) or mechanical punch. Indeed, with the R-Drill 200 no-touch machining, the laser hits its target so quickly that material is vaporised molecule by molecule, without any heat dissipation, according to Raydiance.

COST & COMPLEXITY

This phenomenon was known to academic scientists for years, states Dr. Michael Mielke, chief scientist at Raydiance, but was not previously available to industry,

due to the cost and complexity of early-generation femtosecond laser systems. In other laser-machining processes, he explains, heat causes melting, burring, discolouration and other thermal effects that must be addressed in post-processing.

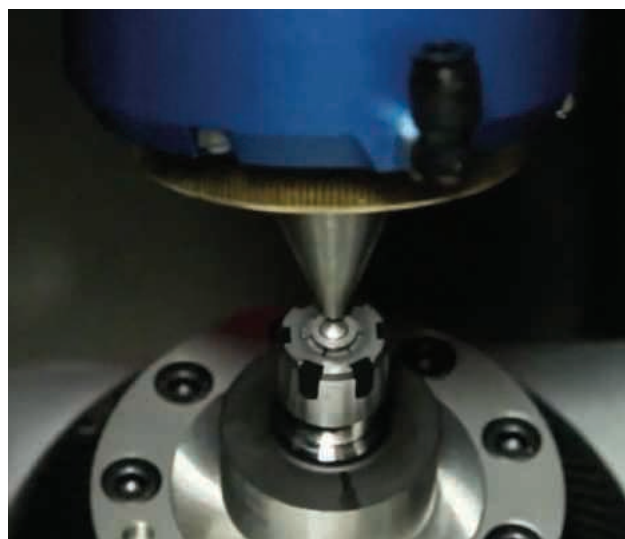
FUEL EFFICIENCY

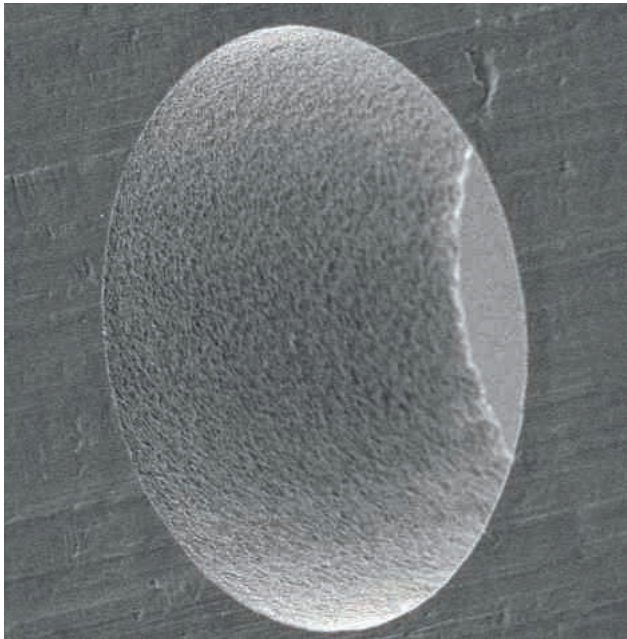
With the R-Drill 200, parts can be machined to extremely precise specifications, with no chemical or mechanical rework. Greater part consistency – at the scale of 1 micron – leads to better performance in the vehicle. For example, GDI spray nozzles made with the R-Drill 200 can deliver precise fuel flow and ideal atomised fuel distribution in the engine cylinder, thereby enabling the 30% better fuel efficiency achievable with GDI, without compromising engine output performance.

SHAPING THE FUTURE

"The R-Drill 200 addresses the simultaneous challenges of greater machining precision, broader flexibility in feature shape and more cost-effective means of manufacturing the next generation of fuel injectors," says Mielke.

"[It] can be programmed to drill virtually perfect spray holes in fuel injector nozzles, in less than a second per hole. The level of precision in fabricating arbitrary





Extreme accuracy achieved by vaporising material molecule by molecule.

hole profiles enables a new generation of fuel injectors to direct spray patterns and droplet size distribution more accurately to where it's needed for combustion."

The speed and efficiency of the process reportedly can lower the overall costs of producing the new injectors.

"This innovation is highly beneficial to [automotive parts manufacturers], because they are able to fabricate better fuel injectors with a process that is faster, cleaner and also at much lower cost.

"These manufacturers are operating under government mandate for fleet-wide vehicle fuel efficiency increases and emissions reduction, and a primary means of achieving the mandate is advancing fuel-injector technology," he points out.

GDI INJECTORS

"The design selection of GDI injectors for more new vehicles is a very visible result of this mandate," Mielke adds.

The realisation of this innovation started with the fuel-injector engineers who design GDI and the higher-efficiency engines.

Raydiance learned the fabrication requirements from these engineers and developed the femtosecond laser-based drilling solutions to keep pace with their fuel-injector advances.

CREATIVE PROCESS

The company's laser applications engineers created a prototype process for precision hole drilling, using early-generation lasers, a laser beam scanning module and some simple injector nozzle mechanical positioning equipment.

"After successfully achieving the necessary GDI spray nozzle quality in the laboratory, our team of optical, mechanical, electrical and software engineers worked with multiple Tier 1 automotive manufacturers, along with their preferred work cell integrators, to develop fully automated and very fast, fuel-injector manufacturing cells, based on the R-Drill 200," Mielke adds.

These advanced machines have now been installed around the world into 24/7 manufacturing environments, Raydiance reveals.

The technology will be on show in the company's SAE 2013 World Congress Booth #712P.

Nine-speed all geared up for front-transverse engines

ZF's nine-speed automatic transmission (9HP) has been designed for vehicles with transverse engines and front- or four-wheel drive.

The housing of ZF's 9HP consists of two parts: a converter housing and a main housing, with an aluminium cover. By default, the 9HP is connected to the vehicle radiator via pipes and a transmission cooler can optionally be attached directly to the housing.

ZF engineers did not use a fully integrated mechatronics module. Instead, the ECU is installed separately from the now "significantly smaller" hydraulic control unit on the upper side of the transmission housing. The sensors can be found inside the transmission; vehicle-side signals are connected directly to the male plug of the ECU.

FIRST-EVER USE

ZF achieved the high number of speeds via four individual gear sets nested within the transmission, and six shifting elements, with nine gears sets. The 9HP also features what ZF says is the first-ever use of interlocking dog clutches for power shifting, and is supplemented by using hydraulically operated constant-mesh elements that reduce its impact on the overall transmission length and optimises efficiency. Its high total gear spread of 9.81 enables the 9HP to reduce 0-60 times by 2s with 10-16% fuel consumption savings, compared to six-speed automatic transmissions. Small gear ratios are achieved, which positively affect driving comfort and allow the engine to run in the consumption-optimal speed range. At engine speeds of 75 mph (121 Klm/h), rpms are

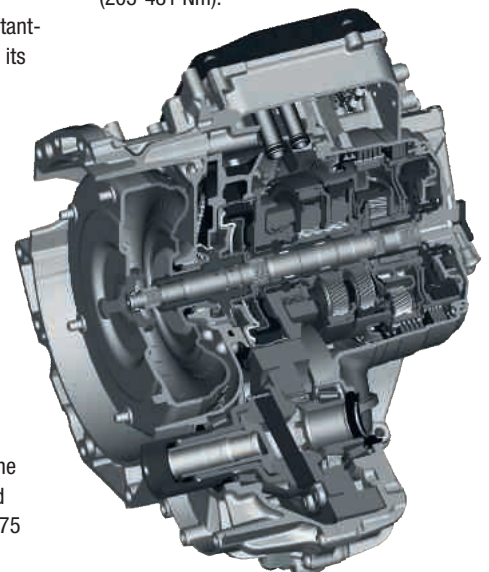
lowered by around 700, resulting in less noise.

