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Launch issue

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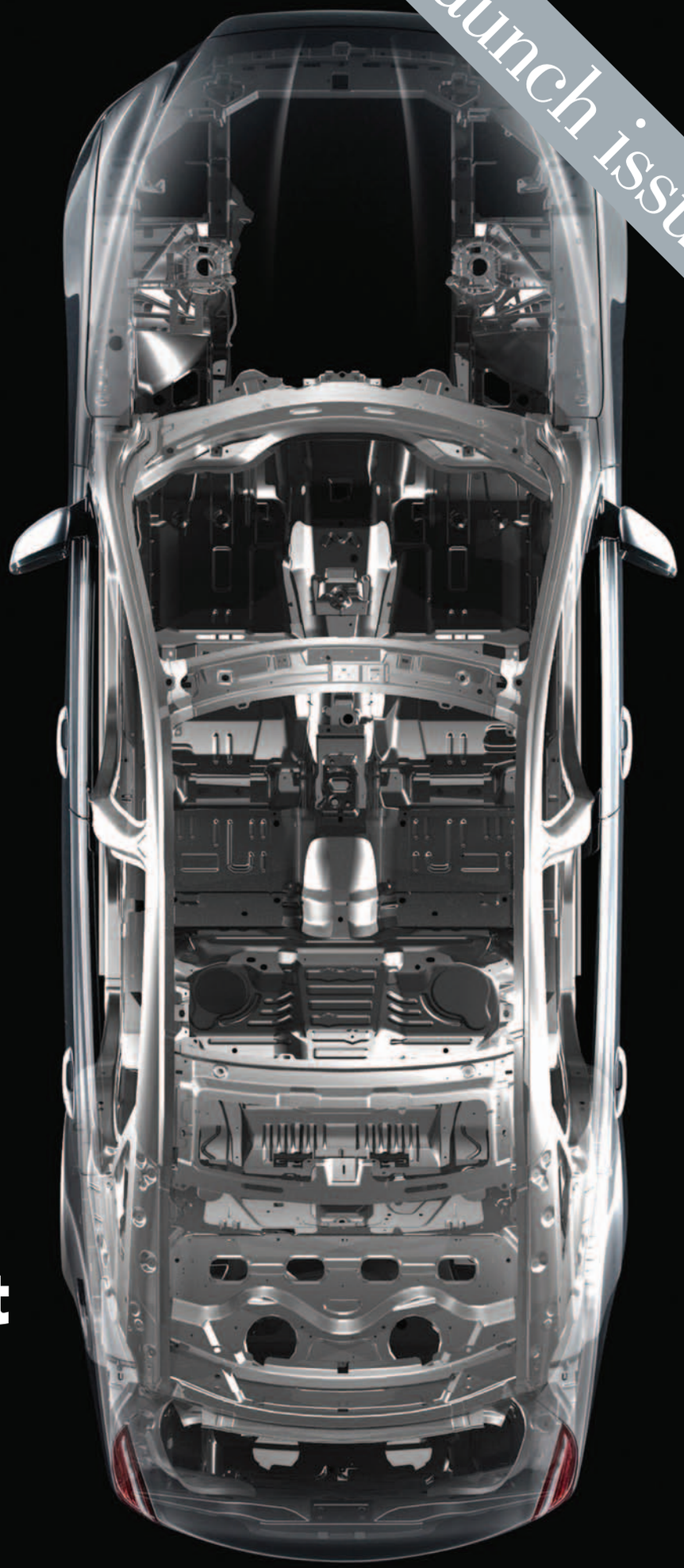
- Lightweight strategies under the microscope
- Ford's EcoBoost delivers 20% fuel savings
- NVH Testing: sound engineering gets serious
- Innovation and collaboration at SAE World Congress



Lightweight champion.

The all-new XJ fully exposed

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Design collaboration will drive recovery

Automotive OEMs stand accused of squandering the earth's resources and polluting the planet. This is an industry in need of new ideas, methods and business models, along with eco-friendly materials and designs.

Only by working with strategic partners and sharing innovative engineering concepts will those OEMs find the right solutions. That's why 'e-collaboration' is the theme of the SAE 2010 World Congress (see page 24), which looks set to attract leading auto design engineers from around the world. The industry knows that design engineering solutions are at the heart of the sector's recovery. Hence the thirst for new technologies, techniques and ways of working. To satisfy that demand, SAE International is collaborating with Findlay Media to deliver this new magazine, Automotive Design, to 20,000 engineers in the European hotbed of automotive development.

Published six times a year, each issue will focus on a particular engineering theme, with features from acknowledged experts, plus interviews with industry leaders, as well as news and product briefs from our editors in Europe and the USA. Between publications, our website will be updated daily with industry news; while videos, white papers and an international supplier directory will provide further essential information.

The site's searchable technology library – comprising material from Findlay Media's European Automotive Design magazine archive and selected features from SAE International's Automotive Engineering International – provides an unmatched reference resource for European design engineers.

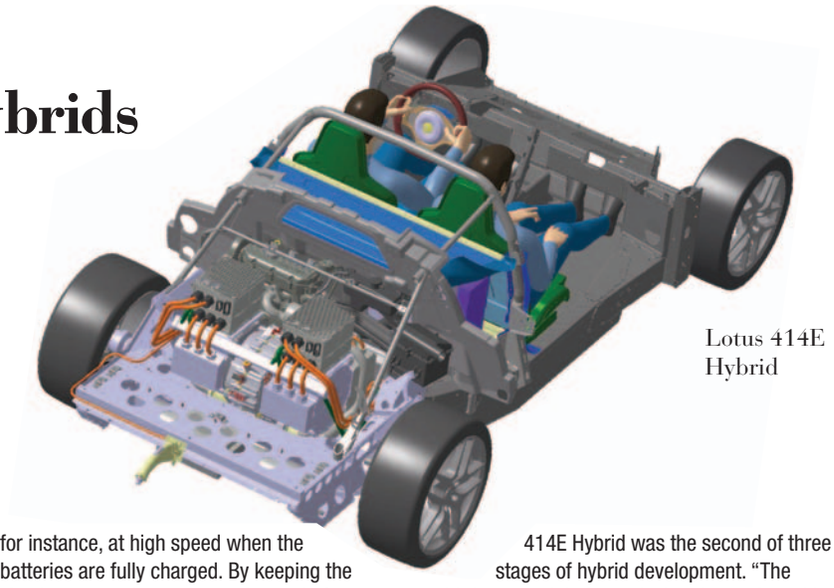
Meanwhile, in this first issue, we focus on lightweight technologies – among the keys to meeting future emissions legislation – with an exclusive insight into the all-new Jaguar XJ's aluminium-intensive structure and in-depth interviews with the people behind the concept. Plus, we talk to Phil Hodgkinson, Jaguar Land Rover's director of product development, who describes his ambitious plans for these iconic British brands.

To guarantee your personal copy of Automotive Design, and to receive regular electronic newsletters, register now on www.automotivedesign.eu.com.

We hope you enjoy the results of our own collaboration – and that Automotive Design serves to help you in all of yours.

Ian Adcock, Editor in Chief

Performance hybrids show the way



Lotus 414E Hybrid

Lotus, Ferrari and Porsche each launched innovative hybrid technology solutions at the Geneva Salon, aimed at making high performance cars more acceptable by reducing emissions and improving fuel consumption, without detracting from their performance.

While the Lotus and Ferrari systems are based on road-going cars, Porsche is developing its hybrid technology on the race track in a 911GT3.

Ferrari 599 HY-KERS

Don't be misled into thinking Ferrari has adapted its F1 Kinetic Energy Recovery System for road use, explained technical director Franco Cimatti, "In this case, KERS refers to the energy captured under braking and used to recharge the 80kWh lithium batteries."

Ferrari 599 HY-KERS

Cimatti believes Ferrari can achieve the best of both worlds, a gain in performance and reduction in CO_2 emissions, by combining electric power with its conventional high performance engines. However, to achieve future emission legislation, it will continue development of more efficient engines, while maximising the potential of low rolling resistance tyres, without compromising dynamics by further improvements in active ride strategies.

The Geneva concept had a number of notable features, not least of which were the ultra-thin, just 20mm, 3kWh lithium-ion packs located beneath the car's chassis, which helps to lower the centre of gravity by 10mm. They are also ideally located to be cooled by the underfloor air flow.

An 82kW electric motor is mounted on the back of the rear transaxle, which shifts 2% of the weight rearwards. For the first time on a 599, dual clutch transmission is used, with the electric motor coupled to the odd gear primary shaft via a dog clutch, so it can be de-coupled, for instance, at high speed when the batteries are fully charged. By keeping the clutches open, the engine and propshaft are disconnected, allowing for up to 10km electric-only, low-speed, stop-start commuting.

A motor generator powered from the batteries replaces the alternator to power the air-conditioning and power steering pumps.

Cimatti predicted another three years development, mainly on battery-engine management. Although displayed in a front-engined car, the architecture can be deployed in mid-engined Ferraris as well.

Lotus 414E Hybrid

The Hethel, UK-based manufacturer and engineering consultancy has installed its 1.2-litre, three-cylinder 35kW range extender into an Evora, with a pair of electric motors each delivering 152kW and 400Nm to the rear wheels.

A lithium polymer battery pack, with 17kWh storage capacity, occupies the space where the rear seat was, which slightly alters the weight distribution towards the rear. Nevertheless, Lotus has managed to keep the overall weight increase to just 100kg, over the Evora's 1350kg.

Computer predictions suggest just 55 g/km, even with a zero 96km/h time of under four seconds. Lotus Engineering's Mark James expects a running prototype to be completed by the autumn and explained that the technology is principally the same as used in Jaguar's 'Limo Green' project and the Italdesign Giugiaro Proton EMAS concept city car.

James also revealed that Lotus had looked at a full electric Evora, but also that the 414E Hybrid was the second of three stages of hybrid development. "The third stage might be replacing the engine with a small gas turbine as a generator."

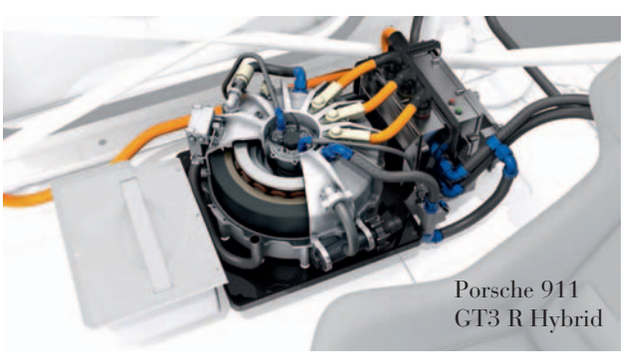
Porsche 911 GT3 R Hybrid

Although the car uses a Williams-developed, F1-type KERS flywheel, it now has a lifetime of one million storage cycles, significantly more than any battery, according to Hartmut Kristen, Porsche's head of motorsport. This has been achieved by use of ceramic bearings, while locating it flat on the floor ensures the system only has to cope with rotational masses. "We are still learning and there are a lot of things on the list for stage two." Rotating at 40,000rpm, the KERS can deliver up to 120kW to the front-mounted electric motors.

As with Ferrari, Porsche sees its biggest challenge as balancing the braking between the mechanical and electrical brakes. "This is really the challenge; we still aren't there yet."

Kristen believes there could be 10-20% downsizing potential for KERS through tighter winding. "I don't know if KERS will make it in significant numbers in production cars. We all need to understand, whatever electric storage system we're developing, that there will be a limited range, especially if it's pure electric.

"We have to learn how to combine reduced energy consumption with driving pleasure, that's the challenge."



Porsche 911 GT3 R Hybrid

VW prepares massive architecture shift

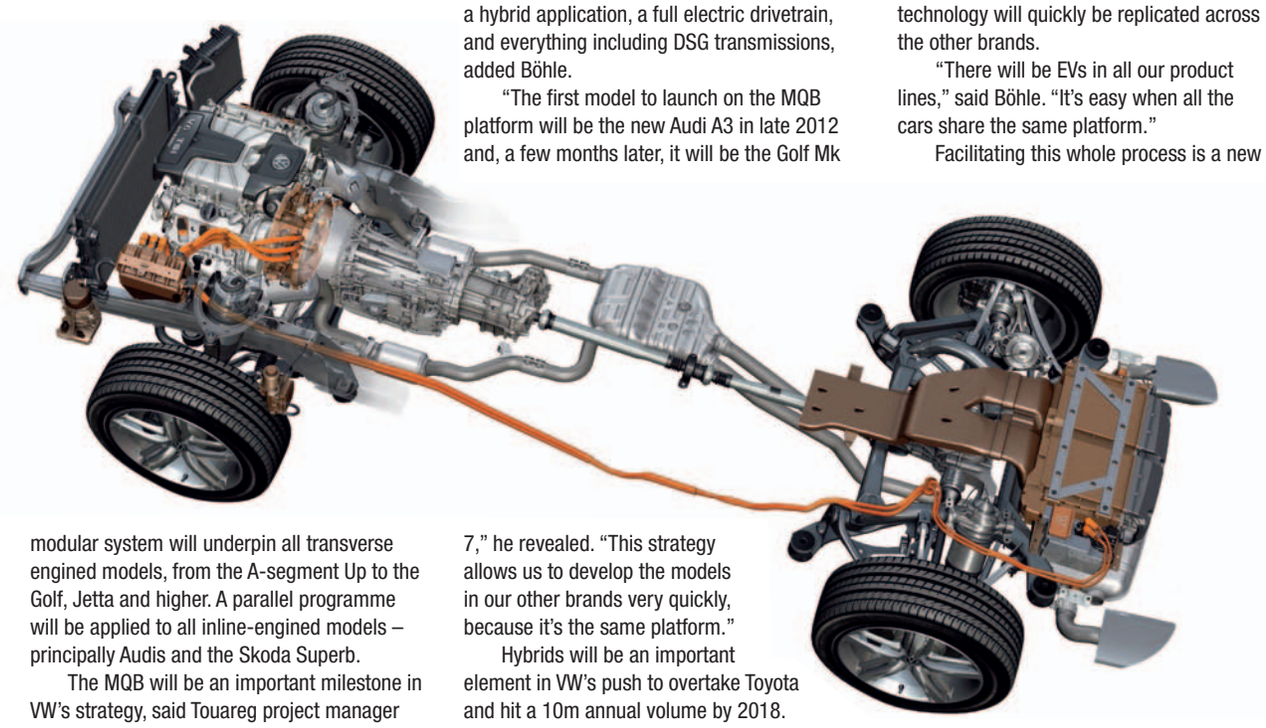
As Volkswagen launches its first hybrid model, the Touareg SUV, details are emerging of the group's ambitious new architecture strategy. Set to begin its rollout in 2012, the MQB modular system will underpin all transverse engined models, from the A-segment Up to the Golf, Jetta and higher. A parallel programme will be applied to all inline-engined models – principally Audis and the Skoda Superb.

The MQB will be an important milestone in VW's strategy, said Touareg project manager Dr Jochen Böhle, as it will allow all technical developments to be quickly applied throughout the group's models and brands.

"All cars in the whole company will get a new platform with the MQB," Böhle told Automotive Design. "The rollout of MQB will take more than a year: it's for all the brands: Skoda, SEAT, Volkswagen, Audi – everything."

Within the MQB programme, there will be a hybrid application, a full electric drivetrain, and everything including DSG transmissions, added Böhle.

"The first model to launch on the MQB platform will be the new Audi A3 in late 2012 and, a few months later, it will be the Golf Mk 7," he revealed. "This strategy allows us to develop the models in our other brands very quickly, because it's the same platform."



Hybrids will be an important element in VW's push to overtake Toyota and hit a 10m annual volume by 2018. The group will concentrate on parallel full hybrids, with the 2011 Audi Q5 hybrid being the ambassador. Jetta and Passat hybrids will follow, but the system will not be applied to the small Up.

With the professed goal of taking electric cars out of their niche and into the volume mainstream to form 3% of VW's output, a battery Golf will appear in 2013 and its technology will quickly be replicated across the other brands.

"There will be EVs in all our product lines," said Böhle. "It's easy when all the cars share the same platform."

Facilitating this whole process is a new electronic hybrid manager system in the engine control unit. This is already in the Touareg, and will be applied to all types of hybrids and electrics across all the brands.

Touareg solves the auto stop-start dilemma

Stop-start systems can cut emissions of CO_2 by 5% or more, but rarely appear on luxury cars, as it is hard to combine stop-start with a conventional planetary automatic transmission. ATs use hydraulic pressure to select their gears and, without the engine driving the hydraulic pump, there is no pressure to engage gear.

ZF has shown a solution on its new eight-speed automatic, using a pressure accumulator to store the required engagement energy during stops, as seen on the BMW ActiveHybrid 7.

