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March 2014

THE AD INTERVIEW

EXHAUSTING POSSIBILITIES: F1 GRADE COATING THAT COULD AID ENGINE DOWNSIZING

CRITICAL MASS

WEIGHING UP THE BENEFITS OF CMT'S FIBACORE

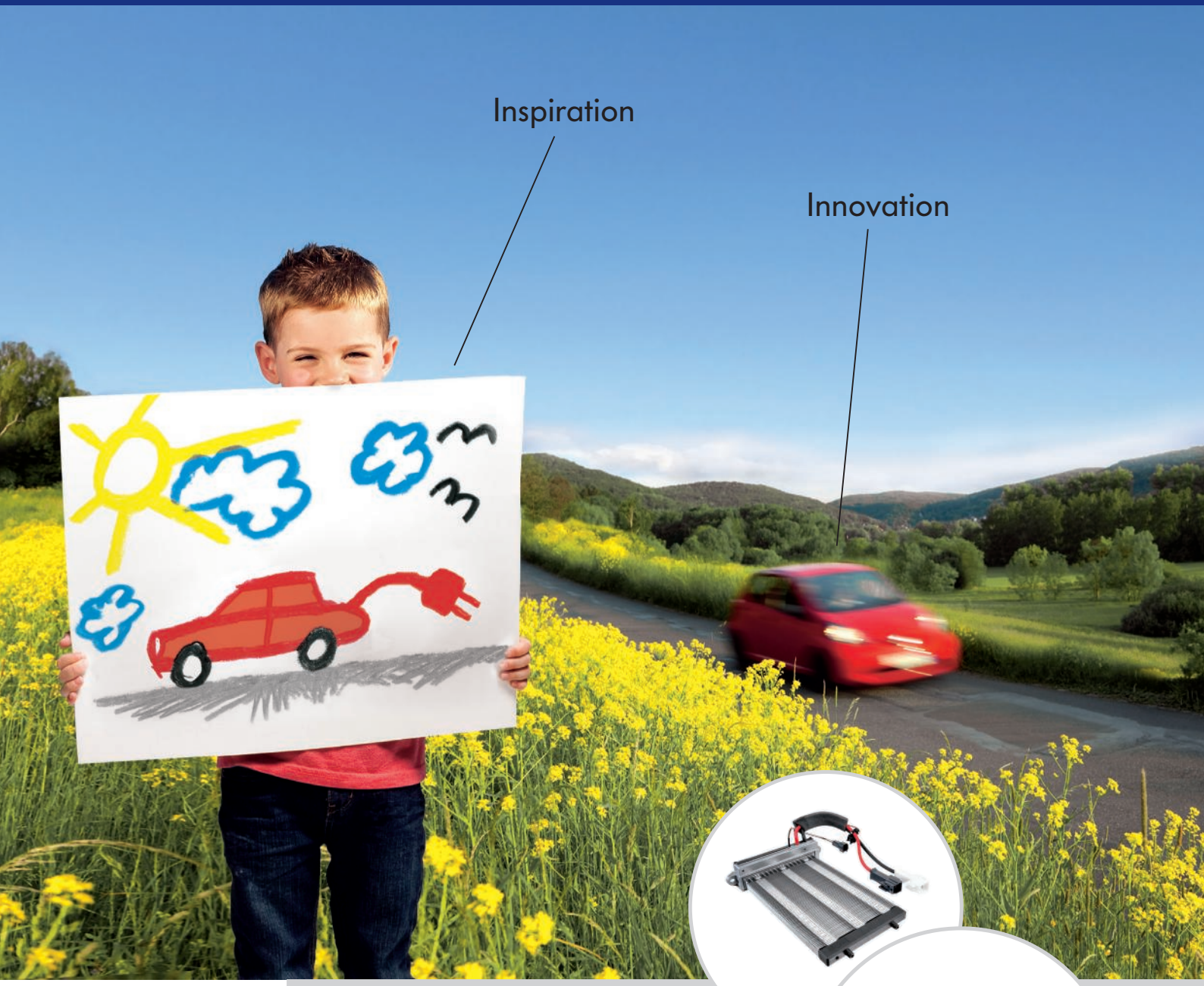
HOW SAFE IS IT OUT THERE?

CUTTING THE COST OF ROAD ACCIDENTS

GENEVA SALON:

3 CYLINDERS RULE

Innovative electrification. We know how.



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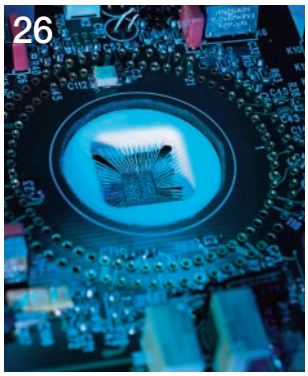

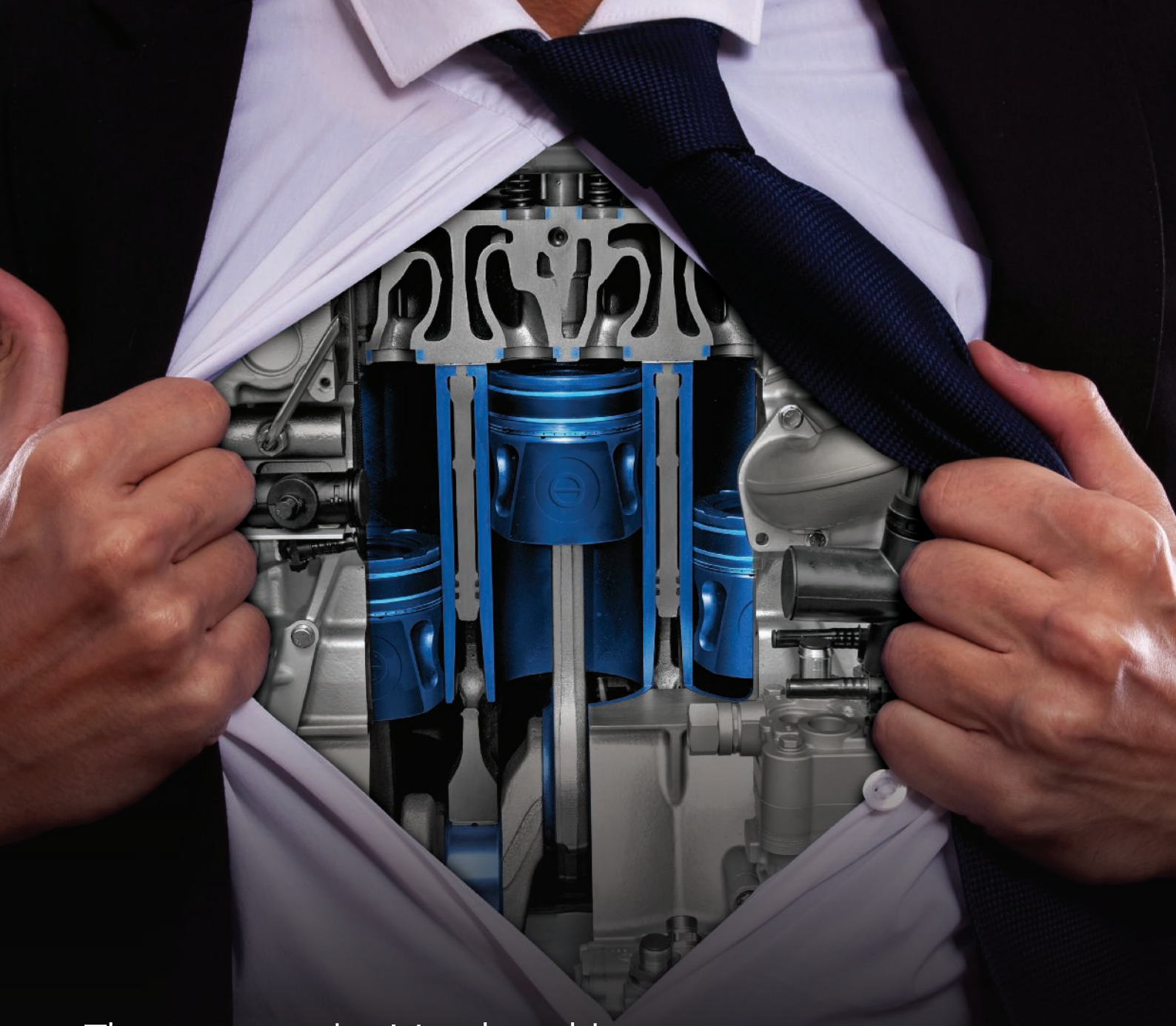

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Powertrains are the heart of a vehicle, and vehicles enable economic progress, individual freedom and automotive passion. We are a global leader in powertrain technology, helping our customers improve fuel economy, reduce emissions and enhance durability in the world's most popular form of vehicle propulsion: the internal combustion engine.

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Hope springs eternal – and at the Geneva Convention!

There was a distinct buzz in the air at the Geneva Salon in early March and the industry's executives had a spring in their step that hasn't been seen for some time. Admittedly, any senior manager who doesn't talk up their business, even in the worst of times, isn't doing his or her job properly. Still, you can usually tell if things aren't good by the stock PR phrases that get trotted out when things aren't quite 'there'. But that certainly wasn't the case this year.

Instead, there was a general feeling that, while the good times aren't exactly with us yet, at least the worst of times are behind the industry. That air of optimism was shared by those who had new engines on display that were making their debuts: many of these being three cylinders, with either MPI or DI systems and turbocharged, indicating that the industry is getting itself into a situation where it can be increasingly confident that 2020's strict emissions regime is achievable.

But scratch a little bit beneath the surface and there were tensions being aired, both publically and privately, that the EU had been bullied into extending the timescale to achieve 95 grams/km to 2022 by the German triumvirate of Audi, BMW and Mercedes-Benz, while other OEMs with their ranges of smaller, lighter cars were closer to achieving the new measures.

Added to that was disquiet over the lack of clarity and guidance for the new real-world drive cycle regulations, due in 2017. "The new drive cycle in 2017 isn't defined and we're starting development of the next generation of engines; and today we don't know what those regulations are," one disgruntled engineering director told me. "Not just the value of the pollutants, but also the procedure."

A key factor in achieving those targets will be reduced mass and, as you can read on *page 18*, one small British company might just have the right solution to help OEMs take weight off their products, at a realistic price.

Ian Adcock, Editor in Chief

Hyundai claims industry breakthrough with new lightweight concept SUV

Korean manufacturer Hyundai is claiming an industry breakthrough with a new lightweight, carbon fibre structure, which was displayed for the first time at the Geneva Salon in its Intrado concept SUV.

Unlike rival carbon fibre structures, which are either solid or hollow sections, Hyundai's is comprised of a series of inner lattice works designed to strengthen sections where it is most needed for stiffness and load paths.

Günter Roos: structure is divided up into beams that are joined together to form the car's skeleton

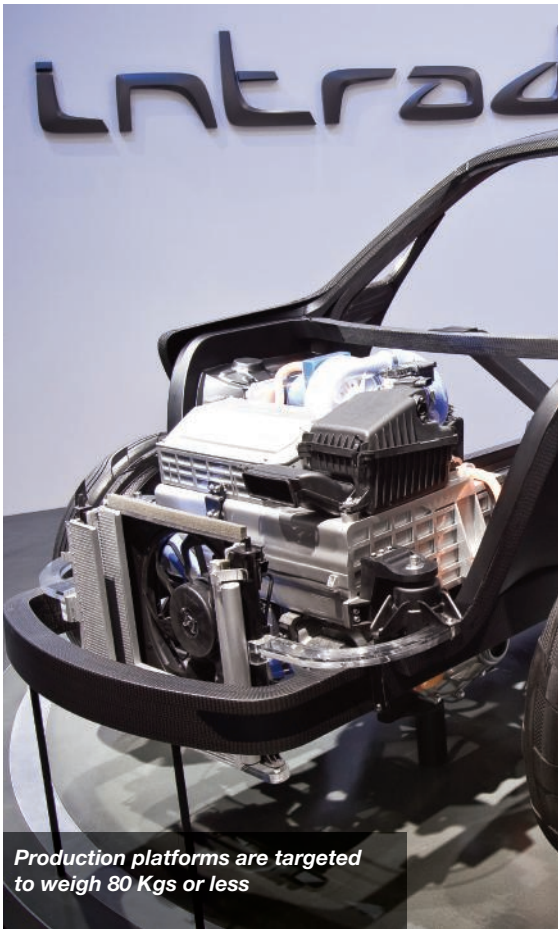
"The technique is quite simple," explained the manager of Hyundai's European design centre, Günter Roos. "We divide the structure up into beams joined together to form the car's skeleton; for instance, the ring structure surrounding the door apertures or the one supporting the roof panel.

"There's an open ring at the front, picking up loads from the suspension, and then taking those loads to the rear in a similar fashion, as you would in a steel chassis."

The inner roof panel and body panels were produced using Lotte Chemicals high-pressure resin transfer moulding (HP-RTM) techniques.

In this first concept, Hyundai is using one grade of carbon fibre and weave pattern, although Roos admitted that future developments could include varied weave patterns, if required. His European team worked with material specialists Lotte Chemicals, Hyosung Carbon Fibre and Hyundai's Namyang R&D centre to develop the new architecture, which Roos predicts could be in production within a decade.

