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Comment

The right connections

Eleven years have passed since Ford debuted its futuristic 24.7 concept at the 2000 Detroit show, with its voice-activated email, ‘phone, navigation system and reconfigurable display. It, and similar concepts, was hailed as the new automotive high ground and profit centre for financially beleaguered OEMs.

I was reminded of this when I read the news that Ford’s president and chief executive officer Alan Mulally had eschewed the Geneva Salon, in favour of delivering a keynote speech at the CeBIT global conference (which clashed with the opening days of Geneva). This comes only weeks after he attended the Consumer Electronics Show in Las Vegas where he was joined by Audi chairman Rupert Stadler.

There was barely a manufacturer at Geneva that didn’t have some kind of connectivity on display, because the Facebook generation now demand these electronics. Owning and driving a car is not the aspiration it once was. “Because electronics are happening so fast, I would say that, in five years’ time, the features we have on the Vision ConnectedDrive Concept will be a reality,” BMW’s head of design Adrian van Hooydonk told me. And with open platform systems combining with cloud computing, Wi-Fi and Bluetooth, it’s difficult to argue against that.

Elsewhere, as you will read in our cover story, carbon fibre is beginning to make the breakthrough it has long promised, but never delivered. Although it is still predominantly the preserve of exotica, BMW’s plans for its i3, and news that VW has bought into SGL, demonstrate how serious mainstream players are getting about this once exotic material. But, for it to truly succeed, suppliers need to develop carbon fibres and resins that are more suitable to automotive applications and costs, rather than the limitless budgets of the aerospace industry.

Ian Adcock, Editor in Chief
Jaguar breaks through the 150g/kms barrier

The latest XF, which debuts at the New York motor show in April, achieves just 149g/kms CO$_2$, making it the most efficient Jaguar to date, writes Ian Adcock.

“It matches the two-litre diesel X-Type, in terms of CO$_2$, but delivers 140kW at 3,500rpm and 450Nm from 2,000rpm,” says chief programme engineer Andrew Whyman.

The four cylinder engine is the same 2179cc mounted transversely in the Land Rover Freelander, but engineered by Jaguar for its first north-south installation. “When the engine was first conceived, Ford and PSA were not massively keen on the programme, because of manufacturing restrictions and engineering, so it came down to us to make the changes,” explains Gary Reid, senior manager diesels.

Principal amongst these would have meant adopting a different injector system to deliver greater fuel flow. “Given a free hand, I would like to have seen 150kW, but we couldn’t afford to have another injector on the assembly line and, without that and other mechanical changes, we couldn’t achieve it,” says Reid.

Eight hole Bosch injectors, running at 1850bar, and engine management system are used, with a 15.8:1 compression ratio. To distinguish the engine characteristics from its siblings, Reid and his team focused on refining noise, vibration and harshness to deliver a more refined sound and engine note.

“PSA did a good job taking the engine from ‘B’ level to ‘C’ level, with a lot of attention to detail in the structure, including lessons learned from our engine programmes. So we thought we could do something externally to the engine to improve it. The main areas of attention were block attenuation and behind the starter motor.”

The team started by using a dynamometer mounted Freelander engine in a semi-anechoic chamber, together with an acoustic camera to map the source of engine noise. They then worked with NVH partner Woco to develop specific solutions to eliminate unwanted noise: a ‘glove’ inside the aluminium casting for the alternator that absorbs radiated noise coming off the engine, and an ‘injector sock’ beneath the top cover, which shrink-wraps round the fuel lines and wire harnesses etc on top of the engine. By injecting air into the foam during the moulding process, Woco is able to tune its density on a local basis.

Navteq and Magnetti Marelli unveil low-cost navigation system

Navteq and Magnetti Marelli have teamed up to deliver the first low-cost navigation system, based on the open sourced Linux operating system, that is fully Genivi compliant. This means it is fully customisable and updateable, as new technologies emerge.

“It also offers full end-to-end support, with a web portal where widgets and applications can be downloaded, so the consumer can build the system the way they want to,” explains Florian J. Künne, VP customer marketing Navteq, adding that it also allowed OEMs to incorporate innovation cycles much faster and the ability to differentiate between each other.

In a separate development, its natural guidance system, which utilises a broad range of prepositional cues such as ‘before’ and ‘after’ to guide the user more accurately, will be available for 200 western cities by the end of the year, in addition to emerging markets.

Again based on the Linux open sourced platform, it can be adapted to any OEM requirement, with a faster speed to market and lower development costs. It also allows the consumer to buy additional widgets directly from the car. “Research showed that consumers were getting confused, especially at complex junctions, with instructions like ‘take the left lane and left again in 150 metres’. This is far more intuitive,” says Künne.
A new sandwich construction oil pan was designed for the north-south location and to further lessen NVH by 3dB over a single metal skin. Rotating the engine to north-south demanded new engine mounts, with that on the non-exhaust side combining the mount, oil filter and oil cooler, which resulted in some weight-saving. At about 172Kgs, the engine is a little lighter than in the Freelander, thanks to fine-tuning of brackets and other detailed work, including replacing the cast steel camshaft with a modular one, that accounts for a kilo on its own.