Now Volkswagen, too, has a solution, using an electric pump to maintain hydraulic pressure and engage gears. Shared with the new Porsche Cayenne and currently fitted to the brands' six-cylinder versions, the new eight-speed Touareg SUV transmission has been co-developed with Aisin. On the hybrid models, the electric traction motor is responsible for restarting the combustion engine.

News in brief

Range extender moves

Audi's new A1 battery electric e-tron incorporates a 253cc rotary engine at the rear, in order to top up the batteries and extend the range.

However, the 5,000rpm Wankel engine, for all its smoothness and ease of packaging, is unlikely to be the VW Group's final choice as a range-extender motor.

"This is a research project, not part of our main strategy," said Dr Jochen Böhle, project manager for the Touareg. "We will be looking at piston engines."

Stepping Up to the mark

Volkswagen's A-segment contender, the Up, will debut next year in gasoline and diesel forms, and will be offered with a new version of VW's DSG dual-clutch transmission, but not as a hybrid.

The E-Up will appear in 2013, with ambitious targets: a range of 80 to 100kms and a full recharge time of one hour. "The board are vey engaged on this," commented Böhle.

Eco-labelling impact

Ralf Najork, head of R&D at Getrag, reckons the eco-labelling scheme is likely to have a profound effect on transmission design. "Automakers will make every effort to tweak their vehicle specifications to nudge particular models down a gram or two, if they are close to the cut-off point between one colour and the next," he told Automotive Design. "That way, the perceived advantage to the consumer will be great, even if the actual improvement is less impressive."

Innovative solutions

BASF and Hyundai have combined to deliver a number of innovative material solutions in the Korean OEM's i-flow concept, including Ultramid Balance for lightweight seats, as well as moisture-absorbing Luquafleece. Meanwhile, the catalyst combined four technologies into two to save weight and space ,with the car finished off in Liquid Metal basecoat finished with iGloss to make it both scratch and weather resistant.

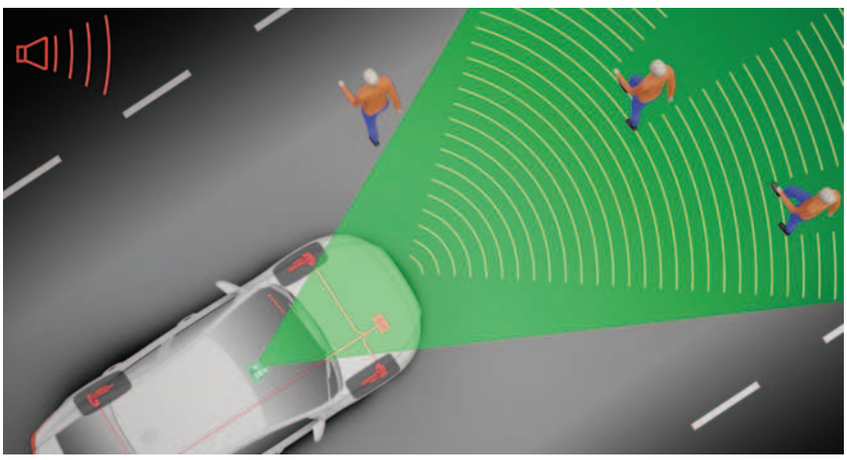
Safety revolution, not evolution

Volvo has further enhanced its automated braking, so it can now detect, warn and autobrake to avoid rear end collisions at speeds of up to 35km/h, as well as addressing more scenarios, such as improved pedestrian detection.

According to safety engineer Thomas Broberg, a new dual mode radar with 76GHz long range for vehicle detection and a second radar scanning up to 60° to track pedestrians, combined with an improved CMOS camera, allows the software to detect and track several pedestrians simultaneously.

Delphi is the main hardware supplier, but, says Broberg, it is the data fusion developed in-house by Volvo that is the big breakthrough.

"The S60 is a revolution in car safety, not an evolution," said Broberg, adding: "We've improved side impact protection as well from more oblique angles, and added a new sensor for roll-over protection to deploy the seat belt tensioners and the inflatable curtain, which covers a larger area than the in previous model."



Renault bids for CO_2 leadership

Renault is counting on two new modular and downsized engine families to reduce its corporate CO_2 emissions average and make it the European economy leader by 2015.

A new 1.6l diesel, co-developed with Nissan, will appear next year. Initially offered in 97kW form, it will power the crucial Mégane and Scenic ranges; later, it will spread to other model lines.

A major step-change in CO_2 emissions will come with the new-generation modular gasoline engines from early 2012. "We will replace all our naturally aspirated gasoline engines for Europe with these turbocharged units," said Philippe Oursaire, director of powertrain strategy and product planning. "This is the main plank in our CO_2 strategy – it will give us 40g better CO_2."

The common base engine was developed by Nissan and can be seen in three-cylinder form in the new Nissan Micra. Renault is developing two principal versions – a 0.9 litre three-cylinder and a 1.2l four-cylinder. Both will be direct injection, turbocharged and will incorporate stop-start, and the latest in internal thermal and electrical management and, perhaps, even electric oil and water pumps, said Oursaire. He did not disclose power or torque outputs. Later this year, Nissan will add a supercharged version of its 1.2l three-cylinder in the Micra.

On the transmissions front, Renault is proud of its six-speed Efficient Double Clutch system, co-developed with Getrag. Oursaire says the company is working on uprating the current maximum torque capacity of 250Nm to "around 300" to allow the system to be used on more models than just the core 1.5l dCi diesel on the Mégane. Even so, this is the first automatic to qualify for Renault's low-emission eco2 status for sub-140g/km models: on the Mégane hatchback, CO_2 emissions are just 114g/km.

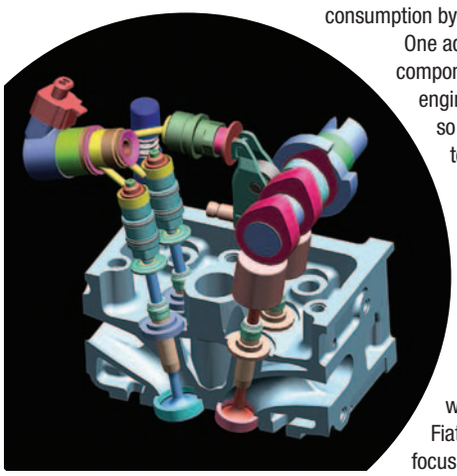
Stop-start capability will be added to the EDC transmission "soon", said Oursaire, and Nissan and Jatco were looking at stop-start solutions for the CVT and conventional stepped six speed automatics on Renault's larger cars, too.

MultiAir set to grow

Fiat's revolutionary and patented MultiAir system will become standard across the groups engines within the next five to six years, according to Massimo Fulfaro, programme manager for MultiAir.

The latest 900 cc version was revealed at the Geneva Salon. The turbocharged twin develops 48kW normally aspirated and 78kW in turbocharged form, while significantly reducing emissions – just 95g/kms in the smaller engine. Its compact design – 23% shorter and 10% lighter than a comparable four-cylinder – means it can be used as a range extender, said platform manager Giovanni Mastrangelo. There will be a CNG version, as well as "other" turbocharged variants, he added.

It will be seen later this year on new 2.0- and 2.4-litre Chrysler engines. The next step, stated Fulfaro, is to combine MultiAir with GDI. "We're currently at the development stage, bench-testing engines, so it will be a minimum of two to four years before it reaches production," he told Automotive Design, adding that it will improve GDI fuel consumption by a further 5%.



One advantage MultiAir has is that all the components are standard, irrespective of engine capacity or format, inline or Vee, so that only the aluminium housing has to be unique to the cylinder block. "The mechanics are simple; even the solenoid valve comes from an ABS system. But the real work is in the air management strategy and software controls," explained Fulfaro who revealed that the concept was conceived by Ferrari 15 years ago. However, development was stopped for three years during Fiat's relationship with GM, in favour of focusing on Opel power trains.

Second-generation DCTs provide efficiency boost

Big-selling B- and C-segment models are being targeted in a new wave of dual clutch transmissions (DCT) that promise to cut CO_2 emissions by up to 20%, writes Tony Lewin.

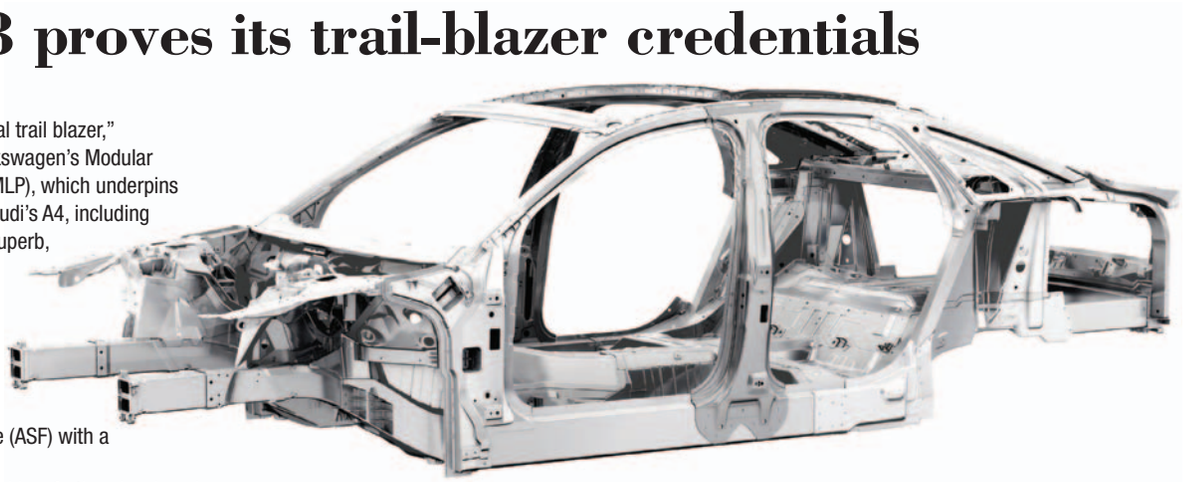
New DCT designs from Getrag and Fiat Powertrain Technologies (FPT) use dry clutches to minimise energy losses, while the switch to electro-hydraulic or electromechanical gear and clutch activation eliminates the energy drain of hydraulic pumps, as well as enabling the integration of stop-start systems.

Both Fiat and Getrag are tooling up for large volumes of their new transmission families – up to a million units, in the case of Getrag, which has secured Renault as launch customer for the initial 280Nm 6DCT50.

With automakers facing the threat of heavy fines, if they exceed future fleet average CO_2 emission targets, efficiency is the priority in the design of these latest units.

"We are fighting for every gramme of CO_2," said Getrag's R&D chief Ralf Najork at a recent conference. The 6DCT250 uses just 15 watts of electrical power to operate its gear and clutch systems.

New A8 proves its trail-blazer credentials



Billed as a "technological trail blazer," Audi's new A8 uses Volkswagen's Modular Longitudinal Platform (MLP), which underpins everything larger than Audi's A4, including the VW Passat, Skoda Superb, Seat Exeo, and the VW Phaeton and Bentley Continental replacements.

Audi retains exclusive use of its Aluminium Space Frame (ASF) with a mixture of 13 different alloys, and has further developed the concept of extruded beams and cast intersections with steel 'B' pillars to pass the latest US side-impact pole tests; their martensitic structure results in a tensile strength of 1,500 N/mm^2 in the pillars' upper sections.

The ASF has also been upgraded, with 25% improved static stiffness over the previous model and a 6.5kg weight saving, which brings its weight down to just 200kg or 50% less than an equivalent steel frame.

Safety breakthrough from predictive lighting

In a safety breakthrough, Hella has partnered with Intermap Technologies to develop a predictive lighting system that judges corners and adjusts the beam pattern of the 5500 Kelvin Light Emitting Diode headlamps into the bend, just as it arrives and before the driver has moved the steering wheel.

This digital pace noting also allows the gearbox to prepare to change down for bends, switching out of cruise control if the bend is deemed too sharp. According to the Insurance Institute for Highway Safety (IIHS), adaptive headlight systems are meant to improve visibility on curved roads.

Accidents related to this type of driving account for 4% of front-to-rear, single-driver and sideswipe same direction crashes in the US – or around 143,000 per year. Adaptive headlight systems could help to reduce the number of related fatal crashes from the near 2,500 that occur in the US each year.

BYD-Daimler join forces

BYD and Daimler are joining forces to build EVs in China for the local market

BYD will provide the lithium ion ferrous battery technology, specify the vehicle's market requirements and the productionisation. The two companies will also build a technology centre in China.

Daimler will develop a C-segment platform for the joint venture. Dr Herbert Kohler, Daimler's vice president E-Drive and Future Mobility, said that work is now underway to establish whether the platform would be all-new or a derivation of existing Mercedes vehicle architecture.

However, he added that, if such a platform were to be designed for the Daimler-BYD car, it would be unlikely that it would then be re-used in the Mercedes product range, because low cost is a prime requirement.

Kohler explained that, although BYD's FE battery technology is suitable for the local market,"it is not the highest level of capacity or life, compared with our Li-Tec type, although it is robust."

GKN pushes hybrid driveline

GKN Driveline hopes the European debut of its electric drive axle on the Peugeot 3008 HYbrid4 and Citroën DS5 HYbrid4 will result in more interest from OEMs who want to offer all-wheel drive, without the penalties of weight, cost, and increased fuel consumption and emissions.

"There are 10 million all-wheel drive vehicles worldwide," said Jean-Jacques Carré, director advanced engineering, GKN Driveline, "and more people are getting interested in this technology as an alternative to mechanical four-wheel drive systems." Development of electrically-assisted rear axles started with GKN's acquisition of Tochigi Fuji Sangyo (TFS). GKN Driveline's Rear Drive Module is a compact, lightweight gearbox, with an active controlled clutch for electric motor-assisted AWD solutions. The simple interface allows the OEM to combine the gearbox with various E-motor technologies, including battery systems. In the case of PSA Peugeot-Citroën, a 27kW electric motor is integrated into the rear axle, delivering 200Nm of torque, although it has a maximum of 1500Nm.

This allows the car to be powered by either the HDi diesel engine and, over short urban distances, by the emission-free electric motor, or a combination of both. Peugeot claims up to 35% saving in fuel consumption and CO_2 in the combined cycle, compared to engines of an equivalent power output.

Carré added that GKN is now investigating the feasibility of a 150kWh system. "We want to integrate the electronics as near to the electric motor as possible to avoid running heavy cabling through the car, and to minimise the weight increase and packaging changes."

Taking the rough with the smooth

Overseas manufacturers, especially those based in Germany and the Far East, aren't paying sufficient attention to British road

conditions and so are compromising the ride characteristics of their cars. That is the verdict of Prodrive's Matt Taylor.

He says British roads are much more challenging, due to rain removing substrate. "This collapses the road in quite a smooth way, up until the point where it breaks the tarmac in a low wavelength, high frequency, way. In Europe, the subsidence tends to be larger, with long undulations and frost damage that tends to be hard edged, with low amplitude.

"When the middle of the road is smooth and the edges have collapsed, the roll stiffness on the car has an enormous influence on how it affects the ride."

This, he says, manifests itself in rocking the occupants head longitudinally or laterally, which "feels terrible because of the high amplitude". German OEMs, he says have "perfected the art" of dealing with their roads, while they have "phenomenal" high speed lane change ability demanded by autobahn driving. "But they still need to do more work over here."

The challenge with Far Eastern OEMs differs, because they find it difficult to accept subjective, iterative methodology. "They don't like the idea of driving with a damper technician who says, 'I don't like that, it's a bit floaty at the back; we need to dial out a bit of rebound'," adds Taylor.

"They want to know how we do it with a computer by instrumenting the car and rig testing the dampers, so they can see the acceleration traces."

Nissan integrates HMI

Nissan has installed a novel mini colour-screen HMI that covers both the climate control and 'sport-normal-eco' drive modes, writes Paul Horrell. Six hard buttons play different roles, depending on whether the system is set to 'climate' or 'D-mode'. To clarify the HMI, the button graphics change accordingly.

In climate mode, their script is lit red, controlling the HVAC system. However, on activating a button labelled D-mode, the script changes and illumination turns white.

The former HVAC buttons become sport, normal and eco activation buttons. These vary the calibration of throttle map, transmission strategy, steering assist level and an air-conditioning economy strategy.

Other repurposed buttons call up information readouts from the screen, which include extremely detailed real-time and historical fuel consumption and average speed data, or engine torque output, or even a longitudinal and lateral g graphic.

The right-hand of the main control knobs, which is a fan knob in climate mode, becomes a push/turn set-up controller when in D-mode. This new HMI is standard across the range.

Jaguar's green technology

The name Jaguar is synonymous with luxury and refinement – and now increasingly with high tech materials and green endeavour. Ian Adcock talks to the all new XJ's engineering design team about what's new and why it matters

Mention the word 'green' in association with Jaguar and you're more likely to think of its five Le Mans victories in the 1950s than the marque's environmental credentials. However, half a century on from those wins in one of the world's most famous motor races, Jaguar is scoring notable victories over rivals when it comes to 'greening' its products.