The tools he also describes as being quite simple. "There's a U-shaped tool with a closing element that is then preloaded, which is why we selected this process, as it can all be automated."



Production platforms are targeted to weigh 80 Kgs or less

Hyundai, as the only car manufacturer with its own steel plant, would then use lightweight steel body panels, said Roos, attached to the carbon fibre inner structure, employing a combination of adhesives or mechanical fixings. Currently, the Hyundai team is moving from the prototype stage to

Rear seat pan for a passenger car that has been manufactured using the new Dow techniques

Dow Automotive unveils formidable new force

In a parallel development, Dow Automotive has announced it can now offer 90-second cycle times for resin transfer moulding (RTM) with its new VORAFORCE 5300 resin matrix, making RTM-produced carbon fibre composites suitable for mass production for the first time.

VORAFORCE 5300 extends RTM process capability via an extremely low viscosity for fast injection, with excellent wetting of the fibre pre-form. Furthermore, the formulation is equipped with an internal release mould package, minimising external mould release costs.

The benefits of VORAFORCE 5300 extend beyond ultra-fast cycle times. Besides the

more detailed analysis and development work to establish how stiff the structure is and its crash worthiness.

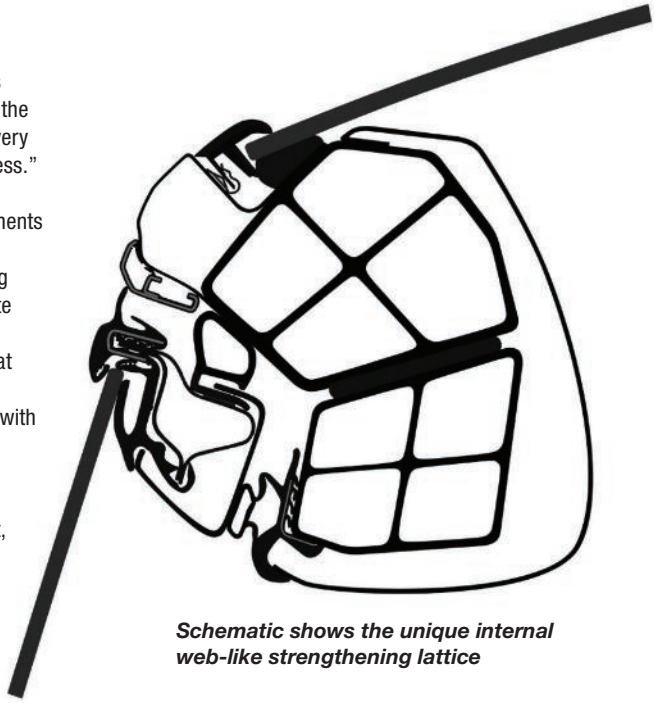
Although the prototype on display had not been weight optimised, Roos predicted that production versions would weigh 80 Kgs or lower. "We know that, if we work with high-strength materials, then NVH is totally different, but we expect the driving characteristics will be very dynamic, because of the stiffness."

He is hopeful that future Hyosung carbon fibre developments will result in a breakthrough to reduce the future costs of using carbon fibre, which have to date restricted its use to high-end performance cars."If you look at the last 10 years of Hyundai's development, it always begins with something like this, which eventually develops into a production variant.

"At the start of this project, we did a lot of benchmarking and workshops with major suppliers, looking into different ways of building monocoques etc, but found that having this new approach was the best solution for us."

Developed under the project name HED-9, Intrado makes extensive use of Lotte Chemical's eco-friendly materials, featuring super-lightweight carbon fibre reinforced plastics (CFRP) for both interior and exterior components.

Injection mouldable long carbon fibre reinforced thermoplastic composite (LCFT) is a new material, mainly focused on replacing metal, which is produced by Lotte Chemical's unique impregnation technology and marketed as Supran. A typical application, as in the Intrado, is as a door module, reducing weight by around 40%, compared with steel. The injection-mouldable LFT resulted in 40% weight loss and 20% assembly time reduction.



Schematic shows the unique internal web-like strengthening lattice

Woven long fibre reinforced thermoplastic (WLFT) composites are produced by woven fabric thermoplastic composite (WFT)and LFT being laminated by a sheet moulding compound process. This new material for Intrado has been used to develop the rear bumper beam by combining compression and injection processes, resulting in a 30% weight reduction.

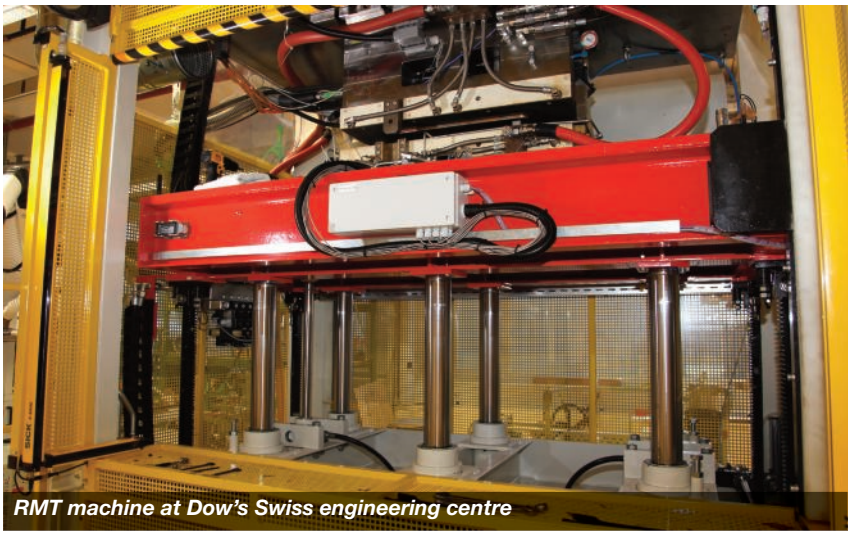
The Intrado's interior fabric makes use of Lotte's Papet Bio, a biomass-based polyester resin that produces only 20% of the CO_2 created when making a petrochemical-based PET; while the headlamp housing is made from a bio-based polycarbonate that, claims Lotte, dramatically reduces CO_2 during the polymerisation process.

material's competitive mechanical properties, it allows for substantial parts consolidation. Customers can now integrate many different parts into one production step, saving extra production and assembly operation costs.

This is something that can make composites an economically attractive solution over traditional metal alternatives.

These key benefits – fast cycle times and part consolidation potential – contribute to make composite solutions a true lightweight technology, fit for mass production of hundreds of thousands of parts per year from a single RTM press.

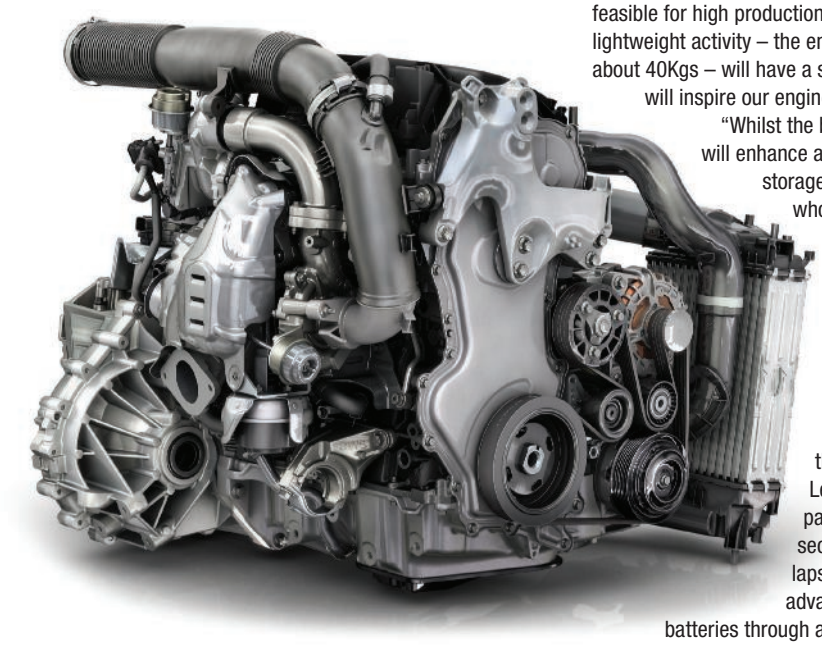
In tandem with Betaforce and Betamate structural adhesives from Dow Automotive, VORAFORCE 5300 offers an integrated lightweighting solution for structural composite parts and hybrid assemblies.



RMT machine at Dow's Swiss engineering centre

Downsizing race gathers pace as new engines up the ante

When Ferrari's latest model, the California T, packs a turboed 4-litre V8, you realise that downsizing can only be here to stay. Admittedly, a few Ferraris sold with a marginally smaller, more efficient engine that still produces 412kW isn't, in itself, any more than an ant bite on an elephant's rump when it comes to lowering global pollution levels, but it's a start, nevertheless.



Of far more import were the three cylinder engines announced by PSA Peugeot-Citroën, Renault and Nissan. Considering that two are deemed to be global engines, capable of being produced in Europe, South America and the Far East for local consumption, then combined production numbers totalling in excess of a million units a year will have an impact on localised emission levels.

BROADLY SIMILAR

The fact that they're three-cylinder engines means they are all, bar a few details, broadly similar – although Renault's admission that it uses a combination of unbalanced flywheel and front end pulley to harmonise its three cylinder engine's inherent out-of-phase vibrations might have Ford's boffins and engineers scratching their heads to see how the French manufacturer has achieved a solution that, on first sight, seems similar to the innovative technology Ford employs on its one-litre EcoBoost engine. Nissan's three-cylinder is the exception that breaks the rule, principally because it is intended to last for just over 24 hours and produces 298kW from its 1.5 litres. Designed to power its ZEOD RC at Le Mans later this year, it is still relevant, however, as Jerry Hardcastle, global chief marketability engineer Nissan, explained. "Nissan goes racing for two purposes: one to tell a story and the other is to test technology in extreme conditions. The aluminium mono-casting isn't feasible for high production runs, but the whole lightweight activity – the engine only weighs about 40Kgs – will have a spin-off, because it will inspire our engineers.

"Whilst the battery technology will enhance and advance energy storage systems, and the whole systems integration, a lot of it is about how software manages events. How do you control energy recovery and its release?"

The plan is for the ZEOD RC to lap Le Mans at LMP2 pace, in the 3 mins 40 secs region for 10-11 laps, replenishing the advanced lithium ion batteries through a kinetic energy recovery system (KERS) before completing one lap powered purely by electricity, but some 15-20 seconds or so slower. While the car has run in private testing, and Hardcastle proclaims the engineers are "pretty pleased with it", proof will only come on the afternoon of 15 June when the race is over. Meanwhile Renault's new family of three-, and four-cylinder engines, says Marc Boudin, director, strategy and advance engineering, powertrain, is core to its global engine strategy. "Initially, production [of the TCe range] will start in Romania, but the engine has been designed in such a way it will be easy for us to source components locally, wherever the location."

Future larger downsized engines, he states, will be developed with its partner Daimler and, while Renault is working on developing e-boosters to overcome low engine speed turbo lag, he feels the technology isn't yet mature enough to be applied in the near future. "Neither its physical size or cost is good enough for the type of customer who buys a Clio-sized car; maybe when you move up a class into bigger and heavier cars, it might be more applicable, but it's still too early to say."

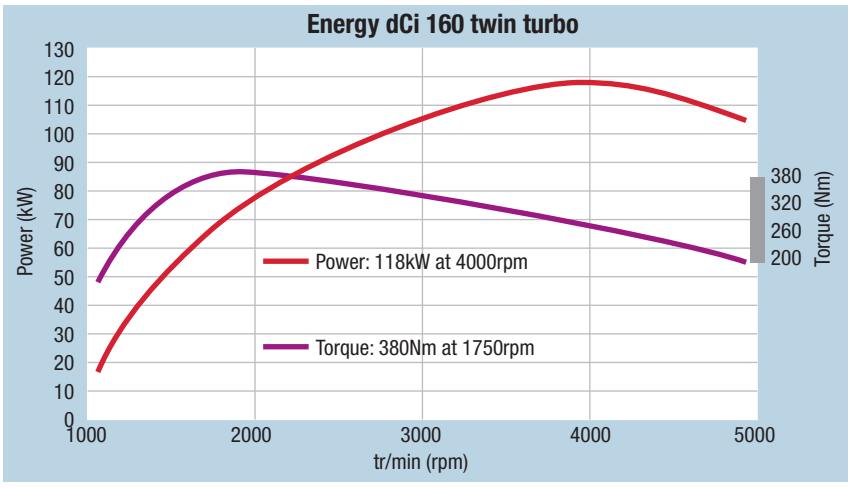
TOUGH TARGETS

Boudin was diplomatic when it came to commenting on the EU's recent decision to allow a further two years before the full implementation of the 95 grams/Kms requirement comes in.

"I wouldn't say we've been 'cheated', but it's clear that the 95 grams target is very, very challenging, and we're focused on that and working hard to meet that target by 2020. The two years' breathing space will make it easier to meet the target, but we're still focused on 2020 and we're on track."