BETTER DYNAMICS

A torque converter is used as the 9HP's standard starting element, which provides smooth starting and improved manoeuvring quality. A multi-level torsion damper system minimises hydraulic losses, while facilitating the quick closing of the torque converter lock-up clutch. This system is beneficial not only for fuel consumption, but also improves driving dynamics.

A powerful embedded flash controller makes complex control algorithms, with a calculation performance comparable to the controller used in the eight-speed automatic that can be increased by about 30% on demand for even greater software functionality. The layout of the ECU has been designed so that different OEM hardware needs can be met.

The 9HP is built on a construction kit principle that creates the flexibility for special requirements by OEMs and to accommodate different starting elements, stop-start, hybrid and all-wheel drive applications. It will come in two torque ranges between 150 and 355 lb ft (203-481 Nm).



On the charge

At the 5th International Conference on Advanced Downsizing & Turbocharging, held in March, new solutions for turbocharger hoses were announced. Ian Adcock got the details from Volker Oehl, Europe area marketing leader for Dow Corning Corporation's automotive industry

The increasing trends towards smaller, highly boosted petrol engines and ever more powerful diesels, packaged in engine compartments that are shrinking in size and loaded with more componentry and equipment, is having far-reaching effects on many aspects of the vehicle's engineering and the materials used.

The latter now have to be far more robust, especially in under bonnet applications, capable of withstanding higher temperatures, along with more aggressive chemical reactions – and none more so than synthetic tubing employed in turbocharger systems, as well as the intercooler.

Previously, materials such as HNBR, XNBR, Urethane, FKM, ACM and AEM dominated many of these

applications, but of late there has been a switchover to Fluorosilicone rubber (FSR) also known as FVMQ.

As automotive manufacturers developed increasingly higher performance systems, it was clear that more durable FSRs would be required. This need was anticipated and met with a continuous improvement in FSR technology, which saw the doubling of FSR tensile strength and elongation characteristics, and a four-fold increase in tear, die B – as shown in Figure 1. This illustrates the typical mechanical properties for three generations of fluorosilicone rubber bases. The first low-swell (LS) materials were developed in the 1950s.

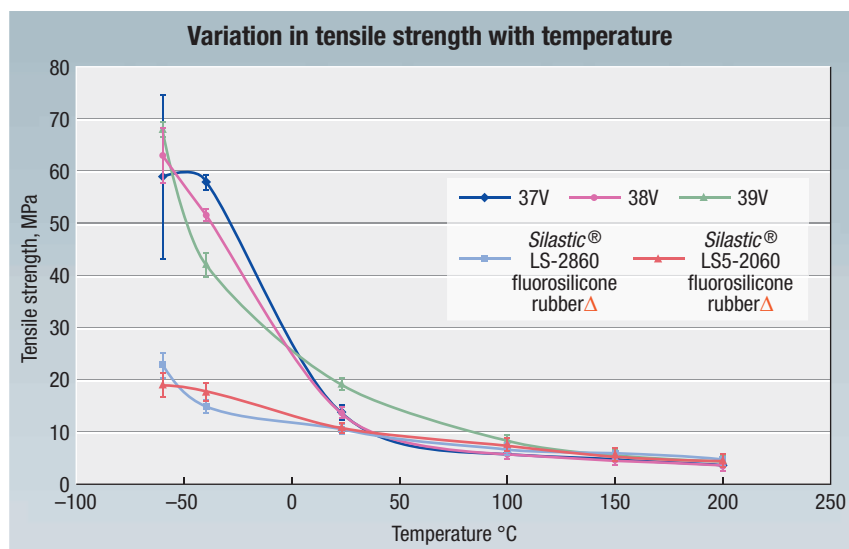
While they exhibited modest properties, the next generation of low-swell fluorosilicone materials,


such as Silastic LS-2840 Fluorosilicone Rubbers, showed significant improvements. Dow Corning's next addition to the base product line, typified by Silastic LS 5-2040 Fluorosilicone Rubbers, exhibit strength and tear properties approaching that of many of the organic rubbers at room temperature and exceeding the properties of most organic rubbers at higher temperatures.

"Silicones are typically used when you need very stable materials where you have a hot environment or when you need certain applications for things like sparkplug boots, engine mounts, sealing applications, cylinder head gaskets etc, so it was only logical to use them for turbocharger hoses," explains Dow Corning's Volker Oehl, before adding: "The turbocharger hose is silicone rubber on the outside, with a layer of fluoro-silicone rubber on the inside, with some people using FKM organic fluorinated materials.

"With silicones, you always get the high temperature resistance; the fluoro-silicones also have excellent shear resistance. The decision to make turbocharger hoses was the logical consequence of an evolution.

"Nor is there much difference between petrol and diesel engine applications. Diesel in the past used to have higher temperatures than petrol, but that's changing. Today, it's more a question of the engine power and geometry that makes a bigger difference than the type of fuel."



A portrait of Volker Oehl, a middle-aged man with glasses, wearing a dark suit, white shirt, and a blue and yellow striped tie. He is smiling and looking towards the camera. The background is a blurred green and white pattern.

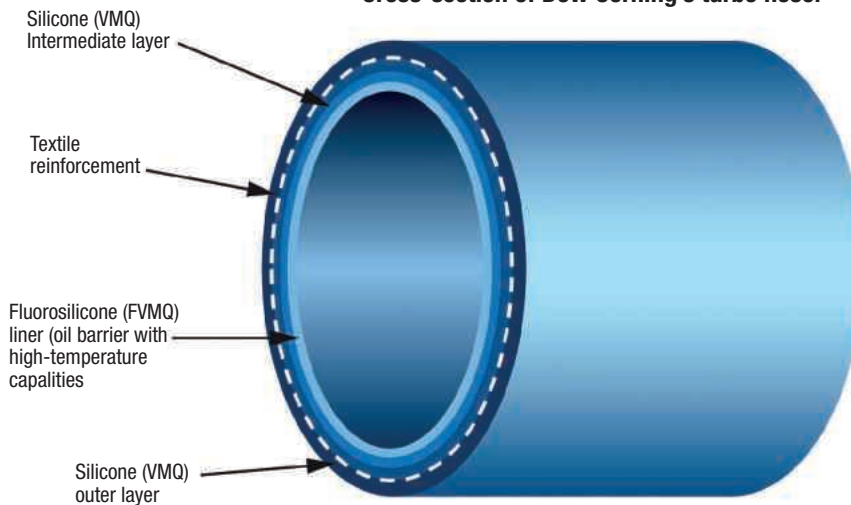
“Silicones are typically used when you need very stable materials where you have a hot environment or when you need certain applications for things like sparkplug boots, engine mounts, sealing applications, cylinder head gaskets etc, so it was only logical to use them for turbocharger hoses.” — Volker Oehl

Volker Oehl

CV

Volker Oehl, (52) Europe area marketing leader for Dow Corning Corporation's automotive industry, joined the company in 1991 and held a variety of marketing positions in engineering, electronics, mould making, appliances, coatings and life sciences, before transitioning to the automotive industry in 2011. Among other duties, he is responsible for developing strategic plans for direct customers and distribution and support implementation, expanding marketing mix strategies to capture business, and exploring market opportunities for geographic development. Fluent in German and English, Oehl holds a degree in chemical engineering and is a member of the German Marketing Association. He is married, with one child.

Cross-section of Dow Corning's turbo hose.



The growing fashion of downsizing across the range of power trains is becoming more of an issue, as Oehl explains: "What we see is engine downsizing with smaller engines, but, on the other hand, there's less space in the engine compartment, so the challenge is you have a powerful engine in a small space, which in itself impacts on the temperatures, so they get higher. And then you have exhaust gas recirculation, which means acidic gases and concentrates in the hose."

Those temperatures, says Oehl, have increased from around the 200°C mark to the 220°C-240°C range, with some OEMs testing as high as 250°C, he reveals.