The all-new, aluminium-intensive XJ saloon is, claims chief technical specialist Mark White, the first mass-produced car in the world not to feature any welding in its structure. "There are other specialist manufacturers that do that, but not in the quantities we're talking about with the XJ," he insists. Furthermore, the car is one of the first European vehicles, and certainly the first made in Britain, to meet the ISO 14040 and 14044 lifecycle assessment standards, as part of the VCA certification process.

"We will use the [all-new] XJ as a benchmark for all future Jaguar Land Rover products," says White. "We are interested in the total carbon footprint effect for the whole car, from dust to dust. We have done it on the XJ and will apply it to all future products… If we want a future with cars, we have to be more sustainable."

There's been a feeling within Jaguar's engineering community that the aluminium bonded and riveted monocoque structure, pioneered in the 2003 XJ, was overshadowed by the car's conservative styling. However, there wasn't anything intrinsically wrong with the structure, which is why chief programme manager Andrew Dobson chose to retain 30—40% of the underbody components, only updating areas for improved noise, vibration and harshness performance.

"It's a continuation of the lightweight architecture, which some of us felt wasn't as well recognised on the old car as it should have been," explains Dobson. But he adds: "Right from the start, the new XJ had to be a strikingly different car, so that presented us with unique challenges." And the biggest challenge of all, says Dobson, was finding engineering solutions to deliver Ian Callum's distinctive design. For example, how to deliver the engineering requirements in the space available. "That's where some of the clever new integrated bodyshell pressings come in," he explains.

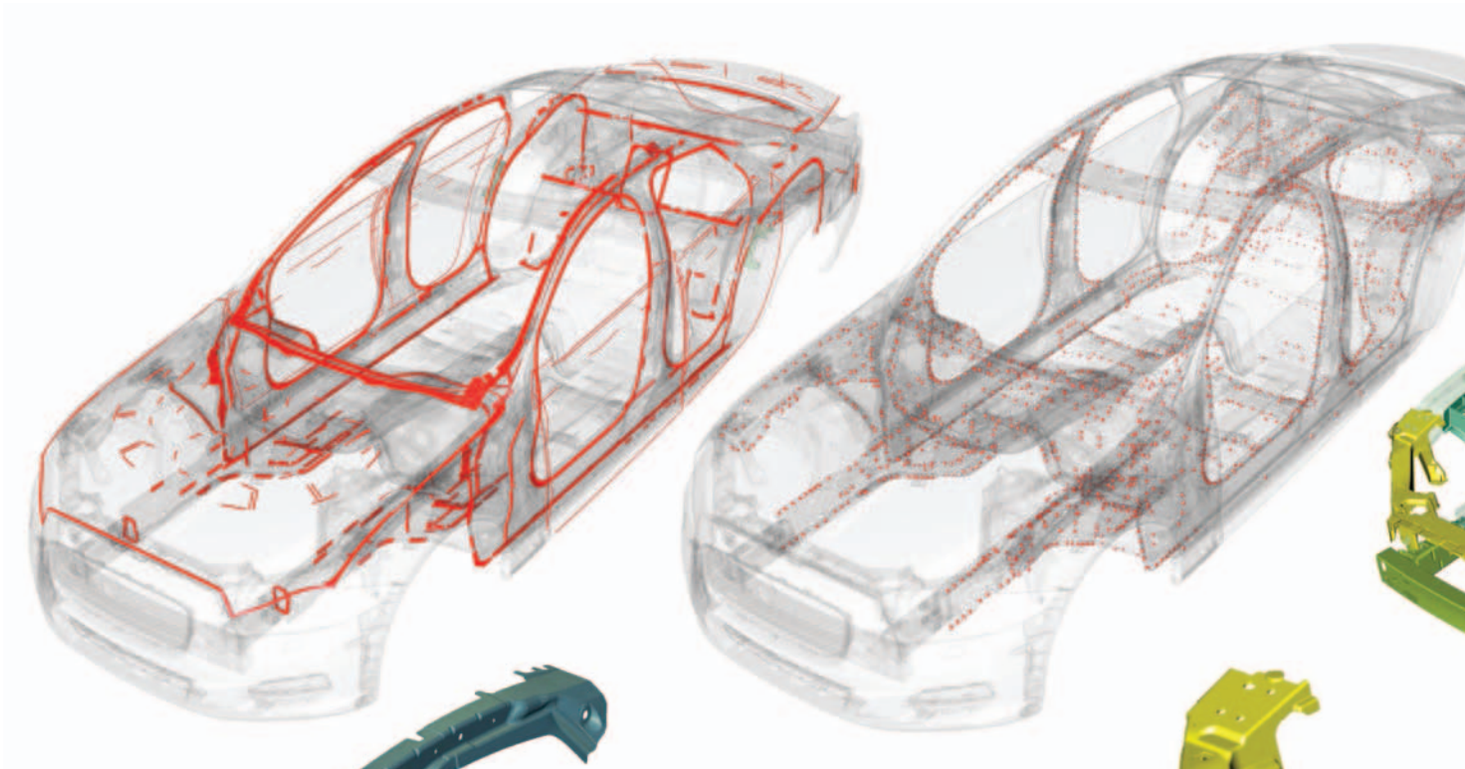
Unique design

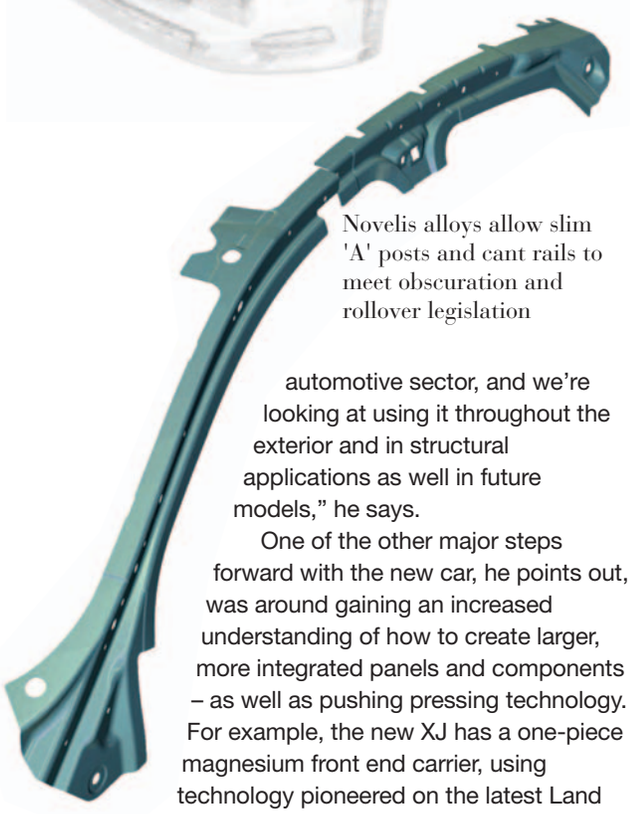
Dobson cites the rear lamp area: "It's a unique piece of design; to make a lamp of that size is challenging in itself. If you look at the detail of that rear fender pressing and how it runs into the lamp, it was very challenging. There's not a lot of area to work with or clamp when pressing it, [so] we carried out a lot of iterations to achieve the right radius and then get it to flow on to the top fender."

Then there was the one-piece deck lid pressing. "I was adamant about that. Not just for cost reasons but, mainly, for quality – without lots of joints running through," recalls Dobson. "We did a lot of pre-work to achieve that. Some of the difficult pressing areas were around the body sides at the bottom of the 'B' pillars, which are quite deep, with a lot of form change and depth. It was a challenge to get the right material flow in that area."

But there was more. Despite its lightness, one of aluminium's shortcomings has been its inability to create sharp crease lines and swages without tearing, thereby limiting designers' creativity. However, new alloys developed over recent years have gone some way to meeting this difficulty, specifically Novelis' Fusion. Although other OEMs employ it in inner structures, Jaguar is the first to use it on an 'A' class surface, in this instance, the front fender, as White explains.

"What Fusion technology allows us to do is put an inert layer onto the outside, so we can achieve good formability, combined with a high strength core that then gives us the best of both worlds. We've pioneered its use on the front fender, as the first external panel application in the





Novelis alloys allow slim 'A' posts and cant rails to meet obscuration and rollover legislation

automotive sector, and we're looking at using it throughout the exterior and in structural applications as well in future models," he says.

One of the other major steps forward with the new car, he points out, was around gaining an increased understanding of how to create larger, more integrated panels and components – as well as pushing pressing technology. For example, the new XJ has a one-piece magnesium front end carrier, using technology pioneered on the latest Land Rover Discovery and Range Rover Sport. That results in a 30% weight saving on top of the magnesium cross car beam inherited from the previous XJ.

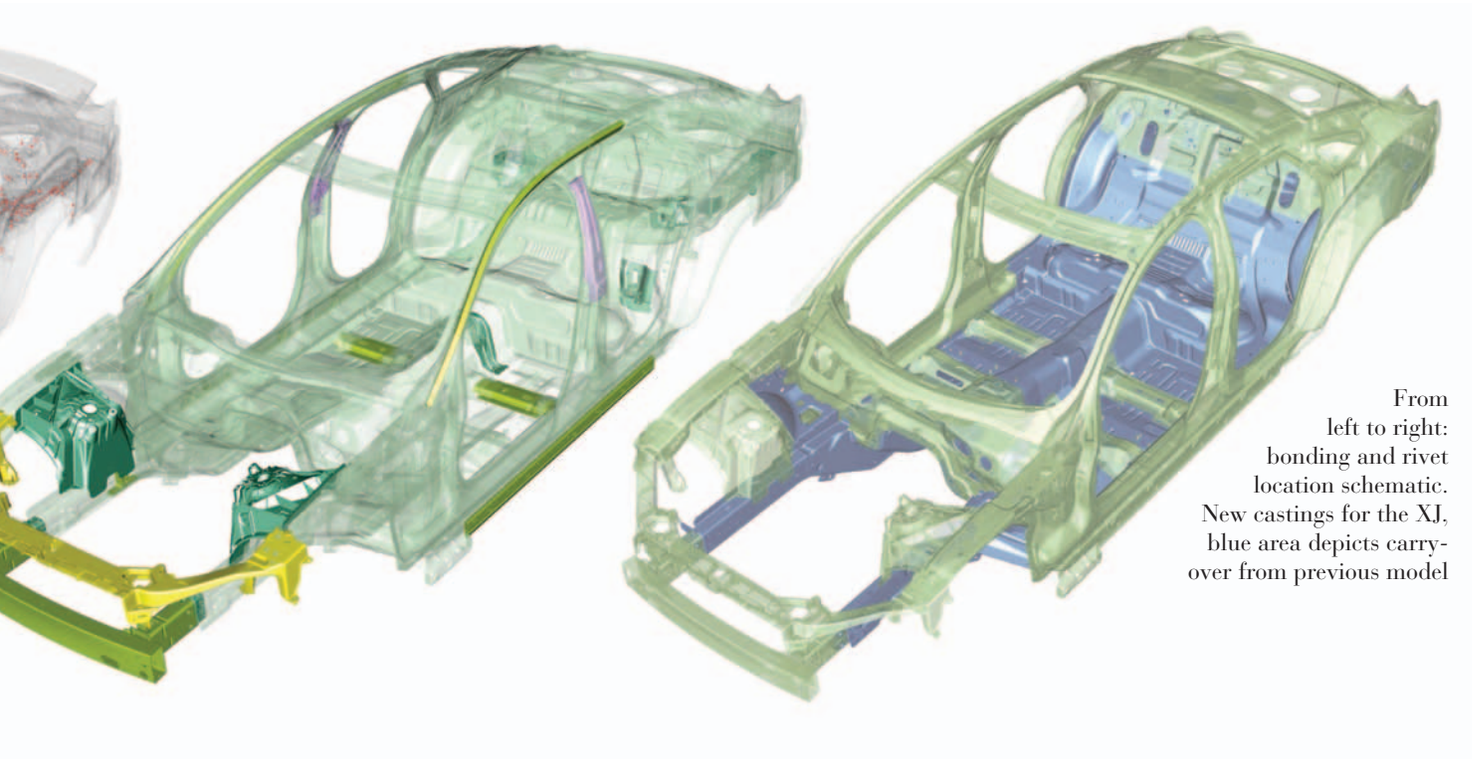
Beyond that, high pressure die castings, supplied by JVM, are used where there's complex geometry in confined spaces – such as the front shock tower and high load applications, like the suspension and engine mounting points, which are then riveted into the rest of the structure. Similarly, the doors now feature a one-piece AA5182 1.5mm alloy pressing, weighing just 22kg – simultaneously reducing the part count from 14 to 10, as well taking 10% out of the cost.

Slim engineering

One particularly challenging area was that involving the 'A' posts and cant rail. Both Dobson and White say they were determined to retain the slim 'A' pillars that Callum's team had created for the XJ's coupé-like profile. However, doing so on the all-new XJ proved difficult, especially in light of the latest IIHS rollover and roof crush tests, and meeting 'A' post obscuration standards. As White explains: "With sheet alloys, that would have meant using between six and 10 parts, but the higher strength hydroformed part in 6082 alloy delivers a better, slimmer package."

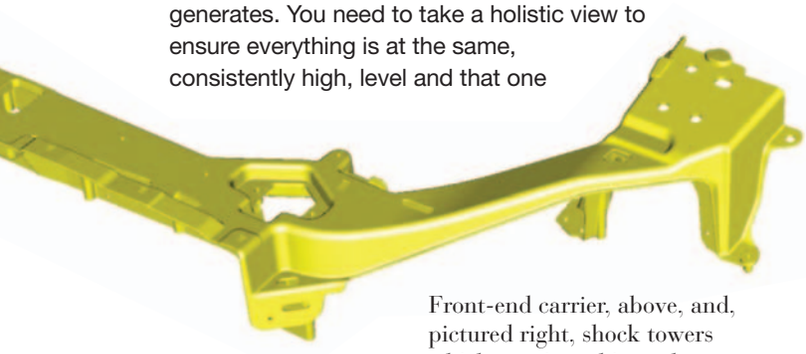
Solutions such as this involve a combination of improved materials and more powerful virtual tools that allowed White's team to do four or five iterations quickly before product release, compared to the previous XJ, which involved "two at most". Just as important, however, was the continuing integration between the design, engineering, manufacturing and marketing teams, building on experience gained during the XF programme.

Both Dobson and White were reluctant to divulge the car's torsional rigidity, beyond saying that it is about 21,000Nm/deg. "Once you get above a certain level of



From left to right: bonding and rivet location schematic. New castings for the XJ, blue area depicts carry-over from previous model

torsional rigidity," explains Dobson, "you're into specific modal characteristics of where the suspension relates to the bodyshell and the modal alignment of the rest of the bolt-ons to whatever frequency the suspension generates. You need to take a holistic view to ensure everything is at the same, consistently high, level and that one area is not significantly better than another."

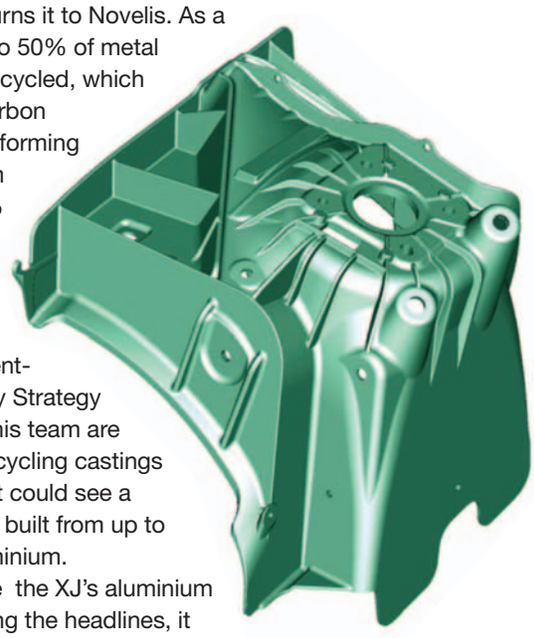


Front-end carrier, above, and, pictured right, shock towers which are riveted into place

Adds White: "Jaguar believes that modal frequency is a much better measure of refinement than pure static torsional stiffness. We would rather concentrate on the modal performance and how the natural frequency of the body reacts to the natural frequency of the engine, road wheels, suspension, etc."

In fact, Jaguar employs a modal alignment chart, with the body shell's natural frequency separated from anything that could induce vibration in the car – such as the engine, steering column or suspension – to ensure that the body is always away from those frequencies. "We set fairly high first order natural frequencies above 40Hz, making sure that isn't disturbed by the engine's natural frequency at idle and full throttle. The modal refinement chart is far more important for vehicle refinement than going purely for static body stiffness," explains White.