The engine also gets a water-cooled Mitsubishi TD04L turbocharger and closed loop exhaust gas temperature control, which measures air temperature going into the turbo, rather than implying it. A stainless steel exhaust manifold allows higher exhaust gas temperatures and the ability to run the engine harder.

Adopting ZF’s latest eight-speed 8HP automatic transmission ensures the XF has the right blend of smooth shifts and optimum fuel consumption, with eighth gear pulling 72.4 Km/h per 1000rpm in top gear, so that, at 112 Km/h (70mph), the engine’s turning over at a lazy 1556rpm.

However, it is the adoption of a Denso-based, but Jaguar developed, stop-start system that is being claimed as a first in this engine capacity/model price category, says Whyman.

Jaguar investigated belt-drive Instant Starter Generator, but its additional cost, complexity and packaging issues mitigated against it, “although we were very impressed with its performance”, recalls Adam Letherland, micro hybrid team leader. While a conventional starter motor doesn’t allow for a ‘change of mind’, “the Denso tandem solenoid starter (TSS) has the performance of a belt-driven ISG, but at the price of a starter motor”, he adds.

The advantage of the TSS is that it can either engage the motor to speed up the pinion and then engage the pinion into the ring gear, so that it extends the restart window, without having to wait for the engine to stop completely; or, if the engine is sufficiently slow, the pinion can be engaged to catch it before coming to a standstill; or, finally, once the engine speed is zero, the pinion can be pre-engaged with the ring gear and then, as and when it’s time to restart, the pinion is ready to start the engine.

A bi-directional crank sensor ensures there’s no loss of synchronisation, so the engine will fire up at the first opportunity, while a solenoid blocks the fuel rail to maintain injection pressure.

The 12v, 110amp main battery is backed up by a small motor cycle battery, controlled by an electrical load manager. All the electrical features are maintained by the larger battery up to a split second before it’s required to crank the engine, at which point the smaller battery cuts in for less than 0.5 secs, before the main battery takes over.

A clever ABS system will hold the car on gradients up to 15%, even with the engine off and the driver’s foot clear of the brake, an accelerometer determining the slope’s angle. During testing, engineers proved it at gradients as steep as one-in-two and one-in-three, but felt this would prove unnerving for customers.

The stop-start also recognises when the car is being parked, as opposed to just stopping in traffic, via a combination of signals from the brake pedal and the driver’s seat belt being unbuckled.
News in brief

Stop-start in US

delayed
Acceptance of stop-start systems is being delayed in North America, because most cars are automatics and not manuals, according to Doug Patton, senior VP engineering division, Denso International. Patton predicts that 'change of mind' stop-start systems on domestic products will launch in 2013, preceded by less sophisticated systems.

Sat-Nav saves fuel

Freightliner in the USA is claiming a 3% fuel saving, thanks to running a Navteq navigation system, linked to its trucks cruise control. Similar technology is expected to be introduced by European car and truck OEMs in 2012.

Vital link

Using a mid-range radar, combined with scalable video, TRW has linked its automatic emergency braking with its active control reactor to prime and apply the brakes, and pre-tension the seat belts prior to an accident.

Intelligent fuel pump

Continental’s intelligent fuel pump, which can save up to 70% electrical energy, compared to a constant supply pump, resulting in a CO₂ saving of 2 grams per kilometre in a 1.8-litre engine, goes into series production in 2013.

New Michelin tyre

Michelin has developed a new ultra high performance tyre for the super sport car segment, using Teijin Aramid’s Twaron as a reinforcement material.

The Michelin Pilot Super Sport tyre contains three new technologies that combine speed and safety. Twaron, the high-performance aramid fibre of Teijin Aramid, ensures the tyre remains in its most ideal shape, even at extreme high speeds. Twaron also ensures the tyre has high-speed stability and resists high temperatures.

Correction

In the last issue, Vittorio Doria was quoted as chief engineer for the FPT C635 DDCT transmission, whereas it should have been Ing. Francesco Cimmino. Apologies for any confusion.

Revised Lotus range extender

Lotus Engineering has made significant changes to its three-cylinder range extender engine, in order to satisfy demands from potential customers.

The biggest single update is abandoning the original’s aluminium monobloc design with Nikasil liners for a separate head and block with cast iron liners. “OEMs wanted proven robustness and a more conventional block, with lower investment,” explains Lee Jeffcoat, chief product engineer, efficient performance Lotus Engineering. Bore and stroke have increased slightly, upping engine capacity from 1.2 to 1.3 litres, while the inlet manifold is now integrated into the block, reducing overall manifold length from 700mm to 200mm.