Inevitably, the forthcoming Euro VI legislation is what Oehl describes as "the biggest influence" in driving up temperatures to the "very hot" 250°C. But the challenge for Dow Corning is that the material's performance as temperatures rise isn't linear. "The higher you go, exponentially, it becomes more difficult, but we do have programmes in place to keep up with the trends and performance requirements."

Dow Corning, he says, has "extensive" research and development programmes to ensure

the chemistry is right to cope with those extremely high temperatures, before adding: "That will make it more complex and the automotive world always asks for reduced costs. It's not just material cost per kilo, it's also processing costs. We look at both, the material chemistry, but we know that, for our customers, processing is a cost as well. The easier we can make their processing, the better it is for lower overall costs. We consider both elements."

"By the time we get involved with our customer, typically the hose manufacturer, then a lot of the design has already been done. They have the engine and the turbocharger and intercooler system, and they need to connect it, so we get involved very often quite late on. That's challenging for the hose manufacturer, in terms of getting the geometry right and, of course, for us to make sure the material is right for the process the hose producer is using."

If there is a problem, then it's more likely to be the challenge of getting the material right for each application, as no two OEMs work to the same specification. "The other point is how do we make sure we get a design of material, in terms of hardness and extrusion rate, to fit the customer's process? That is sometimes challenging, as they need

the material quickly, make sure that it works and then do the scale-ups, because most of the materials are customised for the application, as there are hardly any standard materials.

"Hose sizes differ, from a small three-cylinder gasoline engine right up to a truck engine hose, which can be as big as your arm. The trick is to make sure the material fits the process and application, in terms of pressure and temperature.

"They're different blends and filler systems, so you have a different rubber hardness; when you put a lot of filler into a system, it's more difficult to extrude, because you get higher viscosity or it gets stiffer, so that all needs to be balanced. For a large turbo charger hose with a big diameter for a truck, that material would need to be harder than a smaller diameter one, because it takes more pressure. So it's the fine-tuning of all those components by using the right chemistry and filler systems and stabilisers.

"They're fabricating using either a calendering process, where they wrap silicone sheets round a mandrill to make the hose; or the other process is a co-extrusion, where they extrude the inner layer which is relatively thin, the fluoro layer, then they extrude the high consistency rubber layer at the same time. The design process is getting the right material, in terms of performance, but also in terms of processing at our customers. So it can be a little late and create some challenges for us."

Materials delaminating – typically, the coating flaking from the surface, if it isn't bonded right – can be a headache, but one that Dow Corning has developed a cure for, using an adhesion system with a patented adhesion package, where the fluoro-silicone layer and the standard silicone layer interact and form a covalent bond to make sure they are so tightly bound that they don't delaminate."

Transformational times are with us



One major trend at auto shows has been the unveiling of a widely disproportionate number of 'alternative-fuelled' vehicles—defined as hybrid, plug-in hybrid or fully electric powertrain—compared with actual market share or demand for them, according to Brian Irwin, partner and leader of A.T. Kearney's automotive practice.

January's North American International Auto Show was an example of this. "It was interesting that, after five to eight years of comparatively flat sales of alternative-powered vehicles, there was a 71% spike in the 2011-2012 year," Irwin pointed out. The A.T. Kearney study team found that auto makers showed, on average, three times more alternative powertrain vehicles than they actually sell. That mega trend is supported by findings of a recent KPMG International survey of 200 automotive executives from the industry, covering 31 countries:

Optimised ICEs: Consumer interest in fuel efficiency is the primary factor in vehicle-purchasing decisions, according to 92% of executive respondents. Environmental concerns are still important, but slipped from second to fourth place this year. Just under 30% say they will invest in downsizing and optimising internal combustion engine (ICE) technology. Slightly more than 50% say that ICE

optimisation will offer the greatest potential for clean, efficient engines for the next 6-10 years. "This is quite a turnaround in direction and a sign that some of the newer technologies are taking longer to emerge," said Mathieu Meyer, KPMG's global head of automotive and a partner.

Plug-in hybrid growth: Investment in plug-in hybrid technology will be an area for 24% of OEM and supplier respondents, as against only 8% for pure battery technologies; 36% of respondents expect that consumer demand will be highest for plug-in hybrids over the next five years, followed by non-plug-in hybrids at 20%. A distant fifth are pure battery-electric vehicles at 11%.

Globalisation: Notable market growth among BRIC (Brazil, Russia, India, China) countries and other emerging markets is predicted by 86% of respondents. Nearly 60% say they will increase their investments in the BRIC countries, which are expected to account for almost 50% of global vehicle sales by 2018. China is the first choice for investment, followed by India, Russia, and Brazil. Conversely, BRIC automakers will push to export to new markets in the next 3-5 years, primarily Eastern Europe and Southeast Asia, though they will build production hubs close to western markets. In the Americas, 39% expect Mexico to become a production hub and, for the European

market, 70% favour Eastern Europe.

Countering overcapacity: Sales and production declines remain a concern in Western Europe, where a sizeable proportion of respondents expect sales and production to decrease in Spain, Italy, France and the UK. The US seems to have managed a turnaround, as over 40% of respondents expect that vehicle sales will either remain steady or increase. Just BMW and VW from the West are expected to gain market share over the next five years. Four Chinese manufacturers are expected to be among the top 10. The US's Ford slid from 8th last year to 14th — just above General Motors.

Urbanisation: Over two-thirds of respondents envision alternative solutions to single-vehicle ownership, such as vehicle-sharing or pay-per-use. Over half of respondents believe on-demand mobility will account for 6-15% of market share, vs single-vehicle ownership, by 2025. Meanwhile, increased driving restrictions, and the need to protect cyclists and pedestrians in urban areas, will impact vehicle design, say 83% of respondents.

The changing consumer: While the trend among consumers in mature markets is to downsize to more fuel-efficient vehicles, the reverse is true in emerging markets.

focus@sae.org



GATEWAY TO ELECTRONICS FUTURE

Chris Edwards asks if field-programmable gate array will be the next big step in automotive electronics

The field-programmable gate array (FPGA) is taking root in many parts of today's automotive designs, as it evolves from a device used purely for prototyping to one that can be deployed in production vehicles.

Traditionally, manufacturers have had good reasons not to use FPGAs in production vehicles. Cost was the biggest. Application-specific integrated circuits (ASICs) have the connections between logic gates defined by direct metal connections. Although congestion caused by this hardwired metal network often means that ICs can use their entire surface for logic, this scheme provides the densest way of linking the gates together.

FPGAs rely on a predefined network of wires lying on a regular grid that are then linked together, in most cases, using memory cells. Because the memories can be dynamically programmed, it is possible to entirely rewire an FPGA on the fly. But the designers have to provide a large number of wires and memory cells to support many different circuit designs, as well as a way of programming the memory cells. That network takes up

space, which makes the IC much bigger than a comparable hardwired ASIC.

SOARING COSTS

The problem for ASIC users is that the non-recurrent engineering (NRE) costs incurred during designing them has soared, as chipmakers have made the logic gates on them smaller and smaller. At the end of the 1990s, the cost of a set of masks needed to define the metal wiring on the then mainstream 0.25µm process was measured in thousands of dollars. For the 28nm generation, now in production, that cost is now counted in millions. While the cost per function has plummeted, the cost of entry has risen to prohibitive levels for devices that cannot be unchanged across a wide range of systems.

Kevin Tanaka, worldwide automotive marketing manager at Xilinx, says: "We started crossing into mainstream automotive systems in the 2004-2005 timeframe, from larger geometries to the 90nm process. That's when we started basically an explosion in customers coming to us. Previously, a lot of automotive customers used to use FPGAs purely for prototyping and then move over to

ASICs for production. We saw, with the arrival of the 90nm devices, that it became cheaper overall to use FPGAs than it was to design an ASIC and deal with the associated NRE cost."