Away from design and manufacturing per se, there have also been other key developments. Working with Novelis, for example, Jaguar operates a closed loop recycling programme that now recovers all the scrap aluminium and returns it to Novelis. As a consequence, up to 50% of metal used in the XJ is recycled, which lowers the car's carbon footprint, because forming recycled aluminium consumes only 5% of the energy used with primary metals.

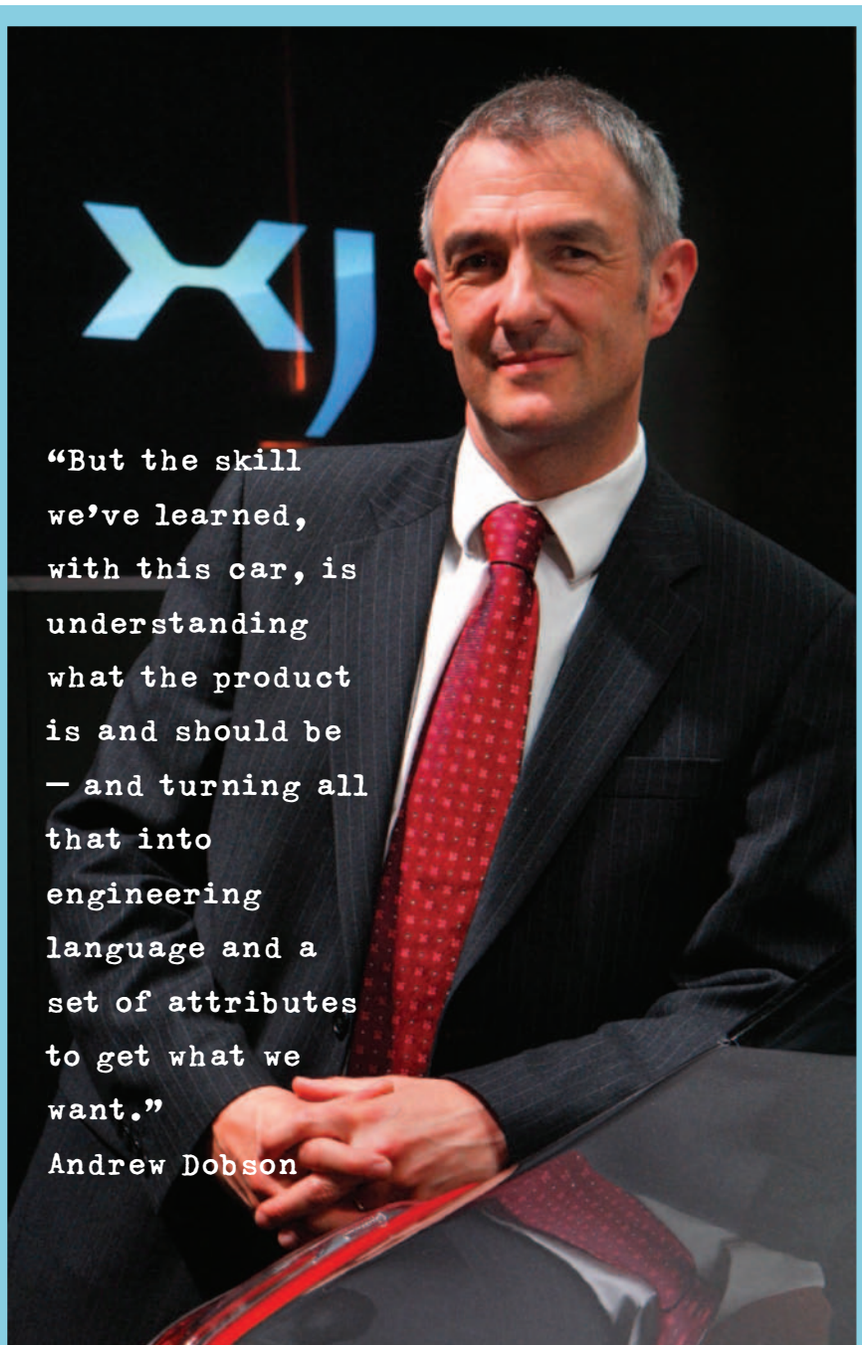


In conjunction with the Government-backed Technology Strategy Board, White and his team are also working on recycling castings and extrusions that could see a future JLR product built from up to 75% recycled aluminium.

That said, while the XJ's aluminium structure is grabbing the headlines, it

would be wrong to assume that nothing else has been updated in the car, albeit less extensively. The most noticeable development is the dramatically styled interior, especially the centre console with its Bosch eight-inch touch navigation system and the virtual cluster from Visteon.

"It's an extension of what we had done before," comments Dobson. And he adds: "We wanted the flexibility of that virtual cluster to display other information and warnings. It also protects us going forward and we're only limited by our imagination, in terms of what we want to display."



"But the skill we've learned, with this car, is understanding what the product is and should be – and turning all that into engineering language and a set of attributes to get what we want."
Andrew Dobson

Virtual screen

With 600,000 pixels and 30 frames per second capability, this 12-inch TFT screen nominally displays a trio of virtual dials for road speed, rpm, etc. The left-hand dial reconfigures for infotainment information and the right-hand display can indicate warnings, such as low washer fluid. The left-hand dial can also zoom in to a junction on the navigation system, as the car approaches it.

Meanwhile, apart from faster shift response times for the ZF six-speed auto – with its revised torque convertor and upgraded torsional damper to improve lock-up capability – the new transmission package also improves both fuel efficiency and CO_2 emissions.

And there's more in the powertrain. Beyond the introduction of a Borg Warner oil-driven variable inlet cam, the most significant update is a new four-point mounting system for the rear differential (which enhances the refinement) and the active differential for its Supersport derivatives. In a novel piece of technology transfer, the GKN/Dana assembly employs the same GKN unit as is used in the centre differential on the Land Rover Discovery – although the Jaguar-developed control logic is, again, all new and, in this case, capable of transferring 90% torque in less than 250ms.

So finally, the big one: when asked what the all-new XJ means for Jaguar's future, Dobson pauses and thinks for a while. "It's not revolutionary; it's a luxury four-door car that's fresh and new in what was a traditional market segment. It also combines a modern approach, but true to Jaguar's identity. For me, it's the technology that gives this car character and quirkiness."

And he concludes: "But the real skill we've learned with this car is understanding what the product is and should be – and turning all that into engineering language and a set of attributes to get what we want."

Inside JLR's DNA

Developing Jaguar and Land Rover products in tandem presents interesting challenges that have to do with commonality at one end of the spectrum and uniqueness of design at the other. Ian Adcock talks to Phil Hodgkinson, director of product development

Twelve months have passed since Ford sold Jaguar Land Rover to Tata – two decades after originally buying Jaguar and nine years since it acquired Land Rover from BMW. It's been something of a tumultuous year as well, with economies collapsing and car sales plunging.

Indeed, many pundits questioned whether the Indian conglomerate had the stomach for its £1.15 billon purchase, especially after its spat with the British government over an emergency £800 million aid package that, in the end, Tata didn't need.

Such a stormy start might well have blown lesser companies off course. However, as JLR product development director Phil Hodgkinson is quick to point out, the two iconic British brands have launched a raft of models under Tata's ownership, culminating in the new XJ, which goes on sale this spring.

His message is that none of this has really affected development operations. "JLR's engineering resources haven't changed that much of late. Since our transition from Ford into Tata ownership, there's been no significant reorganisation," he insists. "But what we are trying to do is rationalise the component and platform strategies. If there is a problem with the legacy platforms, it is that we have too much complexity in the business. We have platforms that have heritage from Ford of America, Ford of Europe and BMW. That's a very complex base for our engineering.

"Clearly, to go forwards, we need to reduce that complexity," he accepts, "and get more commonality and re-use, particularly backstage; but, importantly, also where the customer sees unique designs for Jaguar and Land Rover. This is about more than just the powertrain, wiring harnesses, etc."

Opposing attributes

Of JLR's rivals, he rates Audi as probably the best for getting three or four body styles out of one platform, while JLR "struggles to get one, one and a half". Says Hodgkinson: "We've got some rationalisation to do there, because we're a small organisation and we haven't got the resources, funding or people to re-engineer things we should be re-using."

The key challenge faced by Hodgkinson and his team, however, is that, unlike Audi or any of its main rivals (with SUVs spun off, essentially car-derived platforms), a Land Rover-badged product must possess peerless off-road capabilities – attributes at the opposite end of the scale to Jaguar.

"I don't want to give too much away, but we will have an all-wheel drive platform and a rear-wheel drive platform. What we're looking for is a common assembly process and a design process that simplify the engineering, manufacturing and supply base," he reveals.

"So there will be some common parts, but there will also be a high level of differentiation between the underbody of a Jaguar and a Land Rover. The ride heights and ground clearances are completely different, as are the wheel articulation and lots of other things. However, the principles of how they're assembled – the joining technologies, be they welded, riveted or bonded – we'll try to replicate across car lines and brands."

With the aluminium-intensive XK and second generation XJ, Jaguar has established itself as a leader in this field and, for Hodgkinson, reducing weight is now fundamental to JLR's environmental strategy. "Jaguar has a stronger relationship with [aluminium] technology, and it will get carried across into future Land Rover and Range Rover products," he promises.

"Lightweight strategies are fundamental to our sustainability, so we will reduce weight wherever we can. Will it be 100% aluminium or hybrid aluminium-steel? We will do whatever gives us the best balance. I'll use high strength steels, aluminium and some bits will be plastic. But we will definitely see more aluminium in our products, going forward."

Beyond that, JLR has already embarked on integrating systems, where possible. Jaguar and Land Rover share common V8 petrol and V6 diesel engines, tuned to their specific requirements and mated to a common ZF six-speed auto. But Hodgkinson is keen to see this amalgamation go deeper. "The electrical architecture could be the same for both brands. Clearly, the level of features on a Freelander is quite different to that on an XJ, but, nevertheless, the fundamentals of the architecture can be the same,"

Phil Hodgkinson CV

Phil Hodgkinson was made director of product development for Jaguar Land Rover in July 2008. He is responsible for driving all cross-functional product creation processes for both brands. Prior to this appointment, he was programmes director for Land Rover from 2007. He joined Jaguar from Ford Motor Company in 1990, with responsibility for product planning on the XJS programme. He was subsequently appointed project and launch manager for the XJS, before assuming the same role for the XK8 in 1993. He later worked as Jaguar's powertrain systems manager and was chief programme engineer for the S-Type, before being appointed Jaguar programmes director in 2002.

> We have to pick technology that's most suitable to our DNA and brand values. We want partnerships to develop systems in parallel with our suppliers

he points out.

"Going even further, the seats are different between the two, but many features are common," he adds. "There are many areas where we can get common re-use, even down to door latches, without watering down brand identity and values."

Obviously, this isn't going to happen overnight and the approach needs to be integrated into each brand's lifecycle, as new models are updated or renewed, and as changing legislation and new concepts emerge. Hodgkinson won't put a timetable on it, but, realistically, JLR is looking at renewing its vehicle structure cycle well within the next decade.

Engines also need to be factored into the equation. Currently, JLR sources all its V6s and V8s from Ford, small capacity diesels from its affiliate Peugeot-Citroën and five-cylinder petrol engines from Volvo. Where does JLR go now as an independent?

"We have an agreement with Ford to supply us with engines for the foreseeable future, without disrupting our product cycle plan," he states. "It's a staggered arrangement that, where vehicles and emissions run in and out, we have plans to upgrade engines.

"So there are no specific end dates. What we have to do is work out whether to develop the replacement engines ourselves,or buy from someone else. Across the whole industry now, OEMs are looking for partnerships to reduce development and fix costs, so there are plenty of opportunities to share on big commodities, like powertrain."

But he adds: "It needs to be a well thought-through strategy, rather than just shopping off the shelf. At the end of the day, it has to have Jaguar or Land Rover DNA. It's not just about swapping the cam covers."

And on green issues, he is utterly unequivocal: environmental innovation is one of JLR's three main pillars for the future – the others being delivering great products and an outstanding customer experience.

Massive investment

He points out that JLR has already committed £800–900 million over the next three to four years for powertrain, to reduce tailpipe emissions by 25%. Integral to this will be downsizing, since lighter vehicles require smaller engines. So there is the possibility of higher-powered V6s replacing V8s, and four cylinders replacing V6s.

Additionally, Land Rover has already introduced stop-start on manual Freelanders and this technology will be developed to work on automatics for both marques.

"The fundamentals of a stop-start generator will deliver a modular, scaleable system that can be used across car lines," Hodgkinson explains. "We're also working on full parallel hybrids. But there will be differences between Jaguar and Land Rover, because of two- and four-wheel drive, while the battery package will also be unique to the installation.

"The one exception is Limo-green, which is a series hybrid for Jaguar, although we might consider it for a smaller Land Rover. It takes advantage of the XJ's lightweight technology, as it's the lightest in class and lends itself to an electrification project. It would be more difficult on the Range Rover, because of its weight, and it wouldn't be so good for off-road ability."

Looking to the future, he also emphasises that JLR wants to have partnerships with the best suppliers in the business. "We have to pick technology that's most suitable to our DNA and brand values. We want partnerships to develop systems in parallel with our suppliers. We don't want just to buy components."

And who wouldn't want to be associated with prestige marques such as Land Rover and Jaguar? "But," he warns, "at the end of the day, we're only as good as the weakest link in the car. Where there's a problem, the reputation that gets damaged is ours, not theirs."

EcoBoost set to cut fuel consumption by 20%

Ford's EcoBoost is all about downsizing engine capacity, but adding direct injection, turbocharging and twin variable camshafts. Ian Adcock reveals the technology behind the headlines

Ford's future global petrol engine strategy will centre on EcoBoost technology, combining downsized capacity with direct injection, turbocharging and twin variable camshafts to deliver up to 20% reduction in fuel consumption.

"Fuel consumption is becoming ever more important to our customers," comments powertrain development manager Andrew Fraser, adding: "We need to find a solution for everyone. People want economy, but not hair shirt driving. Over the next couple of years, Ford will revise its powertrain line-up around the globe to improve fuel consumption and CO_2 emissions."

According to Dr Andreas Schamel, managing director Ford research and advanced engineering, Europe, Ford will manufacture 1.3 million EcoBoost engines "over the next few years".

These will include a 3.5-litre V6 in North America, the newly launched European 2.0-litre four-cylinder, a 1.6-litre and a yet to be announced smaller capacity power unit. However, Ford will also continue to manufacture traditional, port fuel injected engines for less developed economies requiring simple engine technology.

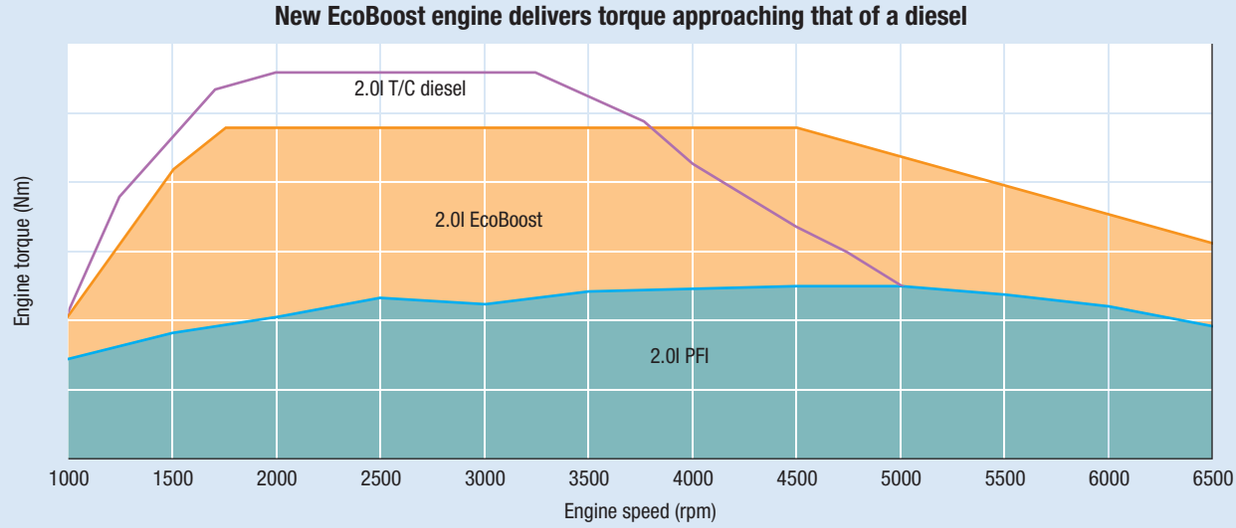
The two-litre EcoBoost engine delivers 149kW at 6,000rpm and 300Nm from 1,750 to 4,000rpm, with a further 20Nm available during transient conditions, such as overtaking. The powertrain offers a 19% reduction in CO_2 to 189g/km, compared to the previous 118kW 2.3-litre, and combined fuel consumption of 8.1 l/kms (34.8mpg).