All of which stood in stark contrast to his opposite number at PSA Peugeot-Citroën, vice president powertrain and chassis, Christian Chapelle, who clearly feels that OEMs such as his own and others that produce smaller capacity cars have been discriminated against by EU bureaucrats who have bowed to pressure from the German lobby:

"The new regulations are made for the Germans; made for big cars with big engines," he said. "In our opinion, it's not the right way



to decrease global CO_2 emissions." Be that as it may, he is proud of the €900 million investment in the design and factory investment that PSA has made in its latest global PureTech powertrain family. He compares the engine's architecture to 'Lego', as both the 1-litre and 1.2-litre engines share the same key dimension of bore centres, enabling common oil and water circuits.

For instance, it allows them to be assembled along common production lines, initially in France, but later in China and South America, where next year a flex fuel version of the naturally-aspirated version of the 1.2 will go into production.

On account of its larger displacement, the 1.2 employs a balancer shaft to even out the engine beat, while the 1-litre currently suffices with carefully tuned engine mounts, although Chapelle doesn't rule out possible future changes. "We studied other solutions like Ford's EcoBoost, but because we have a little higher displacement, it's more difficult to manage without a balancer shaft. The 1-litre doesn't have a balancer shaft, so maybe this story isn't finished. These devices are expensive and we're thinking that maybe for the next generation we will review it and do it

differently. We know Ford manage it and do it, and Renault the same. However, the physics are the same for everyone and you can manage them in different ways."

Key to the turbo engine's low down torque is what Chapelle describes as the 'Airloop' system. Controlled by an in-house engine management system, Airloop swiftly and precisely monitors engine mapping, the cam phasers' valve timing, injection and spark mapping, and turbo wastegate to ensure sufficient exhaust boost to the turbo at low engine speeds.

Sizing up most comfortable and safest seat positions

Johnson Controls has developed an automatic seat pre-adjustment system that brings the driver's seat into a comfortable and safe position, based on an individual's size.

"Many people do not position their vehicle seat correctly. This can lead to back pain and stiff legs, particularly during longer journeys," said Andreas Eppinger, group vice president technology management at Johnson Controls Automotive Seating. "The right seat adjustment is important for safety. This relates not only to the effectiveness of the head restraints, but also to the interaction with the airbags and seat belts. Therefore we have developed a technology that allows vehicle seats to easily be pre-adjusted automatically."

Automatic pre-adjustment of the seat position is especially useful when more than one person drives the same vehicle.

The ergonomics specialists at Johnson Controls developed an algorithm that determines the optimal seat position, according to the driver's size. Based on this algorithm, the adjustment motors automatically move the seat to a position that is both comfortable and safe for the respective individual. In some cases, the driver may still need to fine-tune the seat position to suit his personal preferences.

The experts from Johnson Controls examined the seat positions of more than 100 people. "We discovered that correct positioning of the seat track cannot be derived directly from leg length, nor from height adjustment of the seat derived directly from the torso length. Rather, the human body is more like a complex system. If you change one parameter, this has an impact on other variables," explained Eppinger.

"We were able to programme the algorithm, so that size was sufficient as the decisive adjustment criteria. This enabled very precise default adjustment that was rated as good by the participants in the series of tests we performed. Following minor manual readjustment, they rated the position as very good."

To operate the system, Johnson Controls developed an app that allows drivers to input their size via a smartphone. Alternatively, this information can be entered into the vehicle's digital control console. It is also possible for an on-board camera to automatically measure body size before the driver even enters the vehicle and for the seat to move into the correct position. It is conceivable that the driver's size could be stored in the customer profile for rental cars and car-sharing services. This information would be forwarded to the vehicle upon hire, so the seat can be adjusted before the driver enters the car.

TRW unveiled a new steering wheel concept, shown on the Rinspeed XchangE showcar, with Guido Hirzmann, group leader, new technology, Mechatronic, commenting: "TRW's steering wheel system opens up a world of possibilities to the driver. With the integrated hands on/off sensor and flexible positioning of the wheel, the driver can choose whether to drive the vehicle himself, pass control of the vehicle to the front passenger or have the vehicle drive itself in automated mode.

"Furthermore, with the increasing number of electronically-controlled functions in the vehicle, certain controls can be eliminated or packaged into the steering wheel, offering more space and flexibility for the car interior," he added. "For example, with the XchangE vehicle we have been able to remove the centre console and integrate the gear shift into the steering wheel."

The steering wheel offers a modern, lightweight design, incorporating the following functions that can be immediately activated by

touching transparent switches:

- A 'Drive Mode Manager' (DMM) display, located at the top of the steering wheel, illuminating 'A' when the vehicle is in automated mode. If the driver touches the steering wheel, 'M' (manual) lights up, indicating that the driver is ready to take back control of the vehicle. If he then touches 'Push to Drive' or 'PTD', control is given back to the driver. Similarly, if the driver later takes his hands off the wheel, the DMM display automatically changes from 'M' to 'A' and the vehicle continues to drive in automated mode
- Gear shift – the driver can move from park, neutral, drive and reverse, using the relevant switches on the steering wheel
- Turn indicators – indicator switches are illuminated white (ambient lighting) and, when activated, the relevant arrows flash
- Electronic Horn System (EHS) – the horn can be activated by touching a conductive area on the steering wheel airbag cover.

Turbocharger E-booster stakes its claim

Fiat is developing a turbocharger E-booster, together with an unnamed supplier, according to Paolo Pallotti, engine director for Fiat-Chrysler, who described the advantages the technology offers as "quite interesting."

And he added: "It's a means to avoid as much as possible turbo lag. On the other side, if I have to increase the power from a downsized, I need a bigger turbo. But, if I do that, then I increase inertia and have more problems at low engine speeds. To avoid that, I need the E-booster to compensate.

"However, we have to find the right balance, in terms of cost and performance, although I have to say it's a quite exciting development." Pallotti also said that Fiat will develop more compressed natural gas (CNG) variants of future engines, including those fitted with the unique MultiAir technology. "CNG could be the right enabler for improved emissions performance."

News in brief

Tomorrow's engineers

Ford is making a £322,000 contribution towards the creation of a new university technical college for students, aged 14-19, studying engineering and design at the East London University Technical College in Essex. It will fund key facilities, including a digital engineering and robotics laboratory, and an engineering and manufacturing suite.

Chain reaction

BorgWarner's next-generation 6.35 mm inverted tooth silent engine timing chains are now in service with several OEMs. The chain is designed to reduce friction, resulting in as much as a 0.3 to 0.6% improvement in fuel economy, based on customer testing.

It combines inverted tooth silent chain technology with an optimised link back shape, which reduces contact area and friction as the chain slides along the arms and guides - where most friction losses occur. In addition, super-finish apertures enhance wear and efficiency performance, while 'E' polishing improves surface finish to reduce friction.

New Jaguar engines

Jaguar's new family of engines destined to power its new small aluminium XE saloon, due out next year, will be called Ingenium. They will be totally flexible, says Jaguar, allowing transverse, in-line, front-, rear- and four-wheel drive. The four-cylinder engines will have a power capability ranging from CO_2 emissions of less than 100 g/Kms to sufficient power to give the quickest model a 300 Km/h top speed.

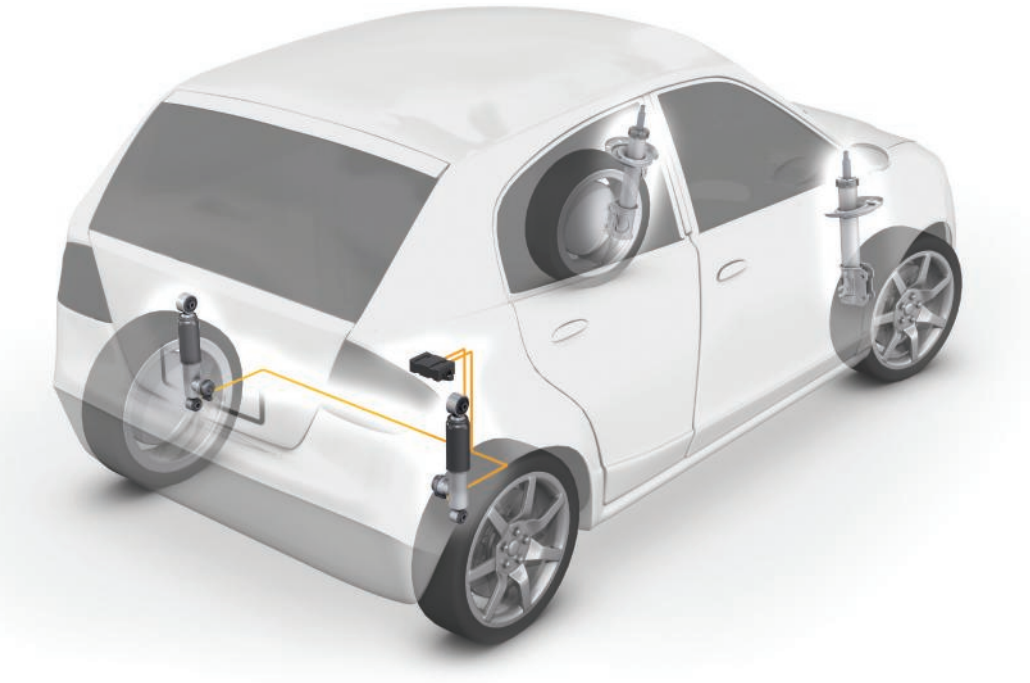
Get connected

Bosch is pursuing three strategic objectives when it comes to connectivity. First, it is making the internet an intuitive in-car experience. Secondly, it is connecting cars to the internet and creating driver-assistance functions with added value. And finally it is networking cars with traffic infrastructure.

Correction

In the December 2013 issue, there was a misunderstanding over a quote attributed to Allan Cooper on page 23, which should have read as follows: "Advanced lead-carbon batteries are now in the vanguard of 48 volt developments."

Driving mode that you desire – at the touch of a button



ZF has revealed a further development of its continuous damping control (CDC) for rear axle systems alone, significantly reducing complexity and cost.

Its CDC 1XL debuted on the Honda Civic Tourer at Geneva and allows drivers to select comfort, normal or dynamic driving modes at the touch of a button. The system will also appear on two other products in 2014 and 2015; ZF is also believed to be in discussion with North American OEMs for applications in truck and vans.

The adaptive damping system has been on the market for premium-class models since 1994, but, reveals Uwe Coßmann, head of ZF's car chassis technology division, there was always a desire to make it available on a volume basis at a more affordable price.

"We tried to develop a system with the same performance as we have with four CDC shock absorbers, but only on the rear axle," he said, "and we have achieved 70% of that performance with the 1XL system."

A control unit analyses data on road condition, payload, vehicle speed and drivability that is gathered by the integrated sensor system, which then optimally adjusts the dampers within milliseconds. This is made possible, thanks to electronically-controlled proportional valves that minimise oil flow in the damper tube (for hard damping characteristics) or expand the diameter (for soft suspension).

Costs have been reduced by locating the ECU close to the rear axle, combined with sensors in each shock absorber, which has reduced costs by half, including development. The next step, says Coßmann, is to develop the technology for front suspension systems within the next two to three years.

Uwe Coßmann: ambitious goals for front suspension systems as well

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"We see potential for our coatings to help OEMs contain under-bonnet temperatures, especially with smaller downsized engines."
-Terry Graham, Zircotec

DOWNSIZING: the heat is off

Ian Adcock discovers why a material that was developed in the nuclear industry could now prove a real boon for OEMs as they look to downsize engines

A side effect of highly boosted downsized engines, combined with tighter under-bonnet packaging requirements, has been a subsequent increase in engine compartment temperatures. This is a problem that is only likely to increase with the growth of hybrid powertrains, additional electric motors driving ancillary components, such as turbochargers, and the prospect of multiple battery systems, as more cars move towards dual voltage systems.

But it's a problem that Terry Graham, managing director of Zircotec, is looking forward to meeting head on, as he explains: "We see potential for our coatings to help OEMs contain under-bonnet temperatures, especially with smaller downsized engines. The trend is towards lower capacity power units and fitting more into the engine compartment, whilst future internal combustion engine cars will also have energy recovery units, batteries, more ancillary equipment and less space under the bonnet. So you are introducing systems that could be damaged by being closer to hot components like exhausts.

"We're seeing that trend in Formula One with this season's rule changes. Zircotec can help with these packaging issues by cutting under-bonnet temperatures by as much as 50°C," Graham states.

POTENTIAL BENEFITS

"There are performance benefits as well; by insulating the exhaust, you can deliver more energy to the turbocharger and by keeping heat in the exhaust, you can improve the engine performance marginally, so all of those are potential benefits to OEMs in their quest for improved fuel efficiency and reduced tailpipe emissions."

The materials that Graham is referring to are Zircotec and Zircoflex, both patented high temperature barriers, the former being a plasma sprayed coating and the latter a lightweight heat shield.

As is becoming increasingly the case these days, Zircotec, the business, was spun out of a government establishment in 2005 – in this instance the UK Atomic Energy Authority (UKAEA) based at Harwell – and sold to venture capitalists before a management buy-out that was led by Graham four years later. "[Zirotec] started back in the 1970s and at that stage it was a very small operating unit within the UKAEA at Harwell, where it was used to coat components that would go into a nuclear reactor where you've got lots of heat and areas you need to insulate against it. But at the same time you also have a high radiation background, so there are only certain materials you can use in that environment."