As FPGAs began to be adopted for use in production vehicles, initially in the entertainment and infotainment systems, suppliers such as Xilinx began to qualify their devices for the automotive market. "We were the first to AECQ1000," Tanaka claims. "There are a couple of areas that we don't play in, but they are mainly to do with the temperature requirements."

DRIVER ASSISTANCE

The memory cells employed in the most commonly used type of FPGA do not retain their contents well when the temperature inside the transistor, normally measured at the junction between the terminals of the microscopic device, increases. This prevents them from being used close to the engine.

"Most FPGAs max out at 125°C. But, in diesel powertrain electronics, for example, you will find requirements of 150°C, with excursions to 175°C. Today, our primary focus areas are infotainment, networking, entertainment and driver assistance,"

Cover story

Traditionally, manufacturers have had good reasons not to use FPGAs in production vehicles. Cost was the biggest. Application-specific integrated circuits (ASICs) have the connections between logic gates defined by direct metal connections

he adds. "The biggest growth we see is in driver assistance," he reveals, pointing to the rise of lane-departure warning, pedestrian detection and advanced cruise-control systems now being added to vehicles.

Todd Koelling, senior manager of product marketing for embedded

processors at Altera, says the company is seeing demand for an upcoming family of system-on-chip (SoC) FPGAs that embed digital signal processing (DSP) and ARM Cortex-A9 cores. For example, DDC, which has built an obstacle detection and cruise control system – demonstrated at the



Embedded World show in Nürnberg in February – that uses a combination of radar and camera inputs intends to move to a SoC FPGA from its current implementation, based on an existing Cyclone 4 product.

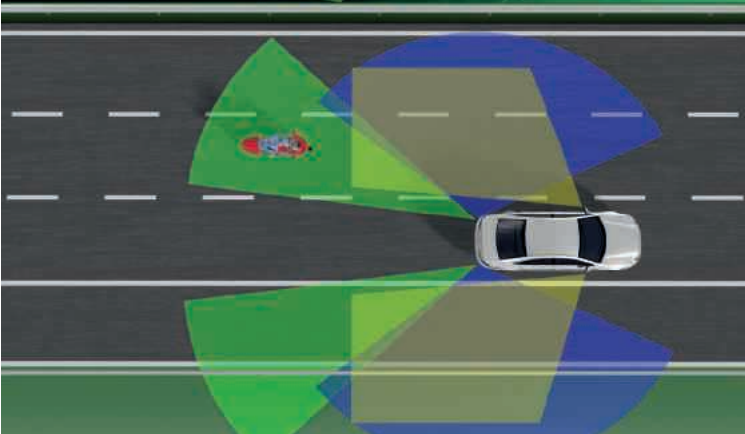
The reason for the interest in SoC FPGA-type devices is one of size, says Koelling: "These devices are going into cameras that fit behind the rear-view mirror or under the windshield. They are very space constrained and very power sensitive."

HIGHER SPEEDS

Xilinx is seeing the same trend with its ARM-based Zynq products, which are now moving into production. "That product is very much in tune with driver assistance. With traditional architectures, people found they were running out of horsepower as they add functions and process the images in various ways," says Tanaka.

Existing designs typically use separate DSP, processor and FPGA devices. "Between the three different chips, there are bandwidth issues," he points out. But, by pulling the functions onto one device, it is possible to pass data across the IC at much higher speeds, because there are thousands, rather than less than a hundred, of data lines between the sections.

Other types of programmable systems aim to break into this market, claiming they can offer better overall



FPGA allows a wide range of radar detection to be combined with cameras for improved safety warning systems.

Cover story



Lincoln concept
employs FPGA
technology.

Picture courtesy of Ford

performance for driver assistance than the SoC FPGA, on the basis that most of the processing can be handled in software, and avoid the need for the hardware-design tools that FPGAs and ASICs need.

Laurent Julliard, director of solutions and software services at French startup Kalray, says: "Our aim is to replace FPGAs, especially high-end FPGAs." Kalray is one of a number of companies that has developed parallel-processor SoCs. The Kalray MPPA contains more than 250 individual processors, connected by an on-chip network used to pass data between them. "You can programme it in C or C++, with no need to use VHDL or Verilog."

QUICKER TO DESIGN

Nigel Toon, CEO and president of XMOS, says the company has found niches for its multiprocessor IC in automotive networking, because software-based design is seen as being easier. The company has developed protocol-handling software to manage the specialised forms of Ethernet now being considered by vehicle makers, as well as CAN, because they are quicker to design in than custom hardware.

Toon says: "Software engineers are making some of these decisions, saying 'maybe we can use this' and not looking at FPGAs."

FPGA makers are responding to the growing influence of software by

making their devices more accessible. Altera has embraced the OpenCL language, originally developed by Apple for use in computationally intensive applications, because it provides a way to map algorithms onto FPGAs, without using hardware design tools.

There is a limit to the reprogrammability of FPGAs that is changing the way they are used to prototype for ASICs. Frank Schirmeister, group director of product marketing for the system and software realisation group at Cadence Design Systems, says the use of FPGA boards in hardware-in-the-loop environments is commonplace, as they allow the prototype to be used with actual sensors and actuators on the road. Software simulation is too slow to support that. National Instruments has produced versions of its FPGA-based CompactRIO system that can be incorporated into experimental vehicles and allow control loops to be modified on the fly.

SOFTWARE SIMULATION

The adoption of safety-related standards such as ISO26262, on the other hand, is pushing some work into the software domain. Although FPGAs can be reconfigured countless times, their now massive logic capacity is proving to be a challenge for design tools. The ability to inject faults into the logic circuits demands that the design be recompiled each time, which can

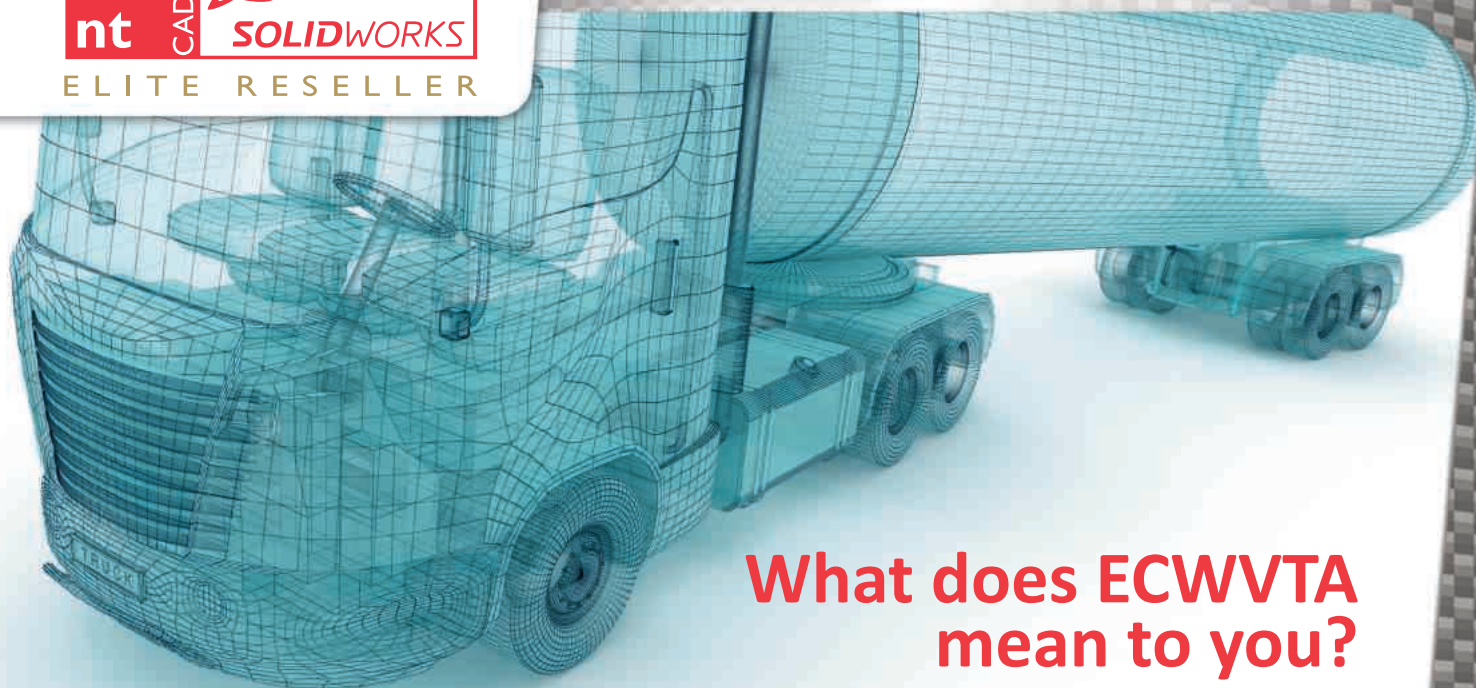
take hours to perform. Software simulation allows those faults to be inserted almost instantly.