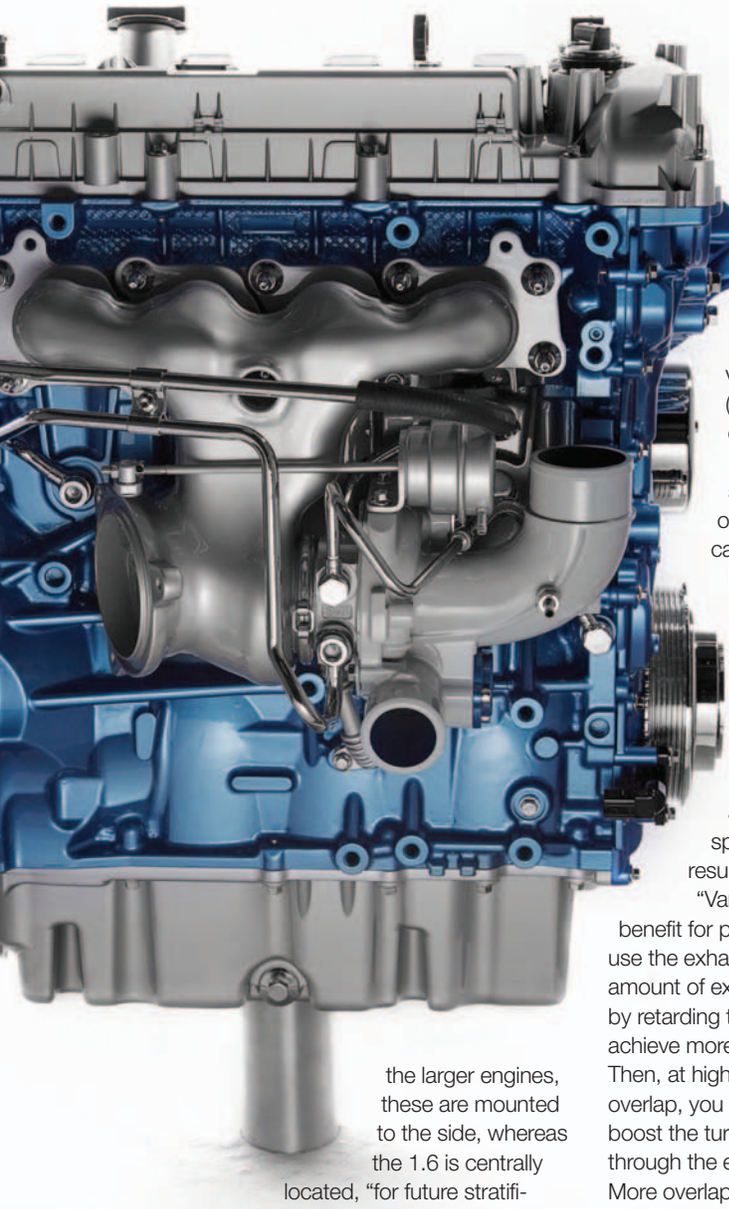
Apart from building a global solution, there were several other factors that encouraged Ford to develop EcoBoost, explains Fraser: "Diesel, although popular in Europe, isn't in the USA or China, while the implementation of Stage 6 emissions will demand NO_x after-treatment, adding further cost to the already expensive technology." Furthermore, phasing in the 130g/km fleet average from 2012 onwards sees an increase from €25 to €95 penalty per gram exceeded. Multiply that by the number of cars sold and, he points out: "You're looking at a €300-400m fine a year. So you really want to achieve that target; it gives you quite an incentive to invest in technology."

Injecting developments

Both the 1.6- and 2.0-litre engines feature an all-new lightweight aluminium block – the smaller engine sourced from Bridgend, Wales, and the two-litre out of Valencia, Spain. Bosch seven-hole injectors are used, running at 150bar. In

New EcoBoost engine delivers torque approaching that of a diesel





the larger engines, these are mounted to the side, whereas the 1.6 is centrally located, "for future stratification flexibilities," explains Fraser.

In start-up mode and at light load conditions, dual injections per stroke quickly light up the catalyst and then stabilise combustion, as load is taken off the engine. Both pulses are injected before the spark, so the air and fuel can pre-mix. Says Fraser: "More powerful versions of the engine are a strong possibility and we think that, at higher loads, we'll use dual injection per stroke to help manage the fuel flow… It's not quite the same as a diesel, but heading that way, and gives us the opportunity to do two or three injections per stroke."

He concedes that Ford has "quite a lot more to learn" about the potential of multi-injection strategies. "It's another degree of freedom we're only just starting to explore," he says. In fact, the company is undertaking extensive CFD work to gain greater knowledge of how the fuel moves in the cylinder during the stroke, so as to optimise injection pulse timing. Although it is not currently using multiple spark, the Bosch system is capable of doing so.

Twin independent variable camshaft timing (TiVCT) also incorporates conventional, hydraulically-driven vane actuators in the sprockets, giving some 60° of relative motion between the cam and the sprockets for both intake and exhaust. Fraser explains that the base timing is "no overlap", which is then progressively increased. "With this level of downsizing, we see low speed scavenging as a fundamental way of avoiding turbo lag at low speed that would otherwise result in a dip in performance.

"Variable cam timing is also a benefit for part load economy. You can use the exhaust cam to increase the amount of expansion work you're getting by retarding the exhaust valve opening to achieve more energy out of the stroke. Then, at higher loads, by moderating the overlap, you can regulate the amount of boost the turbo has to deliver to get air through the engine and achieve output. More overlap means less boost pressure, so a slightly smaller turbo, better matched to lower engine speeds, can be used."

Carefully matching the turbo and variable camshafts also means the variable cam timing can be used to maintain airflow to the turbo at low rpm, overcoming lag and simultaneously cooling the combustion chamber for a denser charge – which then increases output at lower speeds. "This scavenging effect, around 1,500rpm, has resulted in up to 40Nm transient torque improvement," according toFraser.

Low friction components are then used throughout the engine – although an experiment to use Thermaline Carbon on the tappets was abandoned when the gain didn't justify the cost over ultra polished parts. BP has even developed a low viscosity 5W20 oil for the engine and is now working on a next generation lubricant designed to reduce friction by a further percentage point. "That doesn't sound much, but in future European scenarios, where every gram of CO_2 is penalised by up to €95, taking 1% off your fleet can result in a huge cost saving."

That said, a major challenge for engine designers remains rapid warm-up, especially in markets such as the UK where 25% of all journeys are less than 40km (25 miles). While the 2.0-litre's cooling system is relatively conventional, the 1.6 has a three-loop arrangement operated by valves controlled by the engine management software. During engine warm-up, only the interior heater and cylinder head are open; then the block comes in and finally the radiator in series joins the circuit.

Also, to get engine lubricant up to working temperature, oil normally used to cool the pistons is sprayed on to them to dissipate the heat into the lubricant and warm the oil more rapidly. And all EcoBoost engines have an oil-to-water heat exchanger that, at the top end of the operating range, is also an oil cooler and, at the bottom end, an oil warmer.

Charge cooling

Finally, the engines' 10:1 compression ratio was optimised for the engine to run on 91 to 98 RON. Below that, down to 87 RON in China and some rural areas of the USA, knock control takes over.

The next 3-4 years will see a big investment in EcoBoost, predicts Fraser: "They like alcohol: it's great for charge cooling effect, has more latent heat and a higher RON value, meaning you can get a huge output. I can see EcoBoost running on a 20–30% blend of alcohol from renewable resources. Then you get a 50% cut in emissions and fossil fuel usage, without massively complex technology or limited supplies of lithium, etc.

"In the UK, if we improved fuel consumption by 1%, we would save more fuel than all the hybrid sales put together," he points out. " It's all about selling as many cars as possible with moderate gains. If you put [moderate gains] on everything, the scale effect is huge. Rather than a few headlines, it's affordable technology for everyone."

Collaboration and innovation

SAE 2010 World Congress is set to offer more focused technology and cost-saving solutions, says Matt Monaghan

The SAE 2010 World Congress will be re-engineered with a sharper focus on technical and innovative content when it convenes from 13 to 15 April 2010, at Cobo Center in Detroit, USA. It will transform from a large convention format to one that concentrates on value-added technical programmes, an improved session schedule and additional keynote presentations by subject matter experts and authors.

The theme this year is 'ecollaboration: engage, exchange, excel' – all about overcoming economic and environmental challenges, with innovative solutions through collaboration. Host organisation is Ford Motor Co. and the Tier 1 strategic partner is Magna International Inc.

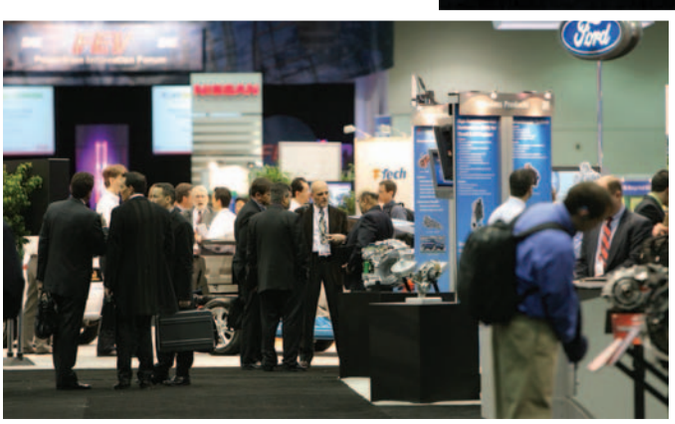
"Collaboration is the answer," says Paul Mascarenas, vice president of engineering and global product development for Ford, and general chair of the SAE 2010 World Congress. "And the SAE 2010 World Congress is the catalyst to initiate this collaboration."

Foremost among the changes for this year's event are the switch from a four-day to a three-day format, as well as a technical programme with a renewed emphasis on only the most relevant and innovative technologies. "We have been conducting surveys and focus groups over the past 18 months to determine how to improve the event," says Patti Kreh, conference director of the SAE World Congress, in an interview with AutoBeat/AutoTech Daily.

"The primary message has been to make the congress smaller and more tightly focused on technological innovations and solutions – particularly in powertrain, materials and safety. Everything about the event will support this mission," insists Kreh. And, emphasising the point, she explains that the technical programme will major on presentations covering cutting-edge topics and innovations, with a distinct change in format. Meanwhile, the exhibit floor will house SAE World Congress' new and exclusive 'Innovators Only' exhibition.

"In today's economic climate, the event needs to be smaller than it was 10 years ago – but also higher quality," states Kreh. "So, for the first time, exhibitors for the 2010 Congress must pass a review panel. Our goal is to make the expo a showcase for the world's most innovative companies."

Networking will also be a key focus, with numerous informal and structured opportunities scheduled. "Networking is an extremely important aspect of any congress, and attendees have told us they want more. So, in addition to the traditional receptions and events designed



Paul Mascarenas, vice president of engineering and global product development for Ford, and general chair of the SAE 2010 World Congress.

The AVL Technology Leadership Centre, shown during last year's SAE World Congress, as well as the FEV Powertrain Innovation Forum, will again feature panel discussions with industry leaders. New this year will be the ability for individuals worldwide to view and participate in the exchange via live Internet broadcasts

for networking, there will be scheduled peer-to-peer discussions to encourage in-depth and insightful interchange. Also, the 2010 Congress will have several technology-specific lounges throughout Cobo Center. These will be areas where, for example, powertrain engineers can mix with their peers and subject experts in an informal setting," she adds.

New networking

"We're also taking several other smaller, but just as innovative, steps to enhance networking. Name badges will be colour-coded by areas of expertise, so that attendees can instantly identify others who share their specialty. We'll also post a list of registrants on the SAE website, so attendees can check ahead of time to see which people, exhibitors and sponsors will be there."

And there's more. The 2010 technical programme boasts 1,100 papers and is also tightly focused on technology. The organisers have selected only the most innovative papers and presentation times have been reduced to allow for more audience interaction with presenters.

"We expect to conduct about 1,000 live technical paper presentations during the congress," states Kreh. "The main difference [this] year is that each session will begin with comments from a subject-matter expert. Presentation times will also be shortened to 20 minutes each, so there is more opportunity for Q&A."

In fact, the technical sessions are organised under seven 'super tracks': electronics; emissions, environment and sustainability; integrated design and manufacturing; management and marketplace; materials; propulsion/powertrain; and safety/testing. Also, the FEV powertrain Innovation Forum and AVL Technology Leadership Centre will, again, feature panel discussions with industry leaders. However, a new addition to the congress this year is the ability for individuals worldwide to be able to view and participate in the exchange online.

"For 2010, there will be live Internet broadcasts – a first for the congress. Speakers and panellists will be addressing such timely issues as energy policy, the business of powertrains, sustainability and such issues as technology transfer across different industries," she adds.

Specifically, leadership panels at the FEV powertrain Innovation Forum will include: 'The OEM dichotomy: meeting environmental and fuel economy requirements and still giving the customer the vehicle they want to drive' (moderated by Gary Rogers, president and CEO of FEV); and 'Rising out of the ashes: the top five emerging powertrain technologies for 2010' (moderated by John Heywood, professor, MIT, with panellists including Trevor Jones, National Academy of Sciences Committee).

Meanwhile, the AVL Technology Leadership Centre will host a presentation on 'Far term powertrain solutions – 2016 and beyond' (moderated by Ray Corbin, president, AVL powertrain Engineering Inc), with panellists including Gerhard Schmidt of Ford and Michael Webber of the Jackson School of Geosciences, University of Texas, Arlington.

Additionally, William Clay 'Bill' Ford Jr, executive chairman of Ford, has been confirmed as speaker at the banquet on 15 April in the AVL Technology Leadership Centre. "He brings a unique perspective on the global automotive industry," says Kreh, "along with the history and prestige of the Ford Motor Co."

And she adds: "The overarching goal here is to give attendees an opportunity to enrich their knowledge and relationships. Ultimately, this provides them with the tools they need to meet the challenges in today's global market."

Sound engineering

Engineers are using ever more advanced tools to create the unique sounds of today's vehicles. SAE International's Bruce Morey reports on the technology and processes behind the words

Driving a car is an experience of the senses. So it is no longer good enough for carmakers to deliver a quiet ride. Today, OEMs are establishing brand identities around an expectation of how cars should sound – just as they do with styling and other attributes.

"To give our customers what they need in sound quality, we first help them design a quiet vehicle and engine – to clean it of objectionable noise. Then we tune in the specific sound quality they want," explains Kiran Govindswamy, chief engineer for NVH, CAE and Driveline systems at FEV.

He makes the point that this is often an iterative process, combining detective work and engineering. "For a given powertrain input, light vehicles present more NVH challenges than heavy vehicles." But that's not all: advanced engine technologies can also cause problems, such as increased combustion noise or direct injector ticking. "Getting the right sound quality is part art and part science," he admits.

Tools that FEV uses to help include a number of NVH test cells and CAE simulation tools, combined with proprietary methodologies. Its CAE tools include: the FEA code (eg NASTRAN); multibody systems software for vehicle-level NVH simulations; and FEV's Virtual Engine suite.