NEW DIRECTIONS

"It's a very niche thermal barrier coating and here we're talking of temperatures in the range of 600-700°C, sometimes a bit higher, and one of the properties of the coating itself is that it will withstand quite high levels of nuclear radiation.

The core technology is out of patent, but the technology itself continued to be developed by the nuclear industry and as it was becoming increasingly commercial and looking for work elsewhere, the technology was taken forward and other applications looked for.

"That's where Zircotec in its present form was born when a number of motorsport companies came along, expressing interested in the thermal coating barrier for exhaust parts back in 1993-94. Since then, the technology has been increasingly used in motorsport."

While plasma spraying is known

Photographs: Steve Crimpson

"For example, in motorsport applications where we were applying ceramic onto an exhaust, it might be running at 700-900°C and for that we have an ultra white coating called 'Performance White'."

and understood technology, what makes Zircotec unique, he explains, is its own proprietary mix of ceramic materials that understandably he is unwilling to elaborate on. "We mix different powders to achieve a particular finish and performance, and then plasma spray it onto the surface. There are different ceramics for different applications, so for some we would need a ceramic that works at extremely high temperatures.

"For example, in motorsport applications where we were applying ceramic onto an exhaust, it might be running at 700-900°C and for that we have an ultra white coating called 'Performance White'. For other applications with lower temperatures, we have 'Primary powder' with different coloured ceramic. It's less expensive as well."

MULTIPLE PATENTS

Apart from the patented ceramic materials, Zircotec also has two patents – "one for the UK and we're waiting for patents in Europe and the USA, "he states – for applying the protective coating to carbon fibre, as well as further patents pending for other materials in the UK, Europe and USA. "We have granted patents for putting the coating onto exhaust systems and tailpipes; that's for the aesthetic coating on the tailpipes for some high-end OEMs." There is also a further family of patent pending for Zircoflex: the lightweight heat shield manufactured in the company's robotic spray facility.

Currently, Zircotec has a compact facility in Abingdon, near Oxford, convenient for both Harwell, where ongoing development into new materials and applications is undertaken to back up Zircotec's own in-house research and development, and the UK's motorsport triangle.

Motorsport remains a large part of Zircotec's business and, walking round its storage area, I noticed that only one current F1 team wasn't a Zircotec customer, in addition to endurance race teams and others at the top level of two-, and four-wheeled competition.

The other main customers are high-end performance cars. Zircotec counts amongst its clients both Aston Martin, for which it coated parts of the carbon fibre rear diffuser for the One-77 supercar, plus other items, and exhaust trims for Lamborghini.

LURE OF LIGHTWEIGHT

"Our niche is the high performance sector, and we expect that to progress downwards as the OEMs learn more about us and start to have problems with packaging. The other aspect is the use of lightweight materials. Two of our patents are specifically targeted at putting our material onto plastics and carbon composites. Carbon fibre is really supercar territory at the moment; we were involved in a lot of components on the Aston Martin One-77, Jaguar's C-X75 concept and are working with Lamborghini on carbon composite coatings. Top end, I know, but what's happening in those supercars will trickle down to more mainstream products in time, as lightweighting begins to play a bigger role in improving fuel consumption."

The actual coating process is fairly straightforward, as Graham explains: "First of all, the surface is grit blasted and within two hours we apply the first layer of coating, because you don't want the surface to have an oxide film on there at all, as when you prepare the surface and blast it, in effect you've taken away all of the oxide film that was there, particularly with stainless steel.

"The first layer of material is a metallic bond coat, our own proprietary mix, and that is needed to give good adherence between the thermal barrier and the component. It gives a very rough finish to the material, so the ceramic can easily bond to it and also covers thermal mismatch: the differential expansion between the underlying component and the coating. Our coating is very robust for a tailpipe; for example, we

Terry Graham

CV

Terry Graham, 53, graduated with a degree in Mechanical Engineering from the University of Leeds. His early career was in the UK nuclear industry, working on a number of highly technical projects in the roles of mechanical engineer, nuclear engineer and programme manager before moving to senior management.

Graham is an experienced business leader, primarily in high technology and innovation, with a focus on growth businesses and start-ups. He is currently managing director and majority shareholder of Zircotec Ltd. He is a Chartered Engineer; Member of the Institute of Mechanical Engineers; and also of the Association of Project Managers. He is married, with two sons.

have to pass a test where it's heated to 600°C and then quenched in water, 30 times. While Zircotec is currently only producing thousands of units a year, Graham recognises that further expansion could mean licensing the process and materials to an OEM or a tier one as the natural growth pattern for the business. "We have had some of those conversations and that really is where the business will go ultimately," he confirms.

"If you look at our history, we've gone from motorsport into specialist high-performance OEMs that will pay the premium associated with small numbers. But as the technology develops and becomes more widely accepted, I think that's exactly where we could go – licensing the technology. It wouldn't be practical for the OEMs to send their components to Abingdon. Technically, we could have a facility latched onto one of the car factories or tier ones."

Lightweight alternative

Zircoflex is an in-house developed aluminium-backed, high performance flexible ceramic heat shield that uses plasma-sprayed ceramic material. "It could be a lightweight alternative to engine encapsulation," he says, adding: "We have single sheets and can fabricate a 3-layer version. Just 0.25mm thick, it can result in a 64% reduction in contact temperatures up to 500°C and is easily applied with a peel-off adhesive backing."

Its flexible nature allows ZircoFlex to be folded through 180°, even in self-adhesive form, enabling it to be easily applied line-side or even as a retro-fit in the field. Available in sheet form, it can be cut with scissors, knife, laser and water jet, allowing OEMs to custom cut parts as small as required with no waste or high tooling costs.

As OEMs strive to meet future emissions legislations, technology solutions from divergent fields, such as that developed by Zircotec, will become increasingly common.

Lightweight Champions

Could an alloy with the strength of steel, but as light as aluminium, prove to be a game changer for the automotive industry? Ian Adcock investigates

More than a decade in development, Composite Metal Technology's Fibacore offers properties that exceed most other materials currently used in automotive structures.

That's the view of David Price, CMT's commercial director, and the statistics are these: compared to aluminium, Fibacore has four times the longitudinal stiffness (240GPa) and three times the longitudinal tensile strength (1600MPa), while its longitudinal compressive strength at 1700MPa is five times that of aluminium, combined with 30% lower thermal expansion – 7 ppm/°C – and minimal elongation. Admittedly, it is 26% denser than aluminium, but it is still half that of cast iron, with greater stiffness and strength.

MASS AND VOLUME CUT

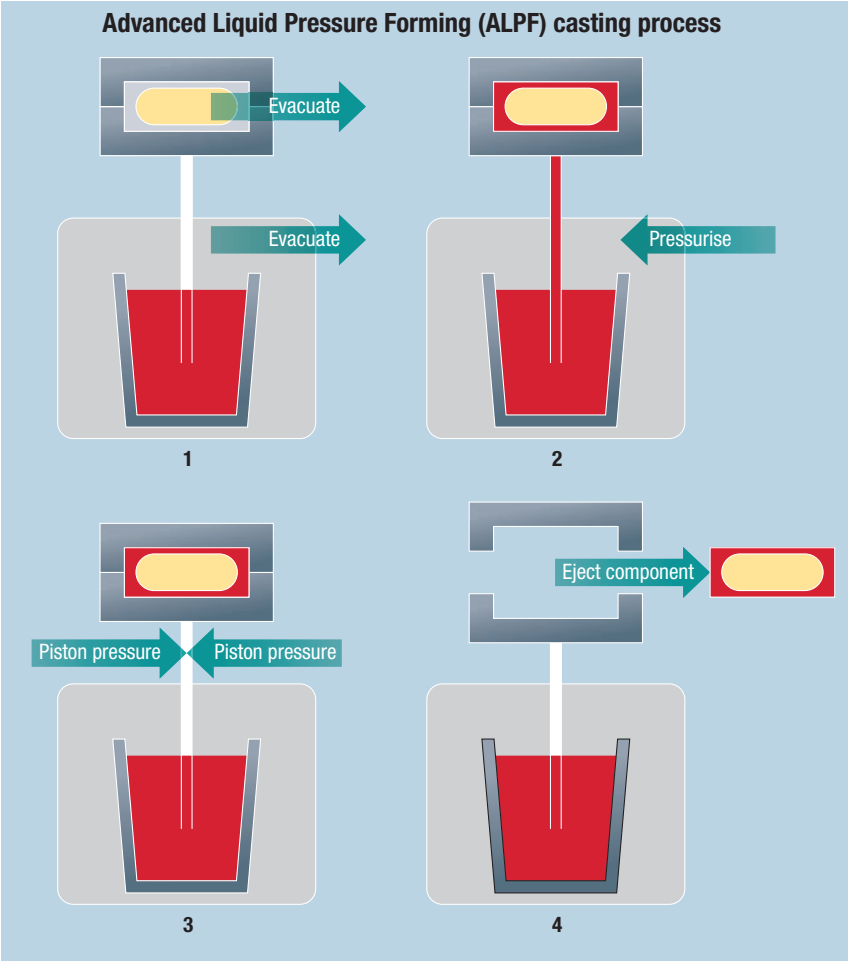
The problem with existing lightweight materials like aluminium is that they are not very package efficient; aluminium components tend to be bulkier than they would be in steel. "What this means for the automotive sector is that, in addition to significant weight saving, components manufactured from or strengthened with Fibacore inserts can be dramatically smaller for improved packaging," maintains Price.

The Jaguar F-Type's development suspension swan neck illustrating the front cover is a typical potential application. With its Al-Fibacore insert, its mass and volume have been reduced 30% simply by adding less than 0.2Kgs of inserts, but there's a 20% improvement in stiffness.

No great significance should be read into the fact that this mock-up hails from Jaguar's new sports car, although CMT and its supplier Antich do have two TSB-funded projects with the prestige car brand, described as CMT's "lead customer".

CMT is also working with a number of European OEMs and Price expects the first volume production application to appear in a European vehicle in 2016-17, although low volume components – perhaps in motorsport – might appear before then. Price concedes that Fibacore's cost currently is too high for mass volume production, but is quick to add "we're getting there," stating: "We're in the ballpark now, typically a 10-25% increase in cost from using the material, depending on how much

David Price expects the first volume production of Fibacore to appear in a European vehicle in the 2016-17 timeframe



is needed and where. That's better than we used to be and interestingly we're now hitting the metrics that the higher end OEMs are applying, in terms of what they will pay for each kilo saved. The OEs will pay more for components that are in critical packaging areas such as the engine or suspension systems. We're feeling quite bullish that we're getting there on cost and believe we can meet those requirements for high end luxury OEMs."

DEFINING ADVANTAGES

CMT's advanced aluminium matrix composite traces its origins back to the 1990s and the UK's Ministry of Defence research into lightweight material for military applications.

Wanting to see a return on its investment, the MoD negotiated the sale of patents covering the material and its liquid pressure forming manufacturing process to CMT.

There's nothing particularly new about metal matrix composites (MMC); it is commonly used in aerospace applications, but CMT's differs in two significant areas that, Price believes, make the product unique. Unlike some MMCs that use chopped and short fibres, Fibacore uses continuous alumina ceramic fibres and, secondly, there's its unique Advanced Liquid Pressure Forming (ALPF) casting process.

Admittedly, there are aerospace continuous fibre MMCs, but these tend to be prohibitively expensive. It is the casting process that has taken CMT nearly a decade and some £5 million (€6 million) to perfect. "Most SMEs are fast growing very quickly; this one has been very slow growing for a long time," Price wryly observes.

CMT currently has two TSB funded projects with Jaguar, including this experimental F-Type swan neck with its Fibacore insert

CMT use 3M's Nextel Continuous Aluminium Oxide fibres – finer than a human hair at diameters of 7-13 microns and more commonly used for high tension electric cables in the USA. Because they are chemically inert within the aluminium, there's no danger of galvanic reaction or any other corrosion problems. The filaments can be wound to provide unidirectional 2D alignment or 3D woven pre-forms and, although the fibres lack the strength of carbon fibre in the longitudinal direction, for instance, transversely they have "very good" properties.