"We are now seeing 'virtual hardware-in-the-loop' for cases where you need to inject specific errors," says Schirmeister.

Marc Serughetti, director of business development for system-level solutions at Synopsys, agrees: "With software-based simulation, I have those capabilities non-intrusively."

Even for engine management, the long-term trend is likely to be away from custom ICs. All devices based on advanced processes are finding problems with high temperature. For example, transistors leak energy more when they are hot. Moving the controllers into a cooler section of the car provides more environmental headroom. "With hybrid-engine technologies coming up, tier ones and automakers are thinking hard about bringing the powertrain electronics behind the 'firewall'," says Tanaka. "Everyone is starting to run into issues with temperature, as you move down the process curve."

Despite the temperature-compatibility issues, FPGAs could ultimately supplant ASICs in engine-management system as automakers adapt to the environmental needs of electronics, instead of trying to make advanced devices fit inside the hottest parts of the car, although that may ultimately be cost driven.



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Emissions mission:

Tony Lewin hears how next-generation engine control units (ECUs) will be central to hitting the European Union legislation target of 95 g/km CO₂ by 2020

Bosch has produced over 250 million engine control units since it developed the first Motronic digital engine management system in 1979, while chipmaker Infineon claims its TriCore microcontrollers are fitted to half of global car production. For the first 80 or 100 years of the automobile's history, they didn't exist at all. There was no need to worry about what came out of the exhaust tailpipe and little real concern about efficiency, meaning that compromise settings for fuel mixture and ignition timing were perfectly good enough for everyday driving – even if performance at the margins tended to suffer. Just two variables needed to be controlled, crudely, and a black box was something for aircraft, not cars.

The contrast with today – and indeed with the likely requirements for 2020 and 2025 – is total. Everything that the vehicle draws in and spits out is policed by aggressive regulations that spell out allowances down to the last microgramme; every moment of the vehicle's operating life has to be precision controlled by complex electronics to ensure absolute minimum emissions under every conceivable condition. For every rotation of the crankshaft, dozens of sensor channels need to be supervised and countless adjustments made in real time to keep the engine in optimum tune. With each of these complex



Gasoline controllers are exceeding 1,500 MIPS.

calculations having to be carried out at least 100 times a second, the enormous scale of the necessary computing power becomes clear.

CHANGING TIMES

Delphi, a major supplier of electronic control systems, says that "just a few short years ago" a 32-bit CPU (central processor unit) operating at 80 MIPS (million instructions per second) was capable of meeting engine control requirements globally. Now, explains Steven M Stewart, Delphi product line executive, Powertrain Controllers, Gas EMS Product Line, multicore processors exceeding 1,500 MIPS are required for many applications.

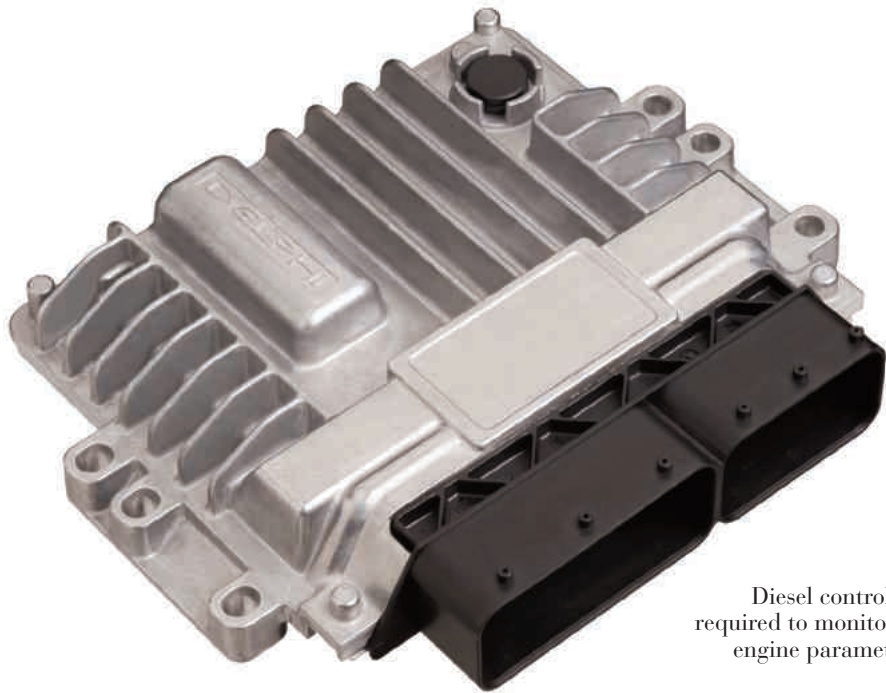
The reason behind the dramatic increase in processing performance is simple: today's engines have many more degrees of freedom than their predecessors

and they run on complex operating maps that continually optimise each of these many variables. Instead of controlling just ignition timing, fuel mixture and maybe turbo boost,



Infineon claims its TriCore microcontroller is fitted to half the world's car population.

2020 vision



Diesel controllers required to monitor all engine parameters.

today's ECUs also manage injection timing, fuel-pulse shaping and quantity, spark timing and intensity, combustion pressures, valve timing and lift, exhaust gas recirculation, catalyst and after-treatment operation and filter regeneration.

And those are just the basics. When the vehicle is hybridised, the blending of the power sources is handled by the ECU; traction control and ESP systems are controlled by the ECU, too, and any modern automatic transmission will have its management integrated with that of the engine. Many safety-critical functions, such as braking, airbag deployment and collision avoidance, are also routed through the ECU, compelling engineers to follow the strict guidelines of ISO 26262. In short, the ECU in its various forms is the high-powered brain of the vehicle and, as is our focus here, one of the keys to making it cleaner and more efficient.

TOWARDS 95 G/KM

Future CO₂ emissions reductions are only feasible using new and more precise engine, and after-treatment control strategies, observes Wolfgang Breuer, head of the Business Unit Engine Systems/Division Powertrain of leading supplier Continental. "Therefore the sensors and actuator landscape will change, the numbers will increase and the electronic control system has to provide the necessary infrastructure."

Kenzo Yano, director of electric and electronics engineering at Denso International Europe/Aachen Engineering Centre, is certain that hybrid systems will be essential, if the new CO₂ requirements are to be met. "One of the key features will be an electronic control system to optimise torque balance in every driving condition.

"This will minimise CO₂ emissions," he told Automotive

Design. "You can expect the introduction of higher performance multi-core processors, with up to 8 MB flash memory."