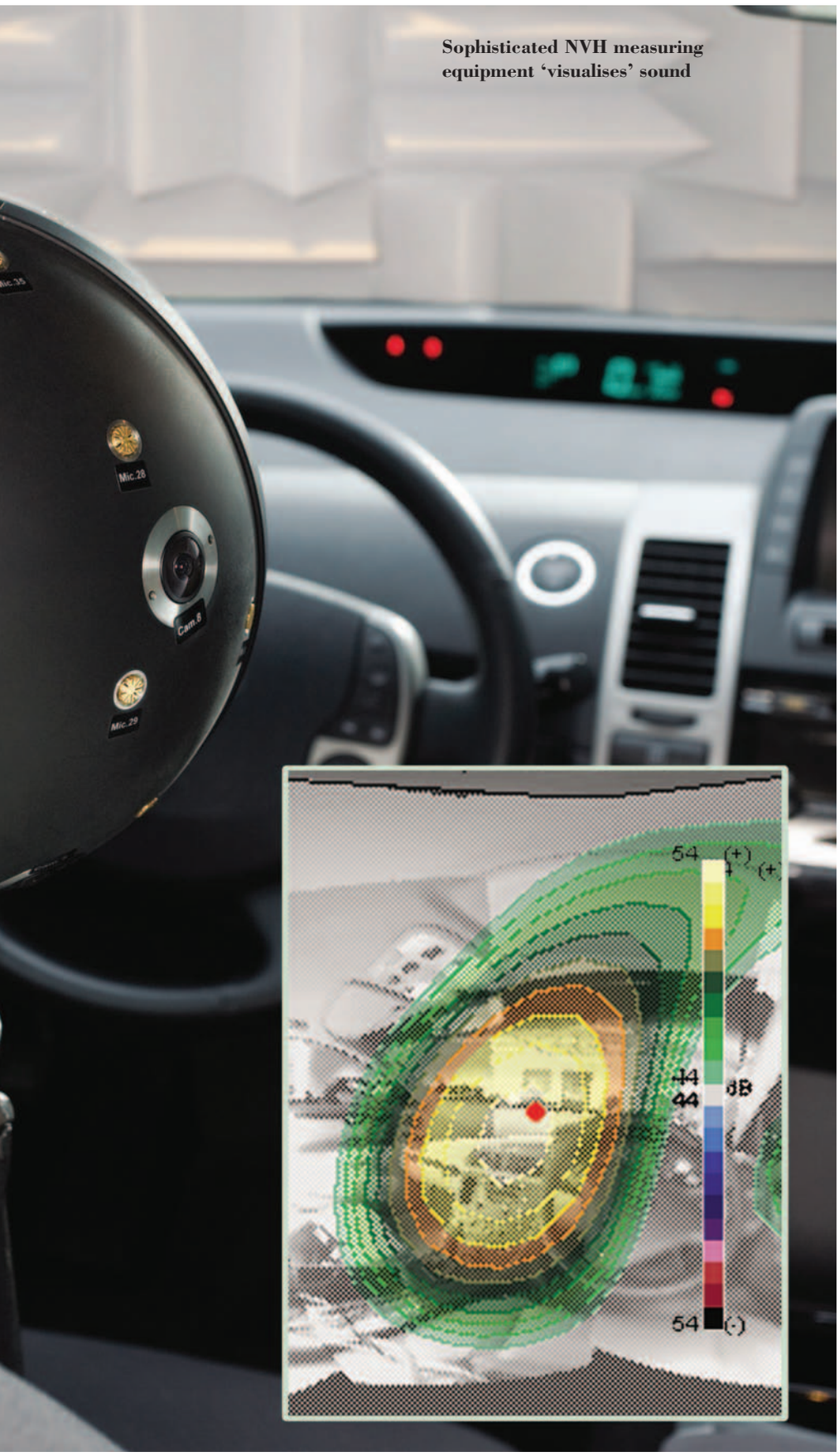
Specifically to aid in the detective work of isolating noises, FEV built its own vehicle interior noise simulation (VINS) software, which creates vehicle sound quality models. Outputs from VINS models are sound files representing the interior noise from all structure-borne and airborne noise paths into the vehicle. NVH and acoustics engineers then perform much of their analysis by representing levels of sound in colour maps plotted against frequency, rather than time.

"These are useful [tools] to clean the sound, but you cannot listen to a colour map," explains Govindswamy. So VINS integrates and converts all data to sounds that analysts can listen to – referred to as time-domain files.

Translation & interpretation

Years of NVH testing, coupled with dedicated databases, give FEV another important tool – scatter band plots. Examples include both time-domain or frequency-domain metrics documenting NVH behaviour of both components (think engines or transmissions) and whole vehicles. These are useful in both target setting and in measuring performance against an industry normalised measure, he states. "We also routinely use a combination of test-based data and CAE-based analyses to conduct 'hybrid' analyses, using our Virtual-VINS process." Why? Because this hybrid process combines modelled forcing functions, such as engine vibration at the engine mount, with measured noise transfer functions – which he describes as "not quite ready for CAE simulation".

Another level of simulation is Bruel & Kjaer's Type 3644 NVH Simulator, which offers a different window into the sound engineer's world. Recognising that sound quality is, above all else, subjective, the NVH simulator stores sound files to create



Sophisticated NVH measuring equipment 'visualises' sound

an interactive driving experience. The desktop version presents the sound of the vehicle through headphones to a 'driver', who controls the 'car' through a computer-generated environment, using a steering wheel, pedals and gearshift. Frequently, multiple models are stored for instant comparison – eg, when examining two brands of luxury cars or, at a more detailed level, two intake manifolds.

To make it scalable, Bruel & Kjaer created a three-level data structure: vehicle level, source level and contribution or path level. "It's important for engineers to know that, though our model can be detailed – even isolating the sound of each engine mount or tyre – it's not always required," explains David Bogema, senior application engineer at Bruel & Kjaer North America. "Someone looking at axle noise doesn't care what's coming from the engine mounts or intakes."

Ceating a simple powertrain model for noise would be sufficient for an axle study, for example, so the NVH simulator brings together all the component sounds, while also accounting for phase.

Modelling sound

Modelling sound and NVH using CAE has its advantages, especially for vehicles in the early stages of design or when many modifications are under consideration. However, there are limitations, especially in the mid frequency ranges from 200Hz to 1kHz, points out Terence Connelly, lead engineer Vibro-Acoustics for ESI Group.

"Statistical energy analysis [SEA] is useful above 1kHz, because the modal density is great enough to treat the problem stochastically," he explains. "Below about 200Hz, the sample size of modes is small enough where a full finite element model is needed." Above 200Hz, model sizes become so large as to make a solution impractical. Establishing which parts of the model should use FE and which SEA requires knowing some rules, he says, but the software helps.

Recognising that creating an FE model for NVH and acoustic studies alone can be expensive, however, ESI offers an integrated option for creating such models from existing crash data. "Our PAM-CRASH and VA-One software are widely used in the automotive world," asserts Joe Strelow, director of VE/VA solutions. "Crash models are critical and are created early in a vehicle development programme. By leveraging these, we

believe we can create an NVH model where maybe 90% of the work is already done." What then remains is adding NVH-specific details for computing the acoustic and passenger comfort metrics that identify the brand. This is a concept Strelow calls an adaptive computing model, embodied in ESI's Virtual Performance Solution.

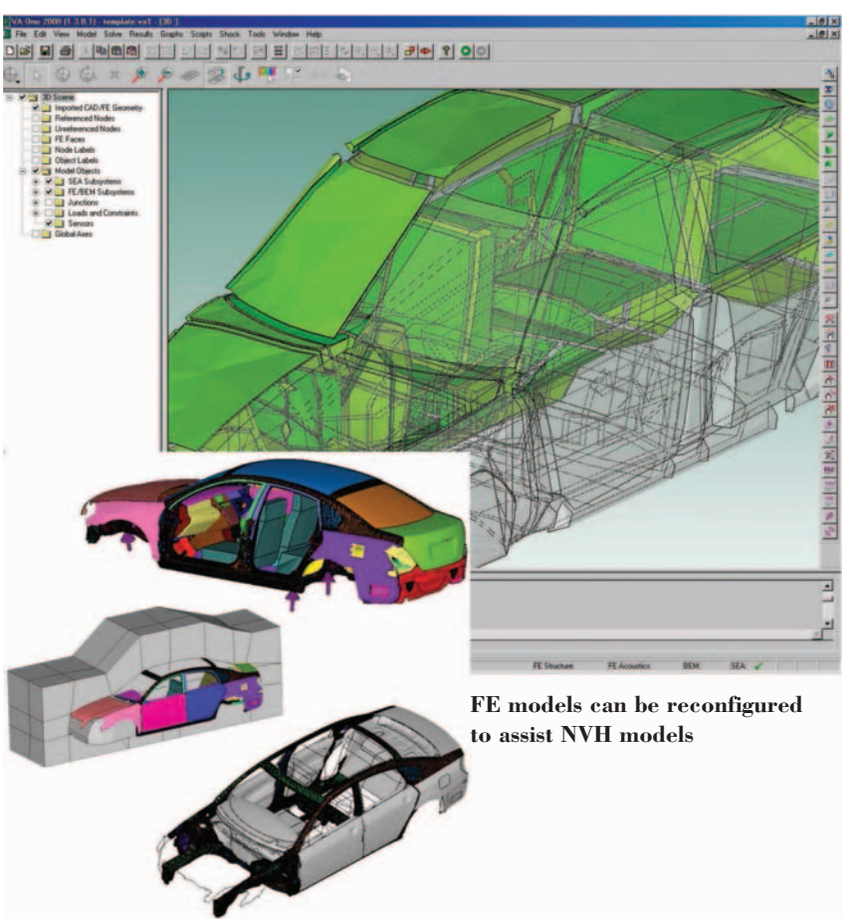
Virtual car simulates sound paths.

Spherical beamforming

So far, so good. But while engineering sound quality uses modelling coupled with measured data, engineers can generally only measure error states, such as buzz, squeak and rattle (BSR). So mapping sound in interiors is particularly challenging. A class of devices to solve that involves a sphere fitted out with microphones and cameras. This creates maps of the energy from directive sound pressure in three dimensions, using a technique called spherical beamforming.

Most often, this uses the acoustic wave equation (sometimes with spherical harmonics) to interpret sound hitting the microphones at the same time – so determining the time or phase differences and thus direction. Spherical beamforming devices accurately map line-of-sight transients, as well as stationary sources. They also map reflections just as easily as sources and are better at higher frequencies, typically above 200Hz.

Nittobo Acoustic Engineering offers a spherical beamforming system called Noise Vision. It is a rigid sphere with 31 microphones and 12 cameras, which maps directive sound pressures on to images to show where the sound is measured. Different diameters of the rigid sphere measure different frequency ranges more accurately, according to Kazuhiro Takashima of Nittobo.



FE models can be reconfigured to assist NVH models

Suite advantages

Bruel & Kjaer is another provider of spherical beamformers and also offering other equipment, such as conformal mapping devices using nearfield acoustic holography (NAH) and planar beam-forming. Using a suite of devices has its advantages, according to Tony Frazer, the company's array acoustics solutions manager. "Spherical beamforming covers a little higher frequency [200Hz to 8kHz range], while conformal goes a little lower, [20Hz to 6.4kHz]," he explains. "Spherical provides a coarse location tool and then conformal provides a fine-tuned, high spatial resolution tool."

Meanwhile, SenSound offers a slightly different take on spherical beamforming, with its acoustic camera, marketed for GFal Tech of Germany.

This is an open system, advertised as acoustically transparent, compared to rigid systems. Instead of mapping sound intensities to pictures that have taken by the camera, the acoustic camera fixes the position of the device, in relation to a CAD model, and then shows the intensities on CAD renderings.

Economics of scale drive global engineering

Kevin Jost, SAE International editorial director

The automotive industry is globalising fast – as growth slows in developed markets, but booms in the emerging ones. The move to global vehicle and powertrain architectures is about reducing cost, speeding development and improving economies of scale. And that, in turn, is driving the transition to global engineering.

By 2012, the industry's top 10 global vehicle platforms (by volume) are expected to produce a further 7.7 million units.

Plans for the platform behind the new Ford Focus, which had its public debut at Detroit's 2010 North American International Auto Show in January, call for variants that will eventually account for 2 million units and up to 15 models. Moving to global architectures will allow greater engineering productivity and resource utilisation – with vehicle research, engineering and testing around the globe for 24/7 project development.

At the same time, engineers working on new vehicle programmes are focused on mass reduction to meet increasingly stringent regulations on emissions and fuel consumption. Engineers fight for every gram of mass, constantly battling creep due to larger models and added features, as well as safety content.

So, in this inaugural issue of Automotive Design, the focus is on the latest techniques to reduce mass and make our cars more sustainable.

Just as car-makers and suppliers must balance global development with customisation at the local level, so must publishers and media providers. With Automotive Design, a collaborative effort between SAE International and Findlay Media, we hope to combine the best global content and experience, while targeting local needs and delivery to a European engineering audience of 20,000 for each of the five issues published in 2010. This will be supplemented by a website containing many Web 2.0 features.

As the global automotive industry works to redefine itself, new technologies are emerging, and vehicle engineers and developers are relying more heavily on information sources, such as Automotive Design, to keep up with technology. This media partnership is the latest in SAE's efforts to expand globally to better serve vehicle engineers.

By 2012, the industry's top 10 global vehicle platforms (by volume) are expected to produce an additional 7.7 million more units

In January, SAE also strengthened its relationship with the Korean Society of Automotive Engineers (KSAE). Both organisations will share editorial content, and the 11,000 KSAE members will be able to subscribe to the digital version of SAE's Automotive Engineering International (AEI) magazine and related electronic newsletters.

SAE also recently strengthened its media offerings and relationships in China, with plans to offer an improved AEI China, in simplified Chinese, six times in 2010. Reaching more than 17,000 qualified design, production and engineering readers, it covers the entire chain, from assembly down to tier three suppliers.

Since 2000, SAE has also had a content-sharing agreement with its affiliate SAE Brazil for the magazine Engenaria Automotiva e Aeroespacial. Currently published four times a year in Portuguese, it reaches 10,000 engineers and product developers in the Brazilian automotive and aerospace industries.

In concert with these is the continued development of SAE's global magazine portfolio, led by AEI, delivered by mail in print and online in electronic/digital formats. And SAE also has an expanding portfolio of 12 technology e-newsletters delivered to readers around the world by email.

Highlights of the new offerings for 2010 include 16 additional digital editions of AEI, two new technology e-newsletters (on batteries and energy, and intelligent transportation) and a new magazine for and by SAE student members, called Momentum.

The electronic/digital magazines and the technology e-newsletters, as well as the partnership with Findlay Media on Automotive Design, are helping to broaden SAE's reach and satisfy its mission of advancing mobility technology to serve humanity.

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The future's in smart alloys

Question Time: Robert Georg of Novelis talks to Ian Adcock about weighty matters and aluminium developments

Talk to any vehicle programme engineer and one of the biggest challenges they face is weight. As fast as they engineer mass out of a car, legislation and increased content finds a way of putting it back on.

According to Bentley's board member responsible for engineering, Dr Ulrich Eichhorn: "If you do nothing to a car, but just engineer it for new regulations, that can add 10—25kg a year. As engineers, we're always fighting that battle, but we never win, as you exhaust most things and it just gets ridiculously expensive."

It's a sentiment Robert Georg, director sales and marketing at Novelis, can sympathise with. "Our industry has reached a point of thinking, 'Where is the next step to ensure its future?' To guarantee mobility, we have to think of new ideas and redefine the car."

But not quite: he believes that Novelis, in particular, and the aluminium industry as a whole, can help manufacturers solve that paradox.

According to Drucker Research, aluminium usage in European cars will grow from an average of 135kg this year to 150kg by 2015. "That's being driven by emissions and economy improvement. At the end of the day, we have to overcome four factors – and three of them are mass related: rolling resistance, acceleration resistance, driving resistance," Georg explains. "Only aerodynamics has nothing to do with weight.