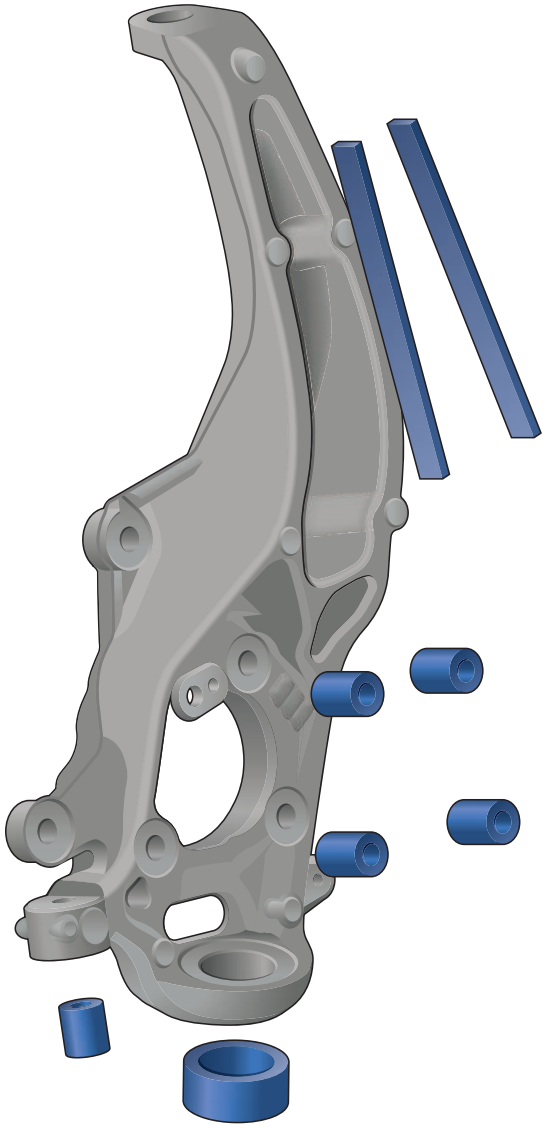
"You actually get stiffening perpendicular to the fibre direction, because of the Poissons effect and that, together with the metal matrix, means you get good transverse properties," comments Price. "What we're finding is that it makes the material of great interest for components that are either subject to high loads or unexpected load conditions; shock loads like a suspension component when you hit a kerb. It's much more tolerant of those unexpected load conditions and that means it's a more forgiving material to design with.

"That makes it suitable for discrete components, whereas carbon fibre will struggle to find its way into a car's suspension components for those sorts of reasons.

RIGHT CONNECTIONS

"We've been told it would be applicable for connecting rods and we're getting quite a lot of interest for engine applications right now, such as gudgeon pins and those reciprocating parts that are subject to high acceleration and where low inertia is important. We're making samples for a customer right now that are plasma steel coated, as the fibres in MMC are very abrasive when exposed," he explains.

CMT's patented ALPF casting process employs hydraulic pressure of "several hundred bar" to force the



molten aluminium into the spaces between the fibres to get full infiltration. “Our intellectual property is in the die design and technology. In a normal die casting process, you put the metal in and get the component out, but in this case we have to manage the pressure, temperature and time through the 90 second cycle to ensure we get full infiltration; otherwise you get failures. This is the key to our business and developing that understanding of how to do it.

“We know of a number of very large companies that have tried to do this and failed, and our technology is essentially in that fast cycle time. We can manufacture components quite quickly, not as fast as the die casting process, but not far off, using ALPF. There are lots of companies that can infiltrate these materials, but doing it fast is the difficult thing.”

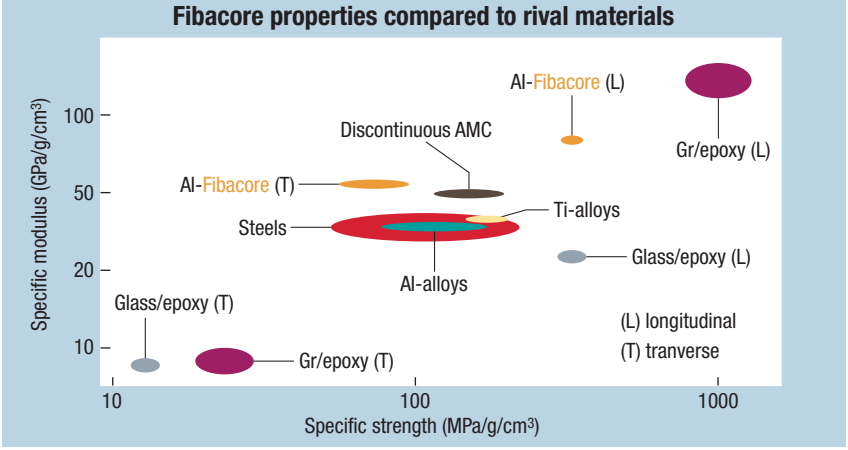
3-D WEAVING

CMT has a collaborative project underway with Bühler to develop die casting machines incorporating ALPF technology, which they will then market for third parties to produce inserts and components.

The third key partnership is with C & J Antich & Sons, which has developed 3-D weaving technology capable of producing fibre T-, U- and I pre-forms that can then be infiltrated using ALPF techniques.

“Using 3-D pre-forms, we can get down to €73/kgs, compared to €108/kgs using 65% uni-directional alumina fibre core material, because of its lower density and alternative, cheaper fibre grades from 3M with different tow sizes and now being marketed as ‘Aluminium Fibacore’.”

Fibacore properties compared to rival materials



However, the most cost-effective means of using CMT’s MMC is to use inserts at strategic locations within a component, as illustrated by the F-Types suspension strut; this entails simply locating the plate within the die and then over-moulding it with aluminium. “This is a good solution, as it allows the inserts to be produced separately from the overcasting and, for example, we could supply the inserts to the Tier 1 or OEMS. They wouldn’t have to invest in the machine to make the inserts,” says Price.

Perhaps the biggest challenge facing the widespread adoption of CMT’s composite material is that each application demands a unique lay-up of fibres or weave.

“There’s a lot of work being undertaken in collaborations to model these materials, in terms of their performance when they are infiltrated. In other words, developing CAE tools that will enable us to say: ‘With this particular weave, these are the mechanical properties that will result when you infiltrate it.’ Also, to go the other way and say: ‘We need these mechanical properties, so therefore this is the weave we need’ – a CAE tool that works both ways.

LIBRARY OF MATERIALS

“That work is quite important, since that part of the CAE toolset is going to be critical in enabling us to do the work in an appropriate timeframe for the OEMs,” states Price before adding: “Eventually, there will be a library of materials, so that won’t have to be done each time a new component is designed.”

An anonymous industrial estate on the outskirts of Basingstoke, Hants, might seem a rather unlikely place for the start of a revolution in automotive lightweighting.

But if CMT’s new MMC lives up to its claims then perhaps the town that’s best known for its plethora of roundabouts will have another, more impressive claim to fame.

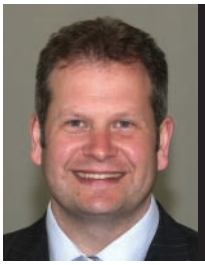
ROAD FATALITIES
Eliminating the human factor

A recent European study into the economic damage that road traffic fatalities cause each year puts the total, in financial terms, at a staggering €229 billion.

Citing this figure, Continental's Dr Peter Rieth, head of systems and technology, points the finger at drivers for being solely responsible for 76% of those accidents. "So, if we can take the driver out of the loop, we can save €175 billion. In fact, 95% of all accidents involve some human error. Compared to that, automated driving might have a 3% error rate."

That's a highly compelling argument for the march towards fully automated driving and one that, according to J. D. Power, consumers would be willing to pay an extra €2,000 for. However, automated driving isn't about to happen overnight, as Tom Overington, Ford's automotive safety officer, Europe, explains: "Lots of questions need to be answered about what it really means, such as how are all the OEMs going to come together to deliver the infrastructure you need, as you're relying on vehicle-to-vehicle and vehicle-to-infrastructure communications."

Dr Peter Rieth
"...automated driving might have a 3% error rate."



Tom Overington
"If you look to 2017-25, there will be semi-autonomous driving, with the driver still in charge."

In the short term, Ford, along with other manufacturers, is looking at technologies like traffic jam assist or assisted parking to make vehicles safer and more efficient.

"If you look to 2017-25, there will be semi-autonomous driving, with the driver still in charge. Or parking assist. But even then you still need high levels of car-to-car and car-to-infrastructure interaction and that's quite a tough nut to crack across different markets," adds Overington.

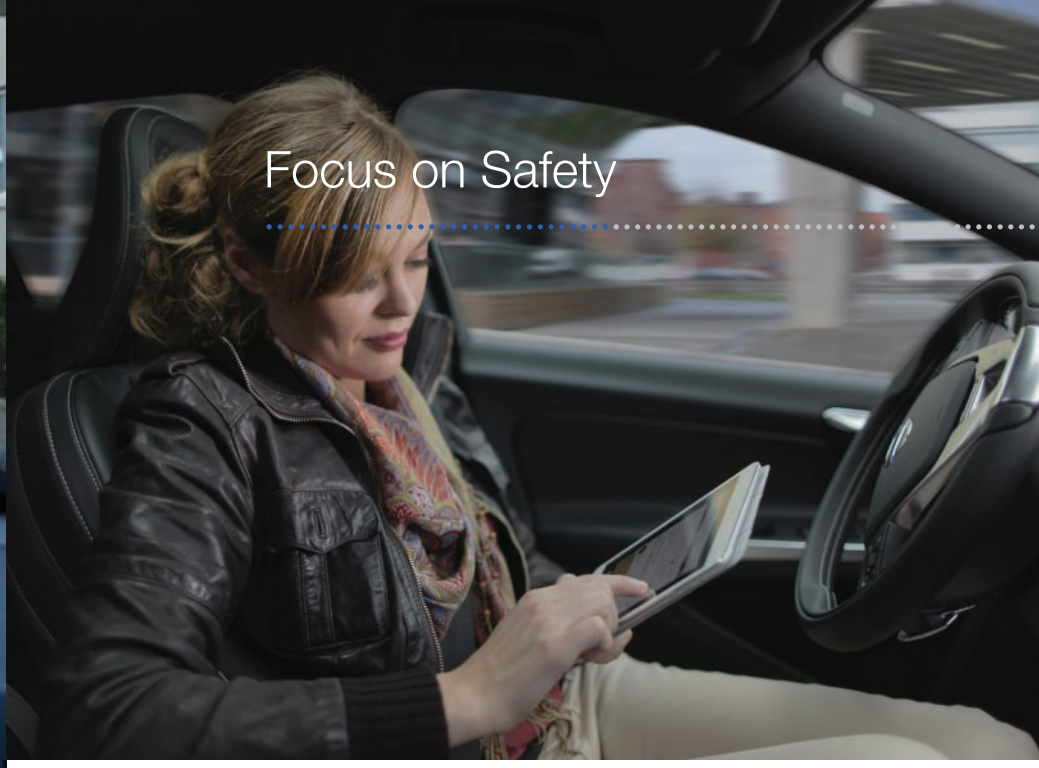
It isn't just the technical challenges that need overcoming, says MIRA's head of certification and homologation Richard Whiting, but also legal requirements and legislation at both national and international levels: "It depends on how you read the legislation. In the UK's construction and use requirements, the onus is more angled towards the driver having the ability to take control and so the argument against it is: 'Well, the driver can always intervene.' It's a tricky one certainly.

"It would also necessitate a change in the Vienna convention. There are certainly a lot of hurdles, but there is also a lot of interest in it at the moment. Many legislative bodies are acknowledging that and will bend the rules a little, so that automated driving can at least be trialled to see how it goes and then see what happens following that."

MATTER OF INTERPRETATION

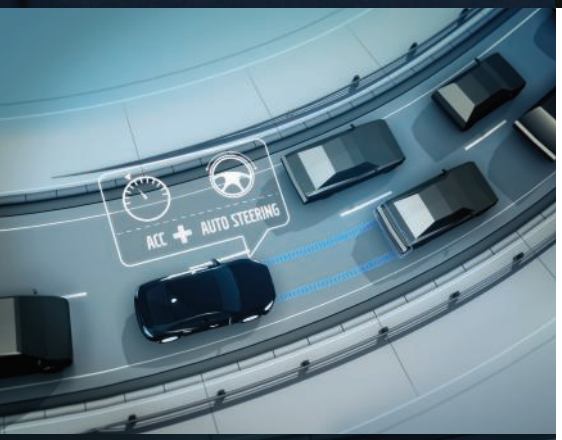
The Vienna convention is certainly a contentious issue and while Bosch's senior vice president for driver assistance Frank Melzer agrees that the convention "basically says the driver must always be master of the vehicle", Continental's Rieth begs to differ: "The Vienna convention doesn't talk about a human being; it talks about a 'driver' or 'person'. So why can't the driver be an automate? Secondly, what is a 'person' – an individual or a legal entity or a company? So there's no

Richard Whiting
"It would also necessitate a change in the Vienna convention."



Focus on Safety

In the first of a series on vehicle safety, Ian Adcock examines the need for more driver intervention systems



need to change the Vienna convention. That's my interpretation. The big question is: how do the lawyers and others interpret that?"

While some OEMs, like Nissan, predict autonomous driving might be with us by the end of this decade, all of those Automotive Design spoke to were far more cautious, forecasting a step-by step approach that would develop from city automatic emergency braking (AEB), gradually developing through to urban and eventually highway AEB.

Beyond 2020, EuroNCAP will need to test for car-to-car communications and road departure prevention, although developing algorithms that can distinguish between the road surface and verges – without a white line – will be a challenge in itself. "One of the major reasons why some of this life-saving technology is delayed is because the processing power hasn't caught up yet," explains Whiting, adding: "In addition, it's the requirement to make sure the algorithm is safe."

SENSOR PROLIFERATION

"We see a multitude of sensors in the future," says Melzer. "There will be a need for 360° coverage around the vehicle that will be achieved by combining existing sensor technology, radar and ultrasonics with high-performance sensors. Dynamic map navigation will evolve to provide lane specific information to the car, whilst further stages of development will see improvements in data plausibility to guarantee functionality; and additionally we need new secure, redundant, very powerful architecture and algorithms. There's a lot to come."