The naturally aspirated version produces 35kW and 35kW electrical power, while the Rotax supercharged variant increases this to 55kW and 50kW, respectively. "A number of potential clients wanted to sustain higher speeds or had heavier cars, which led us to develop the supercharged version," states Jeffcoat. Deciding to use a supercharger, which reduces the compression ratio from 10:1 to 8.5:1 and runs at 0.8 bar boost, rather than a turbocharger, simplified the installation and meant it was easier to run the engine either vertically or horizontally with the exhaust face down.

Engine build starts late April/early May, with the first vertical prototypes running by the middle of the year. Horizontal versions will be fired up later in the year, with the first customer deliveries by the end of 2012.

Jeffcoat says that a number of UK companies are interested in the technology, as well as several European OEMs – but in a different version, on which he didn’t elaborate. The biggest interest has been shown by American and Chinese OEMs.

Currently, the extender uses a bespoke design generator from Fagor Automation that operates at 91% efficiency and above 88% at other operating points. Although Lotus Engineering would prefer customers to take the complete package, an adaptor plate could be fitted to take different generators.
News

Major weight reductions

Johnson Controls has developed a bonded steel and aluminium rear seat structure that weighs 34% less than a comparable all-steel frame. In order to reduce weight, the upper and lower cross members consist of aluminium. The side members and reinforcing cross beam are still steel, resulting in a 30% weight reduction, compared to the conventional steel design. Johnson Controls was also able to reduce the thickness of the steel back panel from 0.6mm to 0.4mm.

Car hacked by Bluetooth

Researchers in the US have brought the prospect of car hacking – where cars’ embedded electronic systems can be accessed and controlled by malign forces – a step closer to reality by demonstrating on a recent production vehicle via Bluetooth that such an attack can be carried out successfully.

Previously, the same team, from the Universities of Washington and California San Diego, had shown that hacking could be achieved via a car’s onboard diagnostic port. By demonstrating that access can also be achieved remotely, in this instance by exploiting security vulnerabilities in Bluetooth connectivity, they have given impetus to concerns that the connected car brings with it new opportunities of attack. (See ‘Lethal Weapons’, Automotive Design, Jan-Feb 2011.)

It took 10 researchers two years to achieve the hack, so the team has emphasised that it requires considerable technical resources to pull it off. There is no known case of criminals having attacked cars in this way and the level of difficulty means that such attacks are not an imminent risk. But the fact that the researchers gained control of safety-critical functions, such as the braking system, will raise concerns that a determined, widespread attack might have major consequences.
Opel/Vauxhall’s Zafira concept, unveiled in Geneva, features an innovative seating concept that converts the middle row of three seats into a pair of lounging arm chairs, complete with arm rests.

The outer pair of seats slide rearwards on rails, increasing legroom 130mm, and over the centre cushion, whose back rest folds forward to form the arm rests. Either both or just one of the rear seats can be converted, says Frank Leopold, GME manager innovation advanced package & concept cars. Additionally, the seat backs can be reclined from 23° to between 33° and 38° for increased comfort and the headrest turned from vertical to horizontal, forming a pillow-like shape. In another first, Leopold explains that the centre seat belt is anchored from one of the two outer seats whose belts come off the ‘C’ post.

Production versions of the patented design are expected to be seen at the Frankfurt Show in September.

The concept also features a novel, polycarbonate roof panel, illuminated by LEDs embedded in its perimeter, that changes colour according to where the passengers are seated. “The material is patented by its manufacturer, but we haven’t decided if it’s going into production,” adds Leopold.

Schaeffler has developed a new slim design of spur gear differential for passenger cars, which is not only 30% lighter than its predecessors, but will also frees up to 70% axial space in the gearbox.

Furthermore, the shape of the differential enables the use of new bearing concepts with optimised friction characteristics, which, in turn, will have a positive effect on fuel economy and CO₂ emissions. Ultimately, the lightweight differential will save space that can be used for larger dual clutches or transfer gearboxes, as well as making room for electrical components on hybrid electric vehicles.

Thorsten Biermann, project manager advance development automotive transmissions at The Schaeffler Group, comments: “In absolute terms, this means up to three kilogrammes mass reduction for each differential and up to 90mm of extra space in the gearbox.”

The design of the new lightweight differential was inspired by another project at Schaeffler. The group’s automotive advance development division came up with the new idea after working on a planetary stage design for an automatic transmission manufactured for a metal-forming process application. This inspired the team to come up with a differential in a planetary design for a typical mid-size passenger car.
BASF targets 400Kms battery range

BASF has announced it is investing more than €100 million in the next five years into battery research, in a determined step to close the gap in future battery technology with its Asian and American rivals, says Dr. Andrea Kreimeyer, BASF’s research executive director (pictured).