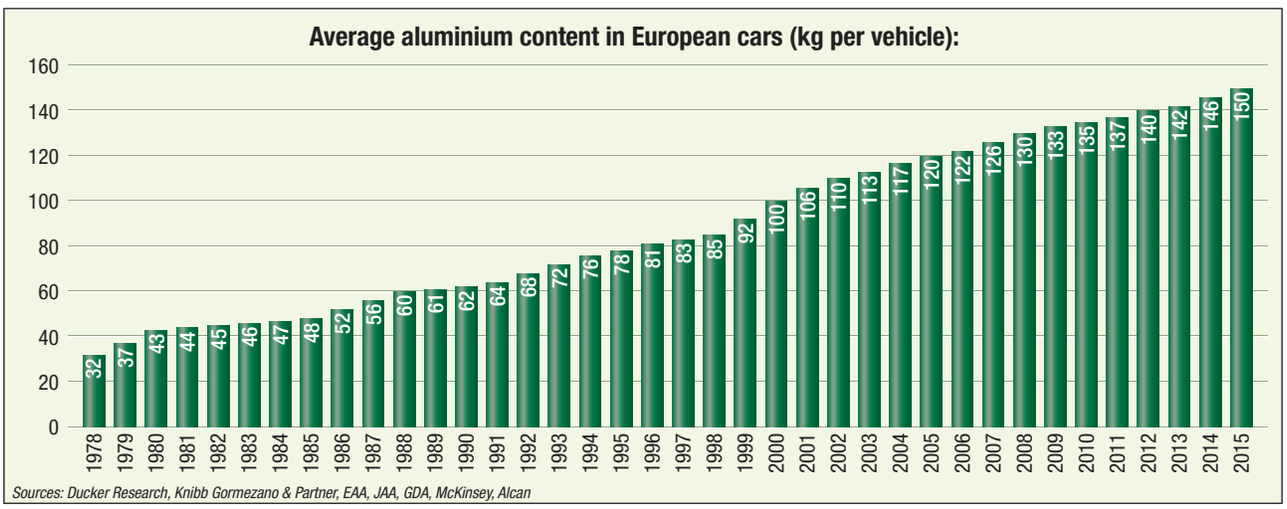
Less is more

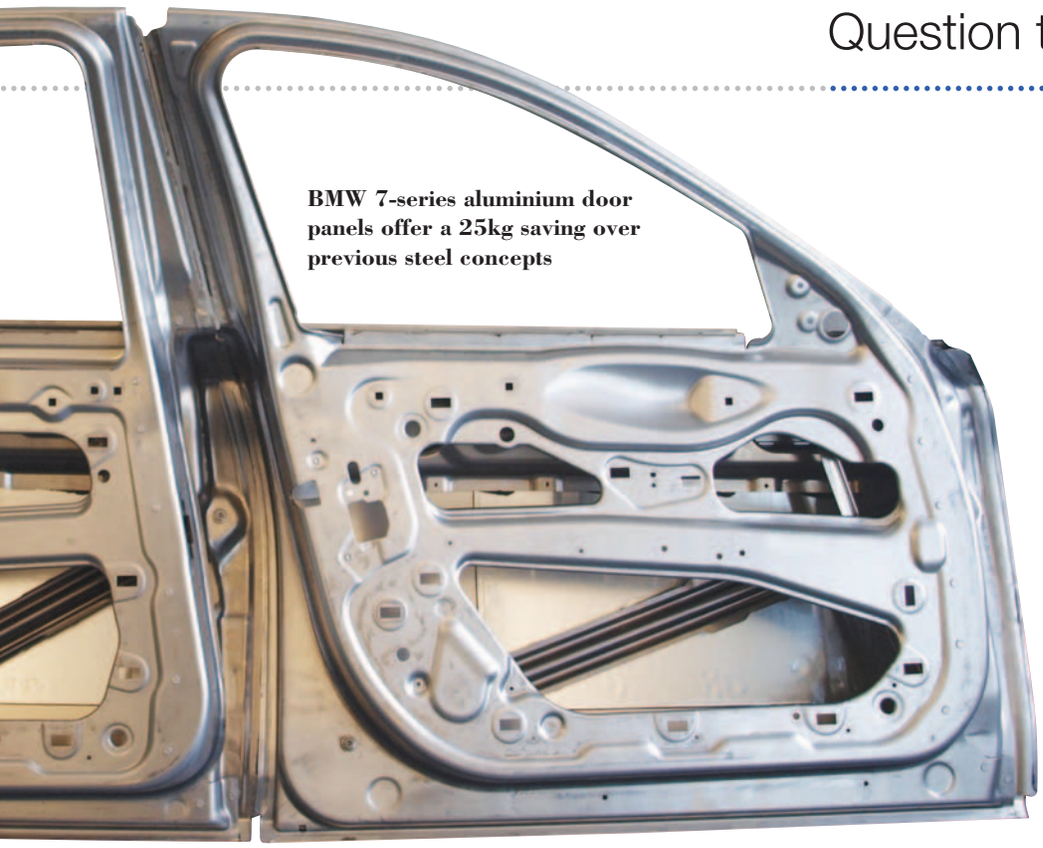
To reduce fuel consumption and lower emissions, we must lessen vehicle mass, he adds. "So you need less energy to go from A to B. That's the key message and that's why everyone is focused on it right now." Even the American big three are beginning to appreciate the benefits of weight reduction, he says – although, with only 45 programmes in place, that's just a quarter of similar projects being undertaken by European OEMs.

While Jaguar and Audi lead the way with aluminium-intensive production cars (rather than limited edition super- and sports cars), he believes the next big step will be an increased use of hang-ons. "There's a steady growth in investigating hang-ons and I think that, from 2011 through to 2014, we'll see more and more."

Much of this increase is down to the development of new alloys, such as the Novelis Fusion range, as used by Jaguar on its XJ, but also as single piece inner door panels on the BMW 7 series – saving 25kg over the previous steel-based concept. It is also employed in the Audi A8's floor tunnel, with reinforcements.

According to Georg, Audi developed a new technical specification for the structure, with strength requirements that standard 6XXX series alloys cannot achieve. "With Novelis Fusion, we are able to offer Audi a material solution to meet





BMW 7-series aluminium door panels offer a 25kg saving over previous steel concepts

this new technical specification," he says, indicating that Fusion offers engineers and designers greater freedom.

"Before Fusion, technicians described what they wanted and, in some instances, we would compromise, because we couldn't get, for example, high strength and malleability combined. With Fusion, we are combining characteristics. So, we can have a high-strength core and protection on the outside that's very soft. At the end of the day, you can get the best of both worlds without too much compromise... It's a designer's dream, as we can create a material for every application," enthuses Georg.

For the automotive sector, there are basically four classes of Fusion: AB9xx, which can be used for both single- and double-sided heat exchangers; AF350, specifically designed for one-piece door inners, and possessing enhanced elongation and excellent hemming; AS250, for inner panels and 'A' surfaces; and TS200 which, typically, is applicable to bright tread applications.

While accepting that rivals are working on multi-layered alloys, Georg clearly believes that Novelis has a head start and that this is the way forward. "We are learning new combinations every day and developing very good solutions for the market. Almost daily, customers come with new requests and challenges for our team to find solutions to."

Although reluctant to divulge too many details, Georg concedes to Novelis using 6000 series as the baseline – as these are "usable and well known in the automotive sector". However, he also says that the intention is to "move the current border line from 240—250 megapascals up to, and even in excess of, 300 for high strength applications".

While the 7000 series, as used in aerospace applications, boasts 440 and more megapascals, they would, he claims, be difficult to use in vehicle applications. Why? Because they have low formability and elongation of, maybe, only 5% – which is equivalent to cast iron levels. Nevertheless, Novelis is confident that, with its partners, it will bring a good solution to the market "within a couple of years," meaning materials should be available for model programmes from 2012 onwards.

Robert Georg: Novelis

That said, a key growth segment for Novelis, explains Georg, is recycling. Last year alone, it recycled 39 billion cans – enough to circle the equator 100 times. Jaguar, as can be read elsewhere, has a closed loop recycling system and Novelis is keen that its other partners should follow suit. "We will try to work with our customers to operate closed loop recycling with them, as it makes sense for us. It takes only 5% of the energy required to produce virgin aluminium."

Jaguar Land Rover is currently the only OEM with closed loop recycling, although we do have contracts with Audi, Daimler and BMW. But it's a bit tricky to talk about future plans, as they are dependent on the volume development in their product planning."

Lifecycle costs

What about commodity prices? Georg concedes that steel has a price bonus over aluminium, but insists that the balance is shifting. "Audi has conducted lifecycle assessments showing that halfway through a car's lifecycle, you start to get a payback. For every 100kg taken out of a car, 0.3–0.5 l/100km can be saved in fuel, and that's into the driver's pocket."

Nevertheless, Georg is canny enough to realise that aluminium isn't going to take over entirely – even if he suggests that, within five to 10 years, it will have the formability and strength to rival steel.

"There's a great opportunity for aluminium in alternative energy cars – especially electric vehicles – because there's a specific need to compensate for the additional weight of the batteries. However, in mid-range models, it will be about hybrid structures, similar to that pioneered in the latest Audi TT, combining aluminium with steel." And he adds that the EU SuperLIGHT-CAR project, launched to develop a Golf-sized car, using a blend of materials – aluminium, steel, magnesium and plastics – is a very realistic vision of the future.

The bottom line is that steel monocoques are unlikely to be rendered obsolete by aluminium any time soon. At the same time, with the continuing development of Fusion-like alloys, it will become increasingly difficult for OEMs to ignore aluminium's green virtues.

Lightening the electronic load

After years of attempts to scale back the burgeoning weight and complexity of automotive wiring, a new way is emerging. Keith Howard reports

It's not so long ago that two technologies were being proclaimed as solutions to the burgeoning complexity of modern car electrical and electronic systems and, in turn, their contribution to vehicle weight.

First came multiplex wiring, whose Utopian vision was of a single wire, or perhaps two, carrying power and data, looped between all electrical components in the car. Multiplexing was deployed, particularly in car subsystems, but the 'ring main' vehicle never materialised. On the contrary, wiring complexity of modern cars continued to increase as further systems were added to meet customer expectations. In the new Jaguar XJ, for instance, there is 1.5 miles (2.4km) of wiring within the cabin alone. That could weigh upwards of 60kg.

So the challenge engineers face today with electrical systems is that wire lengths in mid-size cars might have shortened, but the amount of componentry has grown significantly. That is even more true of luxury cars, where wire lengths have almost trebled in eight years, thanks to the proliferation of vehicle electrical systems – from infotainment systems to electric motors powering seats, soft close doors, trunks, liftgates... You name it.

The second technology, however, was aimed not at reducing electrical system complexity, but at paring back wiring thickness and weight – and that was the proposed transition from 12 volt to 42 volt supply. For a given power draw, a 42V system has only to deliver 1/3.5 of the current – because it delivers about 3.5 times the voltage – so allowing a 47% reduction in conductor diameter.

For the same power dissipation within the cable, the conductor cross section reduces by a factor of $1/3.5^2$, equivalent to a reduction in conductor diameter of 71%. Across kilometres of cabling, the resulting savings in harness weight and thickness are well worth having. All the more so, if allied to the latest insulation materials, such as Delphi's halogen-free ultra-thin-wall cable, which reduced coating thickness to as little as 0.2mm.

However, this 42V vision has not materialised either. The entrenchment of 12V technology has, for the time being at least, cemented its hegemony.

Radical approach

So it appears that a new, but no less radical, approach is needed to stem the tide of increasing electrical system complexity, weight and bulk, over and above the ongoing piecemeal improvements within particular sub-systems that suppliers continue to make.

What might that be? IFR Automotive, based in Reus near Barcelona, Spain, believes it has the answer. Called Unidrive and incorporated into its Aspid technology demonstrator, it goes about the task of weight loss in two distinct ways.

First, all of the conventional instruments and switchgear are consolidated into two touch-screen displays, one of which (showing vehicle and engine speed data, warning messages, etc, and incorporating touch controls for headlights and turn indicators) is located on the steering wheel. The second (showing sat-nav data, HVAC controls, etc) is on the dashboard and can be configured to display "endless telematics, on-board diagnostics and multimedia capabilities". It can also "embrace any new developments, including, for example, traffic management and collision avoidance".

Together, these two displays save almost all the wiring complexity, as well as weight of instruments and switches. They also incorporate redundancy, so that if one display should fail, the other will assume its functionality. Potentially, the driver could be allowed control of factors as diverse as "the rev limit, valve timing, power output, steering assistance, ABS, brake balance, traction control, stability control, pitch, roll, yaw and ride height, as well as damping characteristics". Unlikely in a road car, surely, but then Unidrive also has motorsport applications.

But for the second Unidrive approach, the IFR Automotive design team, led by company founder Ignacio Fernández, has

developed a new system architecture, which does away with much of the inefficiency inherent in the present paradigm – where the suppliers of major sub-systems build in the microprocessors to control them. IFR Automotive claims that, with Unidrive – where the computing power is more centralised and provides system-wide processing services – the maximum number of ECUs required in any road car is just 10. That can represent a four- or even five-fold saving over current practice, and in itself saves weight. But the effect is multiplied by a concomitant reduction in wiring loom complexity, which, IFR claims, typically amounts to a two-thirds saving in overall harness weight.

Fernández quotes an example: "We did a case study of a C-segment car that originally had 3.8km of wiring in its harness. We were able to simplify that to 860 metres, so dramatic savings are possible. We also reduce the number of ECUs and the number of connectors, so the weight saving doesn't just come from the reduction in wiring – it's from the whole of the electrical system in the car. And we save the weight of conventional switchgear and instruments: we can control and instrument the whole car in about 940g. That's the weight of the two touch screens."

Multimedia, plus control

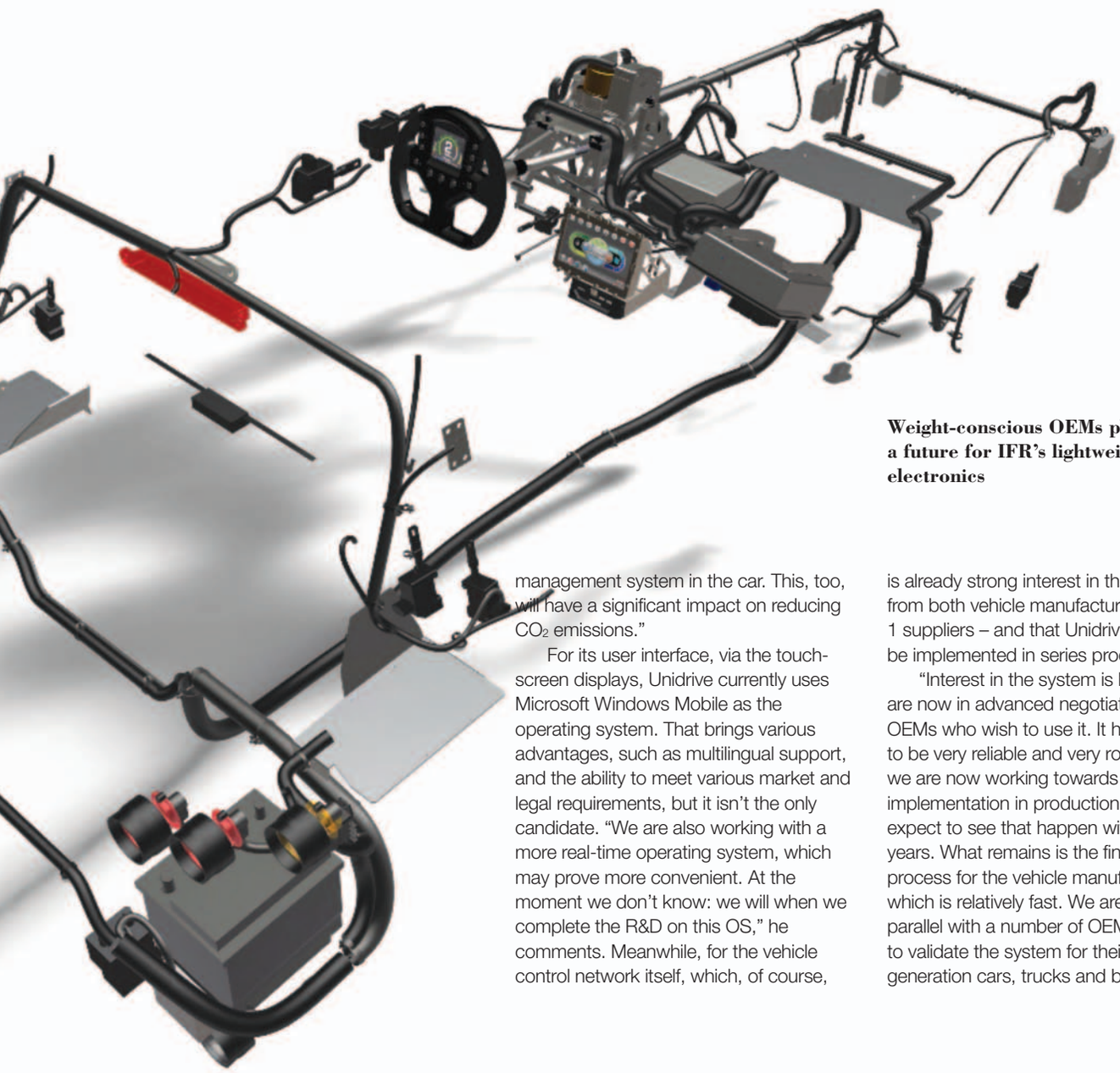
But there's more, he adds: "This is also the first system on the market that connects multimedia capability with the car's controls. That can translate into a much more sophisticated energy management system in the car. This, too, will have a significant impact on reducing CO_2 emissions."

For its user interface, via the touch-screen displays, Unidrive currently uses Microsoft Windows Mobile as the operating system. That brings various advantages, such as multilingual support, and the ability to meet various market and legal requirements, but it isn't the only candidate. "We are also working with a more real-time operating system, which may prove more convenient. At the moment we don't know: we will when we complete the R&D on this OS," he comments. Meanwhile, for the vehicle control network itself, which, of course, includes safety-critical systems, a dedicated operating system is used – one that IFR Automotive has been developing for seven years.

One benefit of the current, established architecture is that it allows suppliers to protect the IP contained within their control algorithms. But Fernández does not see removal of this software to non-dedicated, system-wide processors as a barrier to acceptance of the Unidrive architecture.