While the automotive industry is prepared and willing to bear a large proportion of responsibility for improving road safety, that shouldn't absolve either governments or individuals of their accountability, he adds. "It's a shared responsibility and, yes, governments do have a role to play at different stages of market development, like clear safety targets and support research programmes."

It's a point that's not lost on Overington. "If you look at these things on a pan-European scale, to get all the markets to agree to certain infrastructure changes is incredibly difficult, whereas it's relatively easy to tell everyone to fit a new technology to all their products."

Twenty years hence and we might be much closer to accident-free motoring than we are today, but 100% accident-free? That's probably in the realms of never-never land.

Frank Melzer
"There will be a need for 360° coverage around the vehicle..."

The MASTER PLAN is Everything

How do you maximise the number of models that can be spun off the minimum number of modules? By having a grand plan – and lots of patience

"The lesson that I learned, and it's still not commonly applied, is coming up with a master plan – the range of architectures you want to handle. You need to make that very clear and understood, so you end up with common bill of materials and processes; you can then design around it and make it work. It's down to good planning."

So says Paul Meeson, Stadco's advanced engineering director, when asked about the virtues of modular structures. And nowhere is there a better example of that than VAG's strategy, which embraces four 'assembly kits' – new small family (NSF), modular transfer kit (MQB), modular longitudinal kit (MLB) and modular standard drivetrain kit (MSB) – to underpin the vast majority of its product range from Audi, Bentley, Lamborghini, Porsche, Seat, Skoda and Volkswagen. The only exceptions are the rear-engined 911 platform, Bugatti and the mid-engined Lamborghini underpinnings shared with Audi. Nevertheless, it is this strategy that, says Meeson, "has been a very long journey for them; they're 15-20 years into a grand plan and they are just starting to see the benefits" that will underpin VW boss Martin Winterkorn's ambitions for the group to be world leader by 2018, building 10 million cars a year.

> "You need to come up with a master plan and make it very clear and understood, so you end up with common bill of materials and processes; you can then design around it and make it work." — *Paul Meeson*

VAG isn't alone in this quest for maximising the number of models that can be spun off the minimum number of modules: Allan Mullaly's One Ford policy is its interpretation, while Renault is sharing platform technology with its alliance partner, Nissan, and Daimler. PSA Peugeot-Citroën has recently revealed its own Efficient Modular Platform (EMP) 2, designed as a strategic response to underpin mid- and high-range vehicles, and is compatible with high- and low-seating positions for cars and SUVs, and five wheelbases with a variation of 220mm in 55mm steps.

This is achieved by inserting the strips between the 'B' post and heel board. Also, four different wheel tracks are possible and there is also a quartet of four rear units compatible with seats and boots for saloons, estates and 5- or 7-seater MPVs. In

time, almost 50% of the PSA group's output will be based on EMP2.

As OEMs strive to reduce weight, there will be a move away from mono-materials to an amalgam of both metals and plastics. "In my opinion, there's no one perfect material to build a vehicle with," says Lotus Engineering's Gregg Peterson. "Steel is outstanding in the 'B' pillars, and helps with roof crush and side impact. Aluminium also allows you to cast and integrate 4-6 parts into one piece; you don't need 6 jigs, just one common tool to achieve easier assembly processes in the plant.

"The OEMs need to carefully consider how they're going to join the different materials together. In our case, when joining steel 'B' pillars to aluminium rockers, we used nylon spacers and mechanical fasteners and structural adhesives as well."

But warns Meeson: "Where it becomes difficult is where you have to join them together. Most hot welding processes work on the basis that you're joining the same material to a very similar material. Joining aluminium to steel is more difficult and this is where mechanical joining methods come into play, particularly riveting to join mixed material. It will become even more challenging when you start joining composites to metal, which will bring into play some of the techniques used in aerospace where adhesive bonding alone is used. There's a lot of work needs to be done to ensure the joint is perfect.

JOINING METHODS

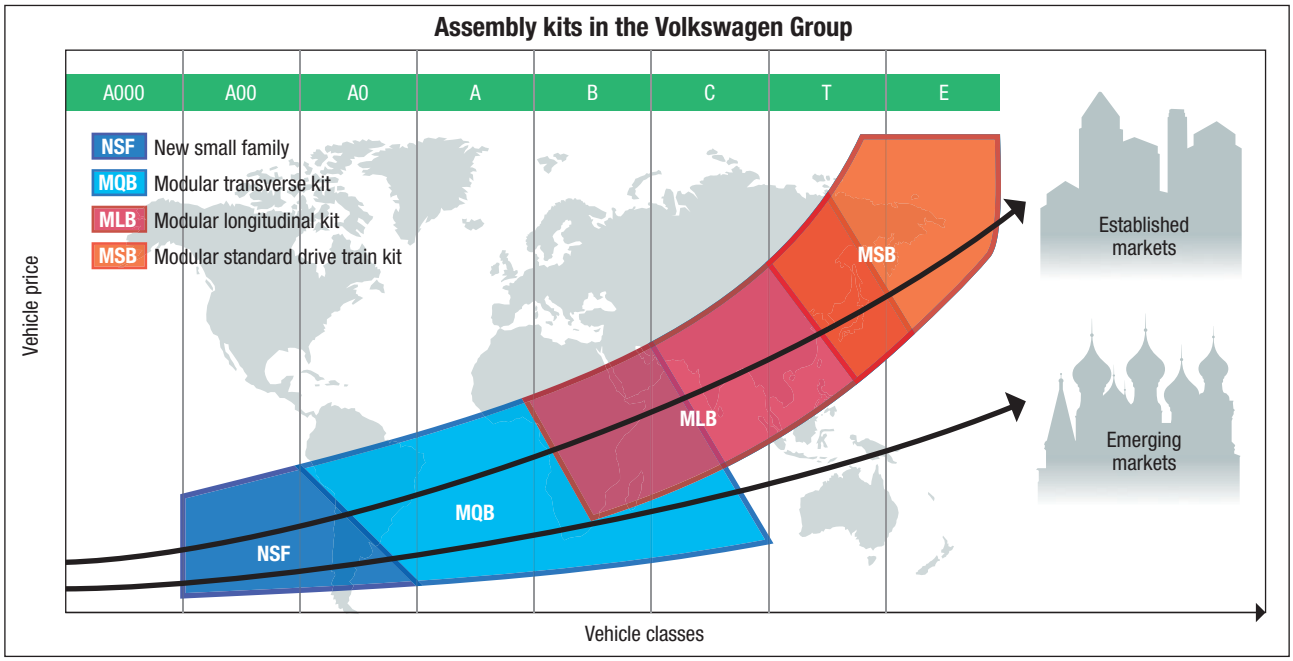
"Joining mixed materials is the biggest challenge, as well as devising assembly lines that can accommodate different materials. From an assembly point of view, we still separate aluminium and steel production, because of the different joining methods," he adds.

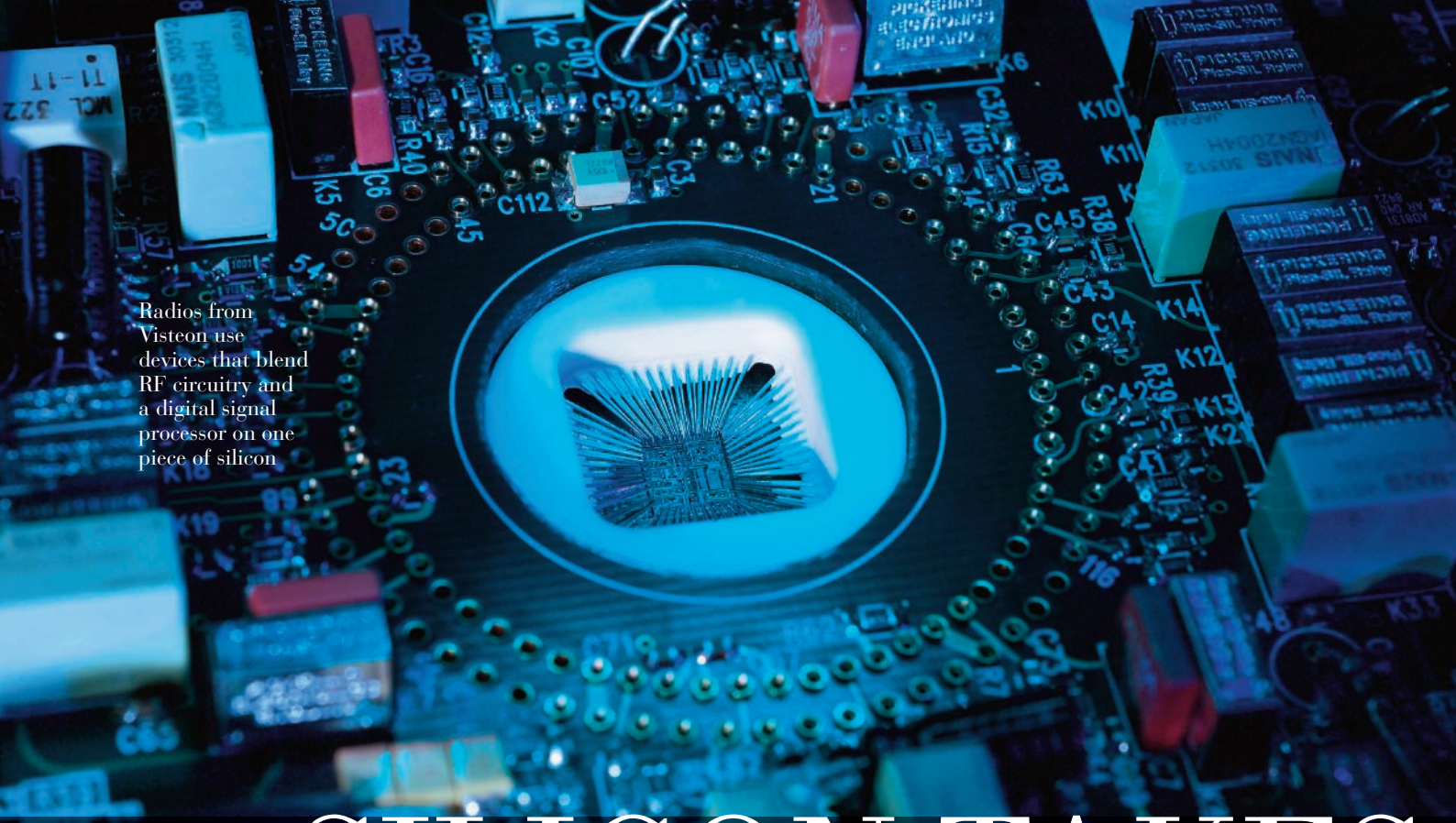
A major challenge created by shared systems is that different brands can look proportionally the same, because of common hard points. And, says Peterson, although to an extent that can be disguised by clever styling cues, Meeson maintains manufacturers have become more adept at building in greater flexibility to accommodate different cowl heights, wheelbase, track and front and rear overhangs.

"People understand better how to build in that flexibility, with the model planning and the manufacturing flexibility now going hand in hand."

The probability is that OEMs will invest 10-15% more to make the body assembly line more flexible by having to include more features than necessarily needed for a dedicated system. But the reusability which that provides means they recoup more in the next production cycle. So the cost savings come in generations two, three or four.

All the OEMs need then are bean counters who think long term.





Radios from Visteon use devices that blend RF circuitry and a digital signal processor on one piece of silicon

SILICON TAKES

Semiconductor suppliers are altering materials, so automakers can add functions and improve reliability, explains Terry Costlow

Just as the compositions that are used in steel and plastics continually evolve to meet changing needs of automakers, the materials used to create electronic systems are also changing. Though the volumes of these substances are extremely tiny, compared to those of steel and plastic, silicon and other materials play a significant role in automotive features and functions.

When device suppliers alter the composition of semiconductors, it can lead to lower prices and improved quality. That's helping developers broaden the usage of high-frequency technologies like radar and gain the lower power consumption of LEDs.

MATERIAL WORLD

For decades, utilising CMOS (complementary metal-oxide semiconductor) silicon technology has been a well-travelled pathway to lower costs. Originally, CMOS had fairly low frequencies, forcing engineers in radar, communications and other areas to use materials like germanium and gallium arsenide (GaAs).

However, CMOS developers continue to stretch the envelope of their capabilities. When chipmakers offer new capabilities, tier ones are quick to utilise them. Radio frequency (RF) devices were once made using GaAs, but they eventually moved to silicon germanium-BiCMOS. Not too long ago, researchers figured out how to manufacture RF chips using CMOS processes.

"Audio products now use RF-CMOS technology," says Mark Fosmoen, associate director for Visteon's electronics technical sales. "Advances in silicon technology have enabled chip designers to integrate two previously separate functions – the RF tuner and the digital signal processor."

The dramatic growth of radar has created significant incentives for chipmakers to step up their research. Though they haven't yet migrated to pure silicon, many automotive suppliers are moving away from GaAs.