Continental's Klaus Hau, head of the Business Unit Sensors & Actuators, Division Powertrain, lists four key drivers en route to the 95 g/km target: optimised combustion; exhaust after-treatment, including OBD functions; electrification; and the ability to operate on alternative fuels. Each has profound implications for the vehicle's control system. "Continental provides a wide portfolio of sensors and actuators that enable optimal control of these subsystems, such as in-cylinder pressure sensors, low and high pressure EGR valves, NO_x, Soot and Flex Fuel / Bio Diesel Sensors, as well as BLDC -based electric water and oil pumps," he says.

UPCOMING DEVELOPMENTS

The industry response to ever-stricter CO₂ and pollutant emissions legislation, especially in Europe and North America, will be significantly greater electrification of the powertrain, as well as increased modularity of components, in order to keep costs under control. This again has implications for ECU design, though there still appears to be some uncertainty as to whether the various electronic components will tend to be integrated into a single large unit or whether they will be increasingly spread around the vehicle, close to the sub-systems they control.

Next-generation ECUs



Denso's Kenzo Yano argues that the overall functions allocated to the increasing number of control units need to be restructured, while Continental also advocates a change of architecture, though the low-end vehicle segment will always require different solutions to the premium end. Delphi, too, sees the value of a flexible approach to suit each OEM's preference, though pointing to a trend towards localised controllers for electrified accessories, such as fuel pumps, heated injectors and water pumps.

Any hopes that the advent of electric powertrains would allow the use of lower-specification controllers are swiftly dismissed by suppliers; electric motors require high-speed electronic control, though again costs can be saved as scalable systems are developed that allow electronic modules to be added as powertrain complexity increases.

CONSENSUS

There appears to be consensus that the 95 g/km CO₂ threshold for 2020 is well in hand, using current-generation electronic systems. Delphi, for one, works with its customers and regional teams to understand what features, functions and requirements – such as operating environment and price points – will be required five to ten

years from now – a horizon which clearly takes in the new standards.

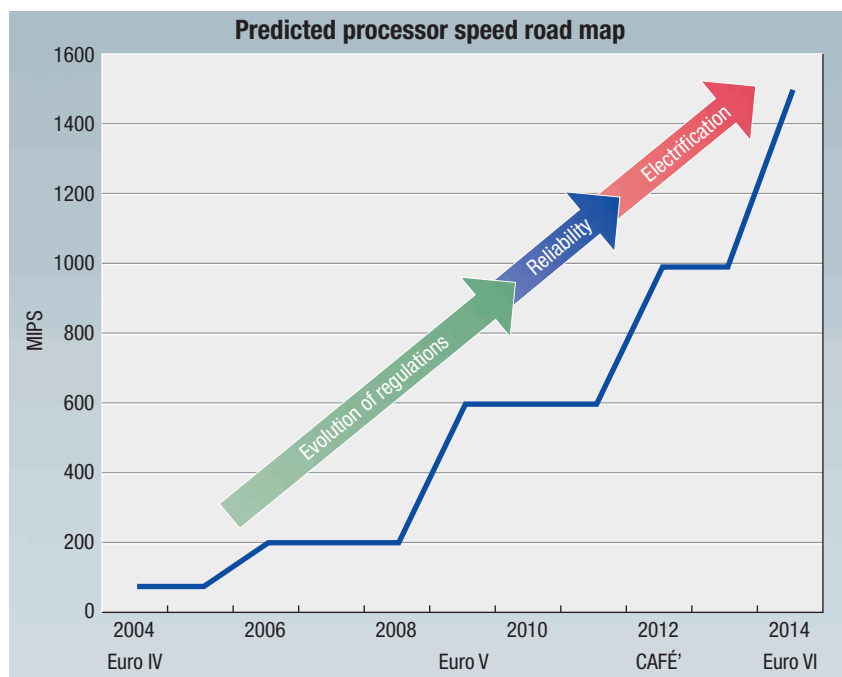
Where more significant change may well be seen is in the run-up to the even more stringent CO₂ emissions standards expected for 2025 and beyond. Europe is likely to see 60 to 70 g/km, say well-placed sources; this figure would be one of several new requirements which could prompt a more fundamental rethink of EE systems design. Continental points to the switch to digital sensors as being an important development, along with the

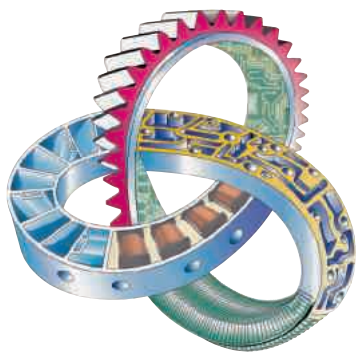
incorporation of ISO26262 protocols for safety-critical functions.

FUTURE DEMANDS

For Denso, a potential concept change for ECUs could be the integration of the electronic functions around actuators, such as motors and valves, while Delphi's product line manager Daniel R Brooks cites component miniaturisation and increased energy-handling requirements among the likely demands for next-generation processors.

Overall, it is clear that increased computing power, speed and memory are important keys to the tighter control of the combustion processes, torque blending and skilful energy management that will enable compliance with the 95 g/km and, later, 60-70 g/km CO₂ limits that the auto industry has come to accept. And with the immense energy of the electronics industry and chip suppliers, such as Infineon and Atmel, behind them, it is equally clear that tomorrow's control systems will not only be faster and more capable, but cheaper and more compact, too.





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VDI



Digital and multi-media technology are forcing a fundamental rethink on how the instrument panel can best support the driver, as Ian Adcock explains

Before your very eyes

It was 110 years ago last October that Otto Schulze registered the eddy-current speedometer at Berlin's Imperial Patent Office and, as we move through the second decade of the new millennia, instrument panels are taking on a whole new era of development as revolutionary as Schulze's speedo.

"Speedometers are necessary, because, although humans with their vestibular system can perceive positive or negative acceleration, they are not so perceptive at constant speeds," explains Eelco Spoelder, head of the Instrumentation and

Driver HMI business unit at Continental. "Anyone who, after driving on the highway for a while, has turned off into a 30Km/h zone and noticed how difficult it is to gauge the speed properly will be familiar with this," he adds.

IN THE ROUND

And while over the years various manufacturers have dallied with numerous interpretations on the speedometer's shape – from horizontal bars, to half moons, digital and even revolving drums – it seems that the familiar round instrument is the one that can be read most

intuitively. "The driver doesn't need too much concentration, can focus attention on the road and still obtains the most important information," says Spoelder. "That is why instruments such as the speedometer, the rev counter, fuel gauge and the most important warning lights are all kept together within the driver's direct field of vision of around 30 degrees."

However, as digital and multi-media technology encroaches further into every aspect of daily life, including cars, there is a growing need for a fundamental rethink in how the instrument panel can support the driver.

The previous separation between infotainment and driver-related information is no longer practical when, in addition to radio and navigation, there is communications via the mobile network and internet/email coming into the car, as well as real-time traffic information. While the overall reliability of engines and other components brings into question whether there is actually a need for a temperature or oil pressure gauge, or even fuel gauge, when





warning lights and/or digital read-outs would take up less space and need only appear as and when necessary.

RECONFIGURABLE

With the rapid expansion of high definition thin film transistor (TFT) technology on smart phones and tablets, consumers now expect similar quality in their cars as well. It also allows the instrumentation to be reconfigurable, as in Volvo's latest V40 range, for example.

Magneti Marelli is one such supplier that has teamed up with Samsung Mobile Display, which will make available its broad and innovative range of technologies developed for display solutions, ranging from TFT to Active Matrix organic light emitting diodes (OLED) to develop a 9-inch (22.8cms)

Head Up Displays, far left, are now being joined by advanced augmented displays

instrument cluster and 12-inch (30.5cms) reconfigurable display.