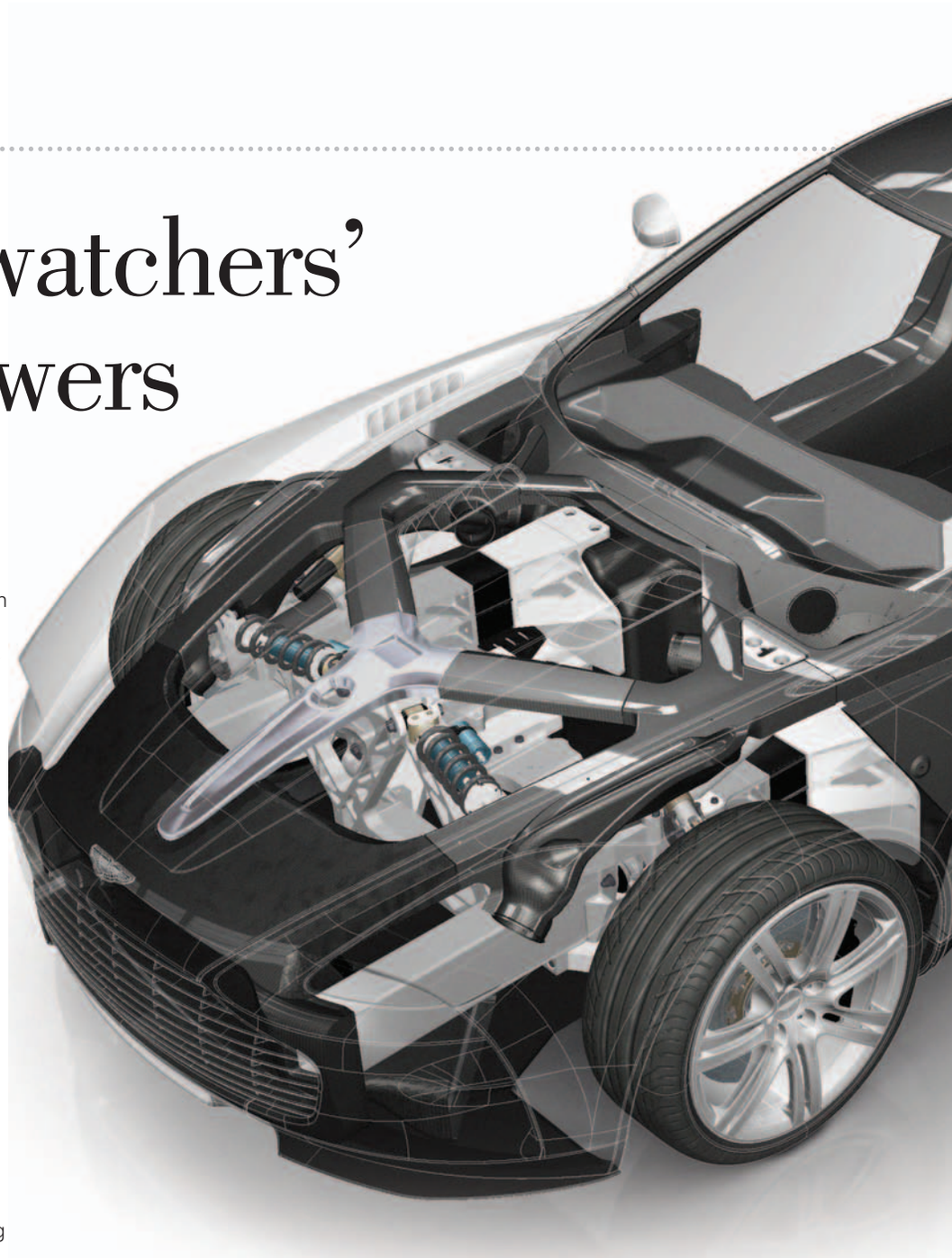
"I don't see that as a problem, because suppliers' software can be incorporated in the system with full protection of their IP. In any case, there's a general realisation among the top suppliers that copying others is pointless. It will always put you behind the market leaders," he says. Indeed, he claims there is already strong interest in the technology from both vehicle manufacturers and Tier 1 suppliers – and that Unidrive will soon be implemented in series production.

"Interest in the system is huge and we are now in advanced negotiations with OEMs who wish to use it. It has proved to be very reliable and very robust, and we are now working towards its implementation in production cars. We expect to see that happen within two years. What remains is the final validation process for the vehicle manufacturers, which is relatively fast. We are working in parallel with a number of OEMs on this, to validate the system for their next-generation cars, trucks and buses."



Weight-conscious OEMs plan a future for IFR's lightweight electronics

Weight watchers' new answers



While the big news in automotive weight reduction is invariably around the body structure, moves are afoot to transform vehicle components' contribution. Ian Adcock reports

Volkswagen's COTY winning Polo tips the scales at 1,092kg – 180kg more than a similarly powered 44kW model a decade ago. Back then, a diesel Land Rover Discovery came in at 2,075kg: you can add 400kg for the latest model. Even a high performance car like Aston Martin's DB9 is no lightweight at 1,760kg, despite extensive use of aluminium.

Increased crash performance is demanding stouter structures, while content is constantly increasing, although one has to wonder at the necessity of electrically-powered soft closing doors on some top end models, such as BMW's 7-series.

Specialist manufacturers, like Aston Martin, have the advantage over mainstream producers, in that their customers can afford to pay the extra demanded when exotic, lightweight materials are employed. Hence Aston is using the rarefied One-77 as a technology test bed for future solutions, including lightweight materials, according to engineering director Ian Minards.

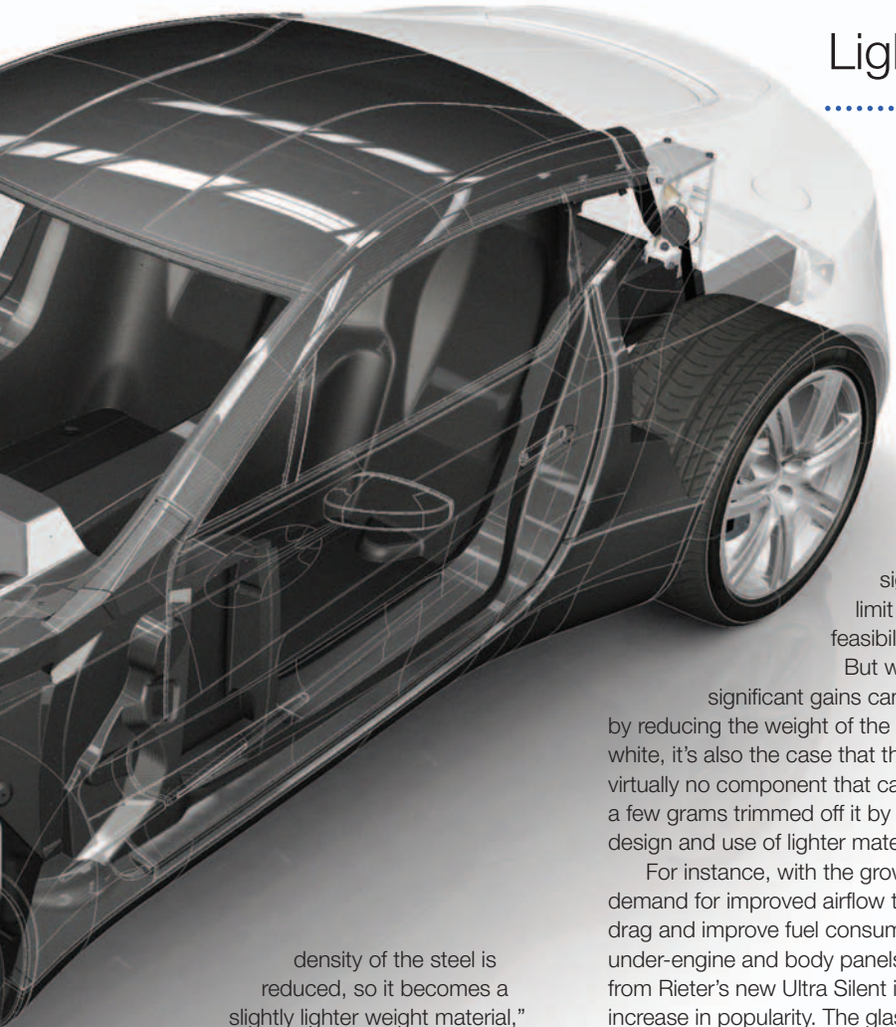
"There are some materials that wouldn't translate into hundreds of cars a year, like pre-preg carbon. But the direction we're talking about is more lightweight body structure and more efficiency on mass throughout the whole car," he explains.

There is already limited use of carbon on the DBS trunk lid surround, but says Minards: "That could lead us to using more carbon in our cars – not just bonded aluminium – in the future."

Built by Canada's Multimatic, the One-77's high-tech, strong, light carbon monocoque "is a signal of where we might go in the future," not with a complete carbon structure, but more carbon in the body, he explains. However, while that might work for a 7,000 a year manufacturer like Aston Martin, it's not close for mass producers that need easily manufactured and affordable solutions.

Steel is still the preferred choice for these OEMs and, says Corus, for every kilo of advanced high strength steel (AHSS) used, there is a total life cycle saving of eight kilograms CO_2. But it's not enough. As Jon King, director of automotive engineering at Corus, says: "If it's mandated, achieving 95grm/km in 2020 is going to be a big task and there's not a lot of time to get there." He expects a more aggressive shift towards lightweight materials for vehicles, especially electrically powered ones, not least to offset the weight of the batteries.

There are solutions. For example, twinning induced plasticity (TWIP) steels, which have high manganese content, exhibit very good ductility, in terms of press forming, although welding and coating can present difficulties. "With its high manganese content, the actual



Aston Martin One-77 features lightweight materials as a test bed for future models

density of the steel is reduced, so it becomes a slightly lighter weight material," explains King.

In the medium and longer term, though, sandwich and laminate steels will start to gain favour, despite a cost penalty and current challenges in welding. King sees future applications in areas such as the floorpan, wheel tubs and front bulkheads, where there's also the prospect of some NVH gain. "The real challenge," he says, "is to come up with steel that's consistent in its manufacturing and its forming and joining properties, and is easy to work with."

Bonding advantage

One solution to joining multi-layered steels and, indeed, hybrid structures of aluminium, steel and composite would be by bonding. And 3M claims that, by using thinner sheet, it is possible to down-gauge 20% on some panels, resulting in a 100kg saving on a C-segment vehicle.

Adhesives can also save weight in more complex areas of the body structure, while more efficient stress transfer can eliminate the need for some reinforcements. Also, a higher level of design flexibility becomes possible, because it's no longer a requirement to provide for weld access, which can significantly limit design feasibility.

But while significant gains can be made by reducing the weight of the body in white, it's also the case that there is virtually no component that can't have a few grams trimmed off it by clever design and use of lighter materials.

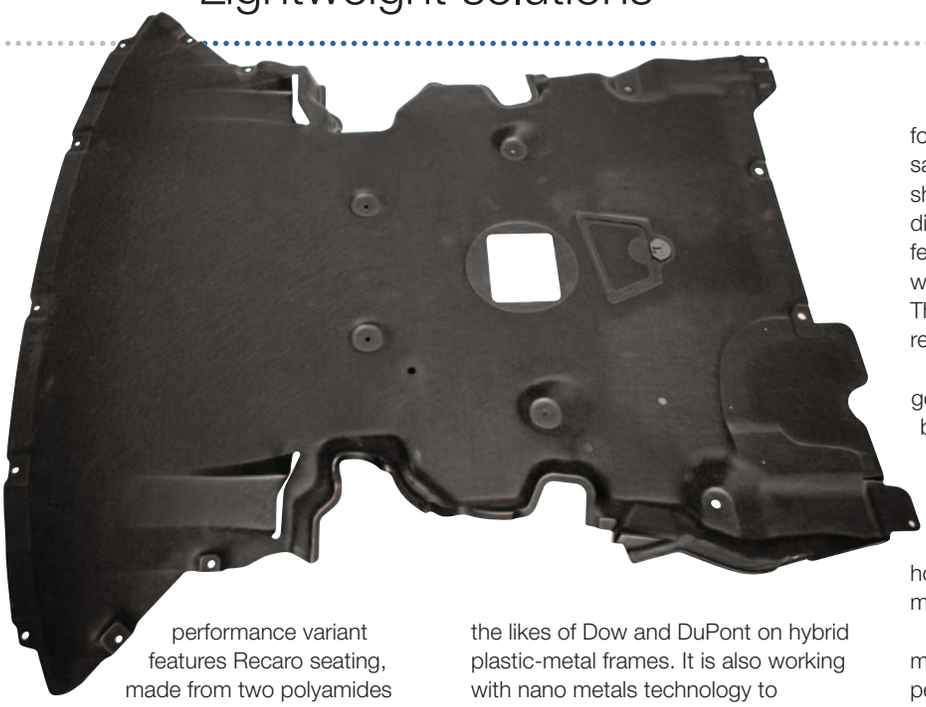
For instance, with the growing demand for improved airflow to lessen drag and improve fuel consumption, under-engine and body panels made from Rieter's new Ultra Silent is bound to increase in popularity. The glass-free polyethylene terephthalate (PET) material is fully recyclable and can result in an average 45% or 2.7kg weight reduction on an underbody package – with no additional acoustic absorber required. Rieter is also developing future interior applications for its Ultra Silent.

Beyond this, advances in plastic formulations mean that there are now applications that would have been undreamt of 20 years ago. ContiTech Vibration Control and BASF, for instance, worked together to develop a lightweight stabiliser for the Porsche Panamera. Manufactured from high-strength polyamide grade Ultramid A3WG7 CR and a function-optimised natural rubber formulation, this high-performance multi-material part withstands engine torques up to 650Nm, yet weighs 35% less than a metal equivalent.

Likewise, the BMW 550i GT incorporates a high-strength polyamide transmission cross beam. By using Ultramid A3WG10 CR, instead of aluminium, it was possible to halve the component's weight. Then again, in an industry first, the new Opel/Vauxhall Insignia has a torque rod support also made from Ultramid A3WG10 CR – again resulting in 35% weight saving over a metal version.

And staying with the Insignia, its high

Recaro seat features two Ultramid polyamides in its structure



performance variant features Recaro seating, made from two polyamides from the Ultramid family, as well as specialty foam Neopolen. Then the seat pan, backrest shell and crossbar were designed using Ultraslim simulation.

While on that subject, seating shows considerable potential for further weight reduction. In the long term, Lear is looking at minimising steel content in its seat frames and is actively working with the likes of Dow and DuPont on hybrid plastic-metal frames. It is also working with nano metals technology to impregnate thin wall steels with carbon, in order to increase strength. Remember, Lear was the first-to-market with metal eliminated from rear seats, having replaced it with 100% recyclable structural foam and removed upwards of 6kgs from the assembly.

But Lear is not alone: Borealis' PP SGF 30 has been developed specifically for structural seat parts with improved safety levels. The new 100% PP Xmod short glass fibre compound offers dimensional stability, design flexibility, fewer manufacturing steps and 35% less weight, compared to steel structures. That also adds up to a 20% part cost reduction.

As for the future, with the latest generation of plastics offering similar benefits to carbon fibre, but without the cost and production complexities, seat producers would do well to look at non-automotive industries, such as aerospace and computing, to see how they integrate wiring and electric motors into plastic sub-structures.

2020 isn't that far away and, if manufacturers are to avoid swingeing penalties for missing the proposed 95g/km fleet average, then reducing the mass of their cars will play a pivotal role in achieving essential emissions and fuel consumption targets.

Top: Reiter weight-saving underfloor pan
Left: Porsche Panamera employs lightweight engine stabliser

Dipl.-Ing. Heinrich Timm, head of the Audi Lightweight Design Centre

Audi leads the way in aluminium-intensive cars, so what does the future look like?

Audi led aluminium-intensive car development, with the A8 in 1994, so Automotive Design asked its head of lightweight design, Dipl-Ing Heinrich Timm, about the carmaker's approach to aluminium, compared, for example, to that of Jaguar.

"Jaguar has been in partnership with Alcan for decades. Their body concepts were developed from the only suitable semi-finished aluminium product available as sheet," says Timm. "In 1982, Audi had to determine whether to develop aluminium as a body material – and, after analysis, we decided that it was worthwhile, but only if we could deploy it in all semi-finished forms. Subsequently, Audi did pioneering work in the areas of thin-walled ductile die-castings and extrusions with Alcoa."

Initially, Audi used small castings, but has long since moved on to multifunctional, large structural body elements. "The ASF [Audi space frame] concept has many advantages: castings and extrusions make it possible to create multifunctional geometries, to transfer bionic principles with better lightweight performance, and to place materials in exactly the place that function demands. It also allows for a reduction in the number of parts.

"Through the use of semi-finished castings and extrusions, ASF also enables better usage of the available package, in terms of stiffness and crash-management. Audi believes ASF delivers the best lightweight performance for each body function. And, in production, the level of automation is comparable to that of a steel body."

> "In general, there will be an increase in the use of hybrid structures"

Although aluminium is currently the preserve of relatively high-end, low volume prestige cars, Timm doesn't see this as always being the case – especially when hybrid structures are factored in. "For many reasons, it makes good business sense to introduce new technologies top-down, and this is also true for ASF. However, the current A4 and A6 model ranges already include some ASF components and the amount will increase in the future," he says.

And he adds: "The state of the art in aluminium technology suggests that further improvements are to be expected. There will also be an increase in the use of hybrid structures, [because] they make it possible to apply the correct material, the smallest amount and at the best place... We have also optimised our processes and that has enabled significant cost reductions. We remain focused on sensible composite developments, which bring additional lightweight potential, and on better joining technologies via improved industrialisation."

Finally, Timm is at pains to reject any notion that aluminium limits a car's appeal: "It's true that the material properties of sheet steel are better for forming and for creating sharp creases. However, Audi has built tremendous know-how. Just look at the sharp design creases on the new A8 and R8, or at the feather edges on the TT."

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