"Silicon germanium-BiCMOS technologies are more and more replacing GaAs processes," states Marcel Urban, application manager at ams AG. "RF front-end modules for radar applications used in automotive products, such as blind spot detection and adaptive cruise control, are manufactured in silicon germanium-BiCMOS processes, which offer cost advantages, lower process complexity, and higher integration level and yield, compared to GaAs."

GROWING POWER

Material changes are also helping the growing number of automotive engineers who need cost-effective high power devices. Often, these power chips help automakers replace mechanical devices with electronics, as when electric power steering

Stylists who want to employ LEDs in headlights will benefit when LEDs are made from silicon (Osram)

OVER

White LEDS from Osram are made with silicon and easier to cool

replaces hydraulic power. Hybrids and electric vehicles (EVs) also use more of these high power devices. Semiconductor suppliers are altering the materials used to build chips and create packages that can control higher-powered motors.

"At this point, we are seeing the substitution of higher current relays, above 50 amps with silicon switches with a true mechatronic approach," comments Joseph Notaro, vice president of global automotive applications at Fairchild Semiconductor GmbH.

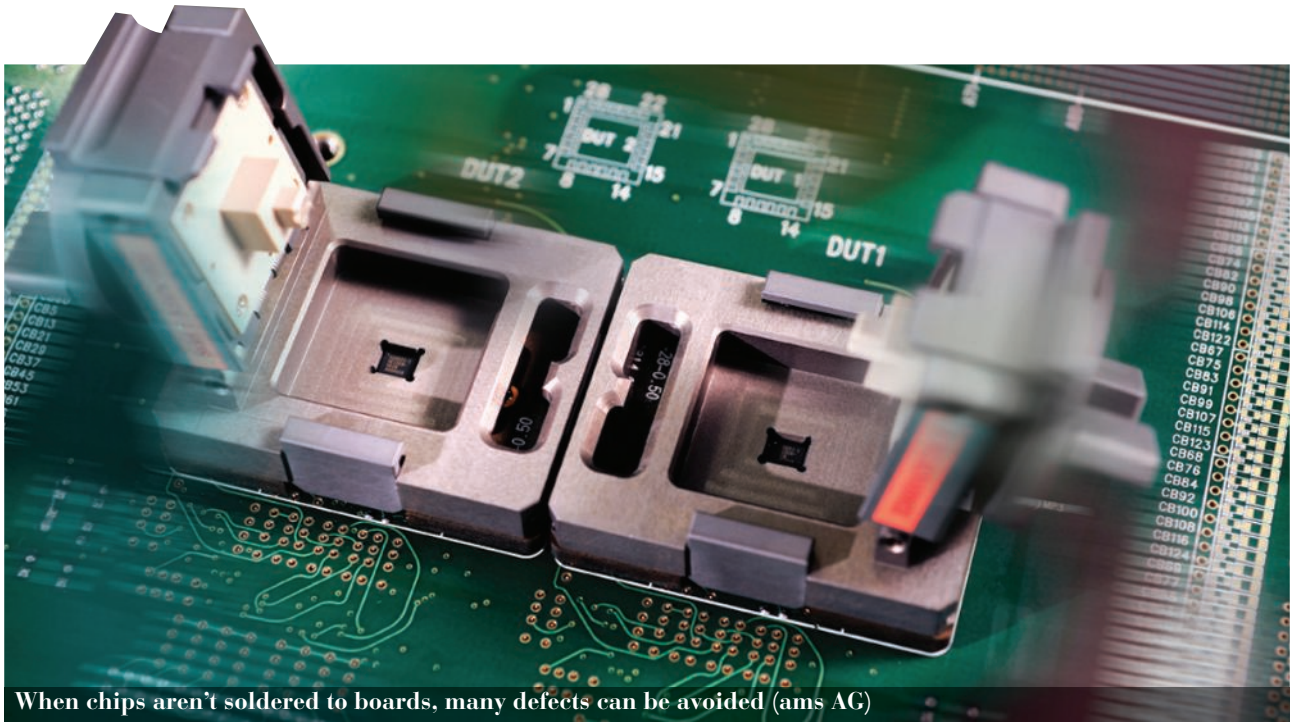
"This is occurring, thanks to the simultaneous advances in both silicon and packaging technologies. The introduction of power modules allows the ability to drive larger loads like electric power steering and air-conditioning that were impossible to drive years ago."

LIGHT TOUCH

Both engineers and body stylists are trying to replace light bulbs with LEDs. Their small size excites stylists, while low power and long lifetimes attract engineers. LEDs' compact size is a lure for both groups. However, the white LEDs needed for headlights are still quite expensive. LED developers are attempting to change that by moving to silicon. Today, the LEDs used to create white light are made with indium gallium nitride, which is expensive and poses thermal challenges. After much research, developers are now transitioning to the industry's mainstream material.

"We're changing to silicon, which lets us increase wafer size and improve heat removal," says Joe Jablonski, application engineering manager at Osram Opto Semiconductors. "The LEDs in headlights generate a lot of heat that needs to be removed, so this improvement will make a big difference." The continuing drive to save fuel and fit more electronics into smaller spaces shines the spotlight on heat and power consumption. In applications as diverse as powertrains and sensors placed near rearview mirrors, keeping chips cool is a key factor for lifetimes. Automotive engineers can't generally use the fans and heat sinks that are used in many other fields.

"There aren't a lot of heat sinks in cars, because there isn't a lot of airflow, so most cooling is down through the board," explains Glenn Daves, director, packaging solutions development at Freescale Semiconductor. "There's a lot of innovation by people trying to improve that thermal path." That's prompting



When chips aren't soldered to boards, many defects can be avoided (ams AG)

chip designers to work closely with suppliers of materials like grease that sit between the chip package and the circuit board. Grease is a miniscule element in the overall vehicle, but it's an important component for semiconductor researchers.

"Working with supplier Henkel Loctite, we developed a phase-change compound material that uses metal oxides, instead of ceramic filler, to achieve a 74% reduction in thermal resistance, compared to traditional thermal grease," said an Infineon technologist.

Both temperature requirements and reliability expectations are increasing as automakers strive to add electronic functions and decrease failures. That's forcing researchers to constantly revise material recipes to enhance component lifetimes. Even slight alterations in the packaging materials that protect chips can help ICs last longer in high temperature environments.

"There are coefficient of thermal expansion mismatches between the lead frame, the substrate, and the moulding compound," Daves says. "Slight changes in materials make a big difference for long-term reliability. For example, we had a moulding compound that worked great, but there was some delamination over time until we tweaked the material."

SOLID FOUNDATIONS

Circuit boards and packaging are important infrastructure items that play a huge role in performance and reliability, even though they're a largely ignored facet of the automotive industry. Automakers in a car are looking closely at ways to ensure that the many connections used on thousands of electronics components don't fail during long, harsh vehicle lifetimes. Boards and solder are rarely considered, except by engineers, who must make sure these foundational technologies support the system.

For some engineers, eliminating solder removes a potential failure point. They're moving to press fit attachment, in which the component's pins are manufactured so that they form a permanent, vibration-proof connection when they're pressed into precisely measured holes.

Back, then, to Fairchild Semiconductor's Joseph Notaro: "Solder interconnections are the most common interconnect technology for many power modules, so it's difficult to achieve low single-digit parts per million (ppm) reliability in automotive environments. In situations where selective soldering is needed, press fit is a valid alternative and it provides a more reliable, faster and less capital-intensive manufacturing."

Many components use grid array packaging or other surface-mount technologies. But most boards still have components such as sensors and connectors that utilise through-hole connections. When leaded components are used, many benefits can be gained by eschewing solder.

"Press-fit technology can reduce or eliminate the need to perform secondary solder operations on board assemblies," comments Guenter Aflenzer, advanced packaging manager for ams AG. "Not only does this reduce labour and work-in-process, it removes an extra heat cycle that can degrade existing components on the board and it reduces the amount of solder used in the assembly.

"The press-fit joint is not subject to quality problems associated with solder, such as cold spots, voids, cracks and solder bridging," he adds.

Kevin Jost, The Columnist
SAE International Editorial Director

New advances in driver assistance

The automotive industry for years has been developing advanced driver assistance systems (ADASs) to improve the comfort and safety of passengers. Mercedes-Benz achieved the top ranking in ABI Research's recent Competitive Assessment of the Market, with Volvo and BMW occupying second and third places.

The survey from ABI Research assessed OEMs, based on a number of implementation and innovation criteria. Volvo ranked first in the implementation category, due mainly to the relatively high fitment of ADASs as standard equipment and the high availability of other ADASs as options across its range. Mercedes and Audi were second and third in the implementation category.

Volvo's portfolio for automatic braking includes several world firsts: City Safety, which is standard and works at speeds up to 50 km/h; Collision Warning, with full auto brake; and Pedestrian and Cyclist Detection, with full auto brake. The leaders in the innovation category were Mercedes-Benz, BMW, and Audi – Mercedes scoring highest, with the widest range of ADAS systems.

The latest S-Class, with its Distronic Plus adaptive cruise control, gains Steering Assist and Stop&Go Pilot. The Brake Assist System Plus with Cross-Traffic Assist can detect crossing traffic and pedestrians, and boost braking power applied by the driver, if needed. If lane markings are broken, Active Lane Keeping Assist can detect when the adjacent lane is occupied and reduce the risk of the vehicle leaving its lane unintentionally by applying the brakes on one side. Adaptive Highbeam Assist Plus allows high-beam headlamps to be kept on permanently without dazzling traffic by masking out other vehicles in the beams' cone of light. Night View Assist Plus is supplemented by a thermal imaging camera to alert drivers to pedestrians or animals in unlit areas in front of the vehicle, and a spotlight function flashes any pedestrians detected. Attention Assist warns of inattentiveness and drowsiness. It notifies drivers of their current state and the driving time since the last break, and can indicate nearby rest stops through the Comand system.

While luxury brands see sophisticated ADAS features as tools that burnish their 'safety-conscious' brand images, the strategy of mass-market OEMs such as Ford and Volkswagen has been to offer ADAS solutions only if there is sufficient consumer demand for them and providing the technology is affordable," says Gareth Owen, principal analyst at ABI Research.

As a result, the penetration of ADAS systems in mass-market cars is very low; however, this is beginning to change. There was a steady increase last year in the number of mass-market OEMs offering ADASs, with key systems such as front collision avoidance beginning to be standard on select models and trim variants in advance of new and more stringent safety requirements.

ABI Research expects this trend to accelerate significantly during the next five years, states Owen. "The decision by car-safety ratings agencies to include ADAS in their ratings reflects a growing awareness of the potential of these active safety systems, and car OEMs will now be challenged to raise the availability of these systems in their new car models."

More cars having ADASs, along with connected car-to-car and car-to-infrastructure technologies, will make the entire global fleet safer. The total integration of all these systems will eventually lead to the ultimate solution: fully-autonomous-driving vehicles. Volvo aims to bring the number of people killed and seriously injured in new Volvo cars down to zero by 2020.

focus@sae.org

Today's vehicles offer a staggering assortment of sophisticated electronic controllers, sensors, switches and wires. A new system promises a simple way to pull all of this technology together, saving space and assembly line time

The RIGHT connections – at a SNAP

Driven relentlessly by consumer demand and government regulations, cars can now have anything up to 100 separate electronic controllers running the on-board engine sensors, safety devices, as well as infotainment and navigation systems. Moreover, as electrical systems in vehicles increase, larger and larger in-line connection systems are needed to pull together the bulky wire groupings. Conventional lever-assisted systems are difficult to handle and take up valuable space in the vehicle, requiring extra clearance and pre-alignment for secure installation on the assembly line.

To meet these demands, Delphi has developed the ErgoMate Mechanical Assist System. With its unique geared cam and slider assembly, the system offers the mechanical advantage of a lever system in a small, easy-to-install package. Connectors snap together with a single-handed plug action – a simple push with one hand, no pre-positioning or awkward grip changes are needed, so a first-time fit is guaranteed.

SPACE EFFICIENT

"In addition to saving time on the assembly line, the compact system saves space," says Jeff Campbell, Delphi application engineering manager. "The lower profile self-aligning design requires no extra clearance for pre-positioning or installation – a big advantage in today's space-efficient vehicle designs."

The growing number of electric vehicles (EVs), combined with cars of the future having more electric motors either to drive components such as steering and air-conditioning systems or assist in powering the car itself, gives further impetus in the development of electrical architecture. This led the Dräxlmaier Group to develop a new automotive electrical system for the StreetScooter electric car in 2011, a tailor-made combination of high-voltage and conventional wiring harnesses.

The company also broke new ground with the Body Controller Module (BCM), the first time it had implemented such a comprehensive electronic control unit for a vehicle.

KNOWLEDGE EXPANDED

"As a multidisciplinary project, StreetScooter gave us the opportunity to experience all facets of the future of the automotive industry in close cooperation with research and industry partners," Professor Jörg Elsenbach, responsible for corporate development at Dräxlmaier, is quoted as saying, adding: "This was a great opportunity for Dräxlmaier to realistically determine the interactions between different modules and components in an electric car and to expand our own knowledge." The Dräxlmaier Group worked with RWTH Aachen University

Cars can now have anything up to 100 electronic controllers running the on-board engine sensors and safety devices etc.

As a multidisciplinary project, StreetScooter gave us the opportunity to experience all facets of the future of the automotive industry."