Meanwhile Visteon, which developed the 12.3-inch (31.2cms) touch-activated TFT in the Porsche Panamera Sport Turismo concept, has teamed up with Japan Display Inc. (JDI) for its third-generation reconfigurable instrument cluster platform to deliver, they claim, superior graphics and animation. This technology supports complex 3D graphics and video features, such as driver awareness and camera inputs. Visteon's latest platform allows the 12.3-inch display resolution to deliver 1920 x 720 pixels and an 8:3 aspect ratio, considered unmatched in the automotive market.

FEELING SAFER

Visteon claims its consumer research shows that vehicle owners are becoming accustomed to HD quality displays in their personal devices and prefer reconfigurable instrument clusters with high-resolution graphics; and that high quality displays provide them with an added sense of safety,

since the information is clear, and can be read quickly and effortlessly.

Even as Head-Up Displays (HUD), to supplement speedometers, navigation and infotainment, become increasingly common, they are in some danger of being overtaken by augmented displays, as demonstrated by Harman at the Consumer Electronics Show earlier this year, as well as providers such as Nvidia.

Meanwhile, Maxim Integrated Products Inc has announced that it is now sampling the MAX3601 – a highly integrated, 8-bit RGB laser driver for pico laser projectors in cars. It is a smaller, brighter and lower-cost solution than traditional technology, enabling sharper, pixel-perfect HUDs. This IC drives three RGB lasers to provide a brighter light, without compromising the low power. The high intensity of the lasers project brighter, more vivid, images onto the HUD to easily alert the driver, while enhancing safety. Moreover, its high integration means longer battery life, less heat build-up and a smaller module size.

MANY BENEFITS

Its key advantages, claims Maxim, include: low cost; minimal PCB area, with functional integration, with three current-output laser drivers combined into one laser; with only 80mW bias current, the device achieves maximum light output, with excellent power efficiency; three integrated lasers eliminate the need for additional optics, reducing size and easing design/manufacturing; finally, its 1W total module power provides long battery life, low heat dissipation and minimal thermal sinking.

"One of the key trends for automotive displays is higher resolution," says Richard Robinson, director of automotive analysis at Strategy Analytics. "Sharper imagery in heads-up displays is critical for clarity, safety and driver assistance applications."



Reconfigurable displays are on the increase

Under PRESSURE

Fuel delivery and storage systems are being pushed hard to keep pace with demanding current and impending legislation. How well are they doing?

The constant drive to lower emissions is now impacting every system and sub-system in vehicles. And, as the spectres of Euro 6 and 7 grow larger, there's an urgency to refine all components that might emit some emissions, no matter how small. Add to that increased use of bio diesels produced from various ester origins and fuels with ethanol content (E10+) – along with their potential impact on fuel delivery systems – and it's easy to see why leading Tier Ones are engaged in an intensive effort to develop solutions that will assist the OEMs in meeting these strict requirements.

Continental, for example, through its IQ FUEL consortium, has developed a highly integrated micro fuel sensor that determines fuel composition in the tank, using a Micro OptoElectroMechanical Sensor (MOEMS) to determine fuel composition – such as density, heat



Electronically commuted fuel pumps.

value, cetane and octane number, sulphur content classification, viscosity etc – by measuring light transmission in the infrared spectrum.

OPTIMISATION

The same sensor covers both diesel and petrol; the data analysed by embedded chemiometric models predicts the fuel content, based on a single specific parameter and provides data to the engine management system to optimise injection timing and quantities, as well

as exhaust gas after treatment.

The drive for high-pressure diesel pumps, up to 2500bar, has led Continental and Schaeffler to develop these specifically with Euro 6 and 7 in mind. Continental has been developing a double piston pump that's capable of delivering greater volumes under higher pressures, while weighing no more than a single piston pump, thanks mainly to improvements in hydraulics and by reducing losses. Combined with virtually leak-free injectors, it has been possible to achieve high efficiency levels and, because there is no need for return pipes, to reduce packaging. This modular system of new diesel pumps is supplemented by a new single piston solution.

With Asian markets growing in importance, Continental has also developed a new low-cost single piston pump that can be easily plugged in to the cylinder head. Designed for delivery pressures up to 1,800 bar, it's driven from the camshaft via a roller tappet and feeds the fuel directly to the injectors, without the need for a high-pressure reservoir. It also uses a digital volume flow valve for the first time for controlling pressure and quantity precisely; production start-up is planned for the first quarter of this year.

PLASTIC FANTASTIC

Today, more than 95% of all fuel tanks in Europe, more than 85% in the USA and more than 40% in Asia, are made of plastic, and there are many reasons why the switchover



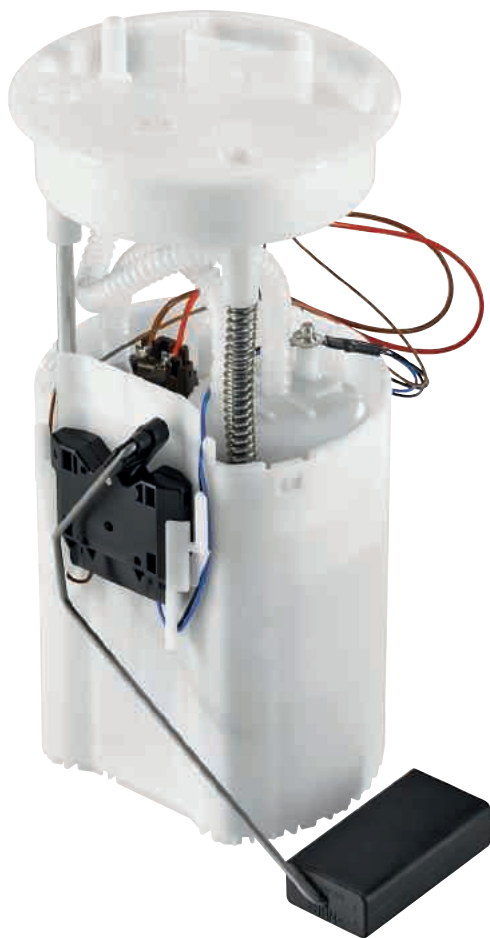
Fuel tanks made from HDPE take on complex forms.

Fuelling systems

from steel has been almost universal; not least of which is weight, since an average plastic tank weighs one-third less than an average steel tank, leading to immediate CO₂ savings. But there is also durability, as high-density polyethylene (HDPE), is resistant to corrosion coming from fuel, but also from the corrosive environments outside the tank, such as road chemicals, salt, mud, gravel.

HDPE can also help to dissipate electrostatic charge and prevent igniting the fuel in crash situations where, in any case, they tend to bend and flatten, rather than tear, rupture and spill, with the resulting fire hazard.

In addition to plastic's low



Modular fuel pumps are more space efficient.



Integrated fuel tanks reduce the number of openings and potential vapour seepage.

permeability and its ability to conform to Tier II/LEV II evaporative emission standards regarding hydrocarbon (HC), tanks like those from INERGY comply where the evaporative emissions of Partial Zero Emission Vehicles (PZEV) are limited to 0.054g/day – barely 10% of the vehicle limit for TierII / LEVII.

COMPLEX FORMS

Uninhibited by their formability, blow-moulded plastic fuel tanks can take on highly complex forms to drape themselves within the car's structure, maximising capacity, while not intruding on potential passenger or luggage space, and still allowing for numerous components to be inserted within the tank to reduce the number of openings, thereby limiting permeation path opportunities.

Technologies such as INERGY's Twin Sheet Blow Moulding (TSBM) are suitable for hybrid applications where internal reinforcements, such as INBAFFLE, can be engineered in to combat slosh noise during stop-start operation or when the car is in electric-only drive mode. A further

challenge arises when fuel vapours cannot be purged in the normal way by the engine when in all-electric mode or when the vehicle is stopped. To meet this new requirement, INERGY offers sealed plastic fuel systems with the capability to store hydrocarbon vapours until the internal combustion engine is running, and able to purge and treat them, rendering them harmless.