— Professor Jörg Elsenbach, Dräxlmaier

to develop a new automotive electrical architecture tailored to the special vehicle concept, with both 120- and 12-volt wiring harnesses. The high-voltage system, which is more sophisticated and elaborate than its predecessors, is limited to the electric drive line and the heating/cooling functions in the vehicle. All of the other systems, such as lights, chassis and safety systems or the integrated entertainment system, are served by a conventional 12-volt supply.

The greatest challenge in this project was the very limited amount of space available in such a small car designed to be economical and highly efficient. The parallel power supply wiring harnesses had to be installed in extremely narrow spaces, along with air ducts and bus systems.

IN CONTROL

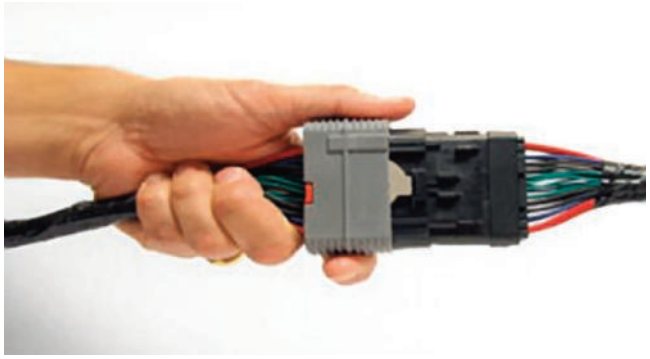
As a central control unit, the Body Controller Module (BCM), also developed by Dräxlmaier, manages all electronic and comfort functions, as well as transmission and control processes in the vehicle, including those of the electric drive line and the heating/cooling unit. Building on its electronics division's experience, the company supplied a control unit responsible for such a wide range of functions for the first time.

Another German supplier, Leoni, has developed a range of resistance or heating wires for windscreen wash systems and selective catalytic reduction (AdBlue). The resistance can be individually adjusted through the alloy employed and the wire's cross-section. Whether copper (Cu), copper-nickel (CuNi) or nickel-chrome (NiCr), Leoni uses all the familiar alloys supplemented with copper-based resistance alloys of Leoni's Histral family.

For very high resistances, the mechanical strength of metals in the strand design is no longer sufficient. Here, the carrier element cushions the forces during installation and use, and eases the strain on the fine resistance wires. In this way, tensile strengths upwards of 100 N can be achieved.

Through the comparatively small gradients of the wires, the heating wires are suitable for high alternating bending stress. The linear expansion of the wires at high temperatures can then be offset through the coil.

While Leoni has been developing and producing plastic compounds for more than four decades, since 2013 these materials have been traded under the Leomer brand. "We regard this as a key competitive advantage," says Frank Dürschmied, head of product management BU Automotive Special Cables, "because not many cable manufacturers have their own formulas and production facilities to precisely match the customer's requirements."



Delphi's ErgoMate ensures first time fit every time.

SPARKING *a world of* CHANGE

Ian Adcock talks to Calnetix Technologies' Keith Ropchock about its electrically-assisted turbocharger machines

Once seen as the provenance of sports and high-performance cars, turbochargers are now widely considered to be a key enabling technology for OEMs as they downsize engines to meet the oncoming tide of ever tighter exhaust and fuel efficiency regulations that governments have announced across the globe.

The challenge remains, to a greater or lesser extent, of overcoming lag at low engine speeds; even more so, if it's a small capacity engine. Three-cylinder power units like Ford's EcoBoost can partially overcome that lag, because the pulse separation from the three cylinders has allowed it to use more of the scavenging effects at low speeds, while overlapping the cams to achieve true scavenging into the turbo. Meanwhile, BMW has opted for twin-scroll turbos, as well as triple turbo technology for its six-cylinder M50 diesel.

But such complex systems are costly and not easy to package, especially in smaller cars. Keith Ropchock, director of business development, Calnetix Technologies, believes the compact permanent magnet electric motors developed and produced by his company offer a cost-effective solution to rapidly spooling up turbines to full operating speed, "in less than a second, to normally north of 100,000 rpm, but we've got requests from 100,000 to as high as 180,000 rpm.

"People are asking for the same speed that turbos run at and you've got to get up there as quickly as possible, otherwise what's the purpose?" he asks. "The whole point is to avoid that lag."

Calnetix, says Ropchock, uses motors that range from 500w to "a couple of Kilowatts power consumption", depending on the application and envisages using the vehicle's standard electrical system, although, as Ropchock also points out: "That does pose a challenge with 12 volt batteries; there is some advantage when you have a higher voltage to minimise the size of the electronics and generators. It can be done on 12 volts. It's just I am seeing that cars are moving towards bigger batteries, because of all the auxiliary systems, as well as hybrids having bigger batteries.

"The specifications we're getting now include multiple voltage options, 12-,48- and 240-volts, that they're asking us to investigate at this stage."

MEASURING THE GAINS

In these early days, Calnetix is not positive of the likely emissions and fuel consumption gains OEMs would see, it states, before Ropchock adds: "From some of our other experiences [large diesel marine applications], we're seeing improvements from low end of 3% to high 7% of performance improvement and fuel efficiency, with typically bigger gains for diesels. That's qualified on what we've been able to do on the bigger engines. On the auto side, we're not 100% certain, but we would hope to see similar results." He admits that a

major issue will be thermal management, with the need to install a heat shield between the electric machine and the turbo itself, although locating the former on the compressor side will help to mitigate some of the challenges.

"Our systems are capable of operating at 150°C, with one of our magnet retention technologies reaching as high as 180°C," he says. "We're also continuing to develop that advanced motor technology to operate at even higher temperatures and have some targets we want to get to. We can't release those details yet, but we are pushing the thermal limits on that side to be able to fit these applications much better.

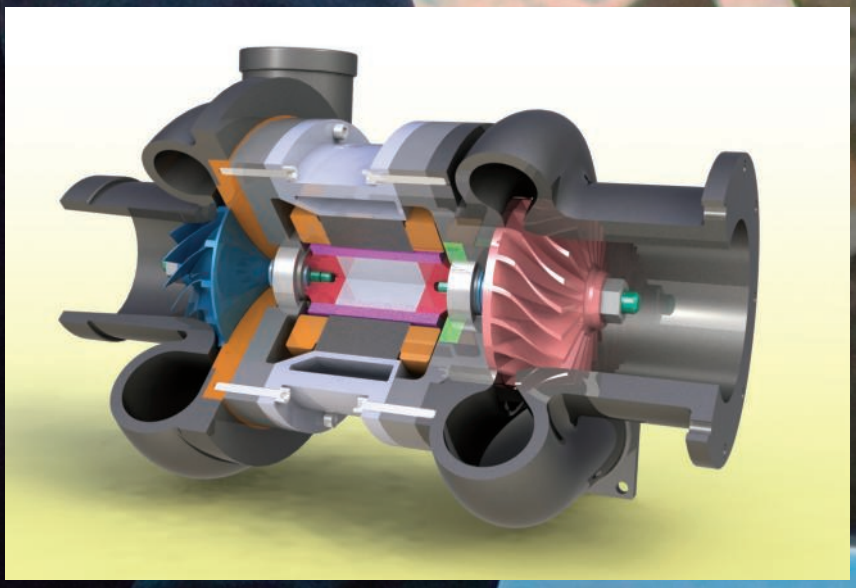
"Basically, we need to prevent thermal soak back emanating from the shaft, so we employ some interesting ways to couple them. Typically, forcing air over the components helps to cool them and dissipate heat, which is what we do in racing applications as there's plenty of forced air available.

TIGHT INTEGRATION

"Production car applications might be a bit more of a challenge, as we may have to give up a little bit of the efficiency of the actual permanent magnet motor to manage the thermal issues and use auxiliary cooling.

"The power electronics will also need to be efficiently packaged for vibration and extra cooling, otherwise they could overheat, so this needs to be a very integrated design for the OEM or their supplier."

Due to the comparatively high cost of the motor's current, applications are restricted to low volume and high-end performance cars or racing applications. "We'll probably see low volume production runs in 2016-17," Ropchock states, "but for what I'd call true production, we're looking at a 2018-2020 timeframe."



Calnetix e-booster can spool a turbo up to 100,000rpm in under a second

Daniel Deiro, director customer management, Honeywell Turbo Technologies

Turbo-charged thinking

"It's clear that turbocharger penetration will be increasing significantly in the coming years, with huge penetration already in the diesel segment, but the growth is more now on the gasoline side for the global market. There is still some penetration to be gained on the diesel side as well.

"Turbo penetration in Europe is nearly 70%, with diesel accounting for half of all that. The average globally is 30%, but we're seeing high growth in the USA, China and India, with all the other regions expected to follow, taking the total to 37% by 2018.

"Principally, that growth will be gasoline engines, as diesel penetration will stagnate at around 20% globally for the next five years, but with continued strong presence in Europe and India.

"The small car A-B sector will decrease, but this will be compensated for with increased use of turbocharging in SUVs and large cars, as well as greater demand from the USA and other regions compensating for any lower sales in other sectors.

"Some customers are now moving to multi-stage turbocharging, whilst others are coming back to single-stage turbos. But I would say that in the future we will see more multi-stage systems, starting with premium two-litre engines.

"I would say that in the future we will see more multi-stage systems, starting with premium two-litre engines."

"Small capacity engines like the new Fiat I.6 Multi Jet 11 diesel and I.4 T-Jet petrol engines are a particular challenge with turbo lag, so we're always working on reducing the inertia and friction in the bearings. New materials will help bring down costs as well, which is always a challenge as manufacturers want improved performance, but at no extra investment.

"E-boosting is something that Honeywell has been working on for a number of years and is part of our future portfolio. We will see the first applications of that technology maybe in 2016-17 and, although some OEMs might want to adapt it using 12-, or 24-volts, it will be limited until there's widespread adoption of 48-volt architecture. German OEMs are testing the first systems already, but I doubt if it will be widely adopted much before 2020.

"In 2014, Honeywell will bring to market new technologies improving turbocharging performance, with innovations such as: new ball bearing designs for improved response and efficiency; improved flow control valves for gasoline engines and variable geometry applications for diesel engines to expand performance capability; new sensors for improved engine integration; improved casting processes and materials development for greater temperature range performance at predictable costs; and new aerodynamic designs to improve speed margins of compressor and turbine wheels inside the turbo."

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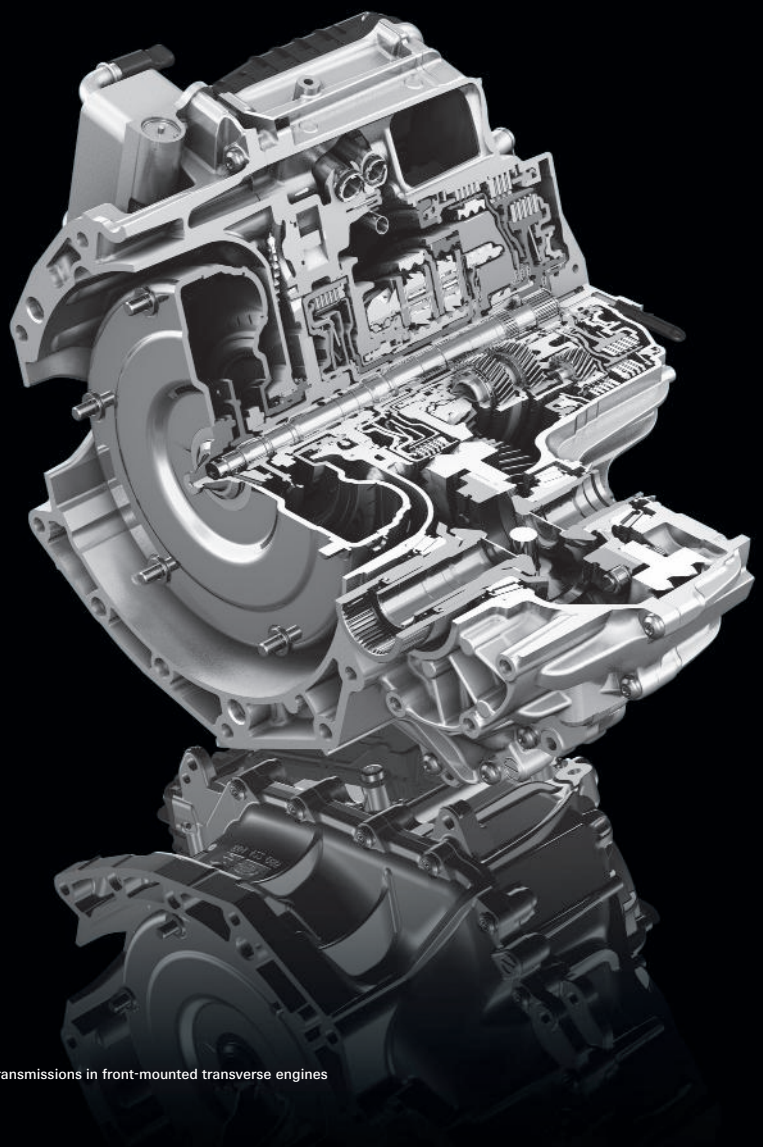

* Compared with today's standard 6-speed automatic transmissions in front-mounted transverse engines