The lifecycle assessment of plastic fuel tanks has also shown that they are 100% recyclable. The Recafuta process, originally the EU-funded project headed by Solvay, regenerates PE, which can be used at levels of up to 40% in new fuel tanks, thus creating a new source of PE for the automotive industry. The process also removes any fuel residues and anti-corrosive coatings from the plastic.

Fuel delivery and storage systems are being forced to maintain a steep learning curve to comply with current and future legislation and, by the looks of it, are maintaining the pace of development to do just that.

Keeping you safe

Continental's Driver Focus Concept Vehicle detects whether a driver will see an upcoming hazardous situation or if his attention is elsewhere. Ryan Borroff reports on the 'eye' in the car

In most countries, the use of electronic devices while driving is either strictly regulated or forbidden. In 2001, in Germany alone, police fined around 450,000 people for using their telephones while driving.

"It is obvious that it is dangerous to use a phone when you are behind the wheel," says Helmut Matschi, head of the Interior division, Continental. "[But] there are more than 700 million vehicles on the planet and the numbers are growing...which...means more congestion. Drivers today need to be more attentive as a result.

"When you consider that one second of distraction at a speed of 100 km/h equates to 28 metres of blind flight, concentration loss is increasingly problematic," says Matschi. "Even though smartphones are used more frequently, they are not the only cause of distraction. Conversations with passengers or trying to calm a crying baby in the back seat have distracted drivers long before phones were invented. But

increased traffic congestion has seen the problem grow exponentially."

In Europe, research suggests driver distraction accounts for as much as 20% of all accidents: "In my opinion, every single one of these is unacceptable. The sheer number of people using a smartphone when driving shows the demand is real and regulation is not working. For us, the solution lies in the integration of such functionality within a safe human-machine interface."

Continental's Driver Focus Concept Vehicle is one solution. It combines driver assistance systems – lane-keeping assist, adaptive cruise control, and collision warning systems – and an infrared camera that monitors drivers' head and eye movements to detect where they are looking. The system is able to tell whether a driver will see a dangerous situation or whether his attention is elsewhere. Its most unusual and innovative technology is a single-line LED light strip display that runs around the perimeter of the interior to direct a driver's attention – in the face of potential danger – using light signals in different colours and shapes.

"The aim is to make the vehicle safer, more intuitive and more attractive," explains Matschi. "With the Driver Focus Vehicle and its LED light strip – or 'Halo', as we call it – we were looking for a system that can actively guide the driver's attention. Using [conventional] displays, single lights in the dashboard can only highlight one specific area. But the

Halo is able to catch and direct the attention of the driver, no matter whether the driver is looking to the back, to the front or to the side."

The system's software combines the information from the assistance systems and the interior camera, and responds accordingly. For example, if the driver is heading towards an obstacle and is looking to the back of the vehicle, the Halo will start at a very early stage to give a comet-like light signal running from the back of the vehicle towards the front, in order to guide the driver's eyes in the direction of the obstacle.

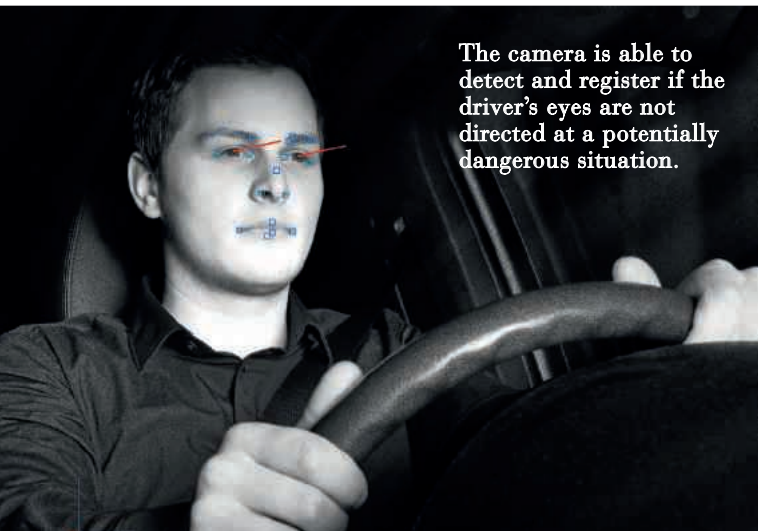
"The closer the obstacle becomes, the more intense the colour and the signal will become; from white to red and from a comet to flashing lights," he states. "On the other hand, if the driver is looking ahead at the road, the light signal will not start as early and behave differently, in order not to annoy the driver. It's a kind of two-way communication between the driver and the vehicle. We can adapt the warning to the traffic situation and the driver's state of attentiveness. So the vehicle warns the driver only when he really needs it."

Currently, Continental's technology is undergoing testing in real-world driving situations, with the aim being to bring it to series readiness within the next three years. Although it's too soon to estimate pricing, Continental expects it will be affordable enough for larger volume vehicles.

One obvious question is whether there's a danger that drivers could become too dependent on such a



when danger looms



The camera is able to detect and register if the driver's eyes are not directed at a potentially dangerous situation.

system, taking their eyes away from the road for increasingly long periods of time.

"At the moment, we see this kind of system to assist drivers in critical situations, but the ultimate responsibility clearly lies with the driver. In the future, we [anticipate] situations where...the driver has something better to do than looking at the road. [Not just during] boring traffic situations, but also a situation such as when a child in the back seat is choking. We think we should give drivers the power to decide whether they want to steer their vehicle or do something else."

And, like it or not, the ultimate destination is automated driving. "We see partially automated driving in situations like stop-and-go traffic at low speeds coming to the market by 2016. By 2020, highly automated driving at higher speeds will be possible and, by 2025, we can imagine fully automated driving vehicles in an increasing number of situations," says Matschi. "A system like Halo in the Driver Focus Concept Vehicle will play an important role."



"At the moment, we see this kind of system to assist drivers in critical situations, but the ultimate responsibility clearly lies with the driver. In the future, we [anticipate] situations where...the driver has something better to do than looking at the road"

— Helmut Matschi

Halving time to market

Automated Manual Transmissions (AMTs) are complex mechatronics systems that are difficult to design, as their performance depends on the operation of three different subsystems, all working together in perfect harmony: an electromechanical actuator that shifts the gears; electronic sensors to monitor vehicle status; and software embedded in the transmission control unit (TCU).

Ordinarily, up to a year is required to define overall functional requirements, design the actuator mechanics, develop and calibrate TCU software, and validate the complete system. Software development and calibration are particularly troublesome bottlenecks, since these tasks typically require extensive trial-and-error physical testing cycles that cannot be performed until hardware prototypes are built. By then, mechanical and electronics designs are nearly finalised and cannot be changed appreciably to improve powertrain performance. Considerable time is spent troubleshooting problems near the end of design, rather than refining TCU control strategies.

This wasn't the case with Renault's development of its dry six-speed dual-clutch, says Gallo. "At the beginning, the project started with a classic process, with Renault asking the supplier for 6-8 prototypes for bench testing and development. But, by using LMS Imagine.Lab AMESim, they were able to reduce the number of prototypes by half, because they already knew by simulation that the design wasn't right in the first place.

"With a rapid prototyping system, they were able to testbench the controller on the prototype just one day after receiving it. At the end, in only 2-3 months' time, they were able to assess the new gearbox actuation systems in a car on the development track. That saved around one to two months' research time: one month for the reduced number of prototypes and making parts for the actuation systems; and another month running on the bench, and then on the road, to test in a car.

"Within the programme, we were able to simulate and test all the shifting parameters, such as the shifting delay and controlling the clutches, to ensure smooth engagement and slick gear changes. But we could also model in parts of the chassis, as well as adding the engine block and engine mounts, so we could see the effects of zero torque or holes in the torque that produce jerk, as well ensuring they weren't excessive friction or gaps in the fork that causes delay and backlash – creating that familiar 'clack', 'clack' in some cars fitted with AMT."



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