It will be researching novel cathodes and anode materials, as well as electrolytes and separators, with the Karlsruhe Institute for Technology at their recently announced Bella laboratory. Although initial research will concentrate on lithium ion batteries, BASF has also licensed a broad portfolio from Argonne National Laboratories for second and third generation Nickel Cobalt Manganese, as well as Li-ion phosphates – that should appear by 2015-16, predicts Kreimeyer. The longer term objective is to move to lithium sulfur by 2020-2022.

“Our activities must be focused on guaranteeing a range of 400 Kms for a battery weight of 200Kgs,” Kreimeyer adds.

Electronic aids help CO\(_2\) reductions

Customer acceptance is holding back the wider adoption of electronic driver aids, claims Jerry Hardcastle, Nissan’s vice president vehicle design and development. “It’s not the technology, but the customers. EuroNCAP coming on board with its Advanced awards will help drive customer awareness and to reduce the accident rate.”

The systems could also impact positively on CO\(_2\) emissions as well, he says. “People tend to brake too hard and too late, wasting fuel. If that was a more controlled process, it would help with CO\(_2\) emissions.”

He also warns that the infrastructure must be in place as well, with consistent roadside warnings for speed and other driver information.

Zulieferer Innovativ 2011

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Save the date: Audi Forum Ingolstadt, July 6, 2011
Ferrari’s new FF four-seater has a highly innovative lightweight four-wheel-drive system, designed and assembled in-house. The company’s engineers say that, including driveshafts, it weighs just 45kg – about half that of a conventional hang-on front-axle drive.

The drive unit takes its power directly from the nose of the V12 engine’s crankshaft, so there is no transfer case or forward-leading propshaft. The engine is mounted far enough back that the whole front-drive system can be fixed to its nose. The rear wheels use a seven-speed, dual-clutch sequential transaxle, similar to that in the rear-drive California.

Within the front drive unit casing are a two-speed gearbox and a pair of electronically controlled multi-plate oil-bath clutches. When the car’s ECU determines that drive to the front is required, it progressively closes the clutches. The two clutches are independently controlled: one drives the left front wheel, the other the right. Thus there is no need for a front differential and torque vectoring is achieved.

The front gearbox’s two ratios are similar to second and fourth in the main rear-axle gearbox. Any discrepancy in the drive ratio between front and rear wheels is taken care of by the slippage of the clutch packs. Above the speed of fourth gear – approximately 180km/h – drive to the front is disconnected.

The system will send drive to the front wheels, if the rears spin. But it does not demand that condition. The car has a model-based map of circumstances when drive to the front would be advantageous.

The front-drive mapping is one factor controlled by the ‘manettino’ control on the steering wheel, which allows the driver to dial the car’s various dynamic systems towards either stability or sporting response. If the manettino is dialled towards the ‘race’ setting, the front-drive torque is reduced to a minimum, to preserve steering purity and the traditional Ferrari rear-drive dynamic feel.

SKF has launched an innovative new rocker arm bearing, developed to enhance the operating of valve mechanisms in 4-stroke engines. It is claimed this new technology allows significant fuel savings to be realised, along with major reductions in both friction and operating temperatures, and has been introduced to meet the increasing demands of a competitive global market, as well as end users looking for more pioneering, fuel-efficient engines.

The pre-assembled rocker arm bearing unit produces appreciably lower levels of friction than conventional rocker arm designs, helping to extend engine life and reduce service cost. The novel design of the unit draws on SKF’s expertise in different fields, including bearing, seal and lubrication technologies.

This has resulted in a cutting edge design of radial clearance, outer ring crowning profile and an engineered surface pattern to achieve extremely accurate valve timing and far quieter operation.

The new technology has undergone extensive endurance test cycles, as well as component validation tests, and has proven to be exceptionally robust and reliable. SKF’s engineers will also work closely with designers at specific manufacturers to retrofit rocker arms of existing designs with an SKF rocker arm bearing unit or to modify the unit to match new application specification and demands for the ultimate in design flexibility.

Franco Ferro, director of electrical and two wheeler business unit at SKF’s automotive division, comments: “This new bearing solution is yet another successful step in our strategy to be an innovative partner to the global two- and three-wheeler industry, through the delivery of ultra energy efficient vehicle performance.”
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Shape of things to come

Tony Lewin talks with TRW’s Matt Roney about the megatrends shaping future vehicle technology

As the man responsible for product planning at the world’s eleventh largest automotive components supplier, Matt Roney exerts above average influence on the technologies that go into the vehicles pouring out of international car plants. His job is to make technology happen – not in the laboratory, nor for just a handful of wealthy buyers in top premium automobiles, but for the vast mass of motorists driving everyday cars, on an everyday budget.

At TRW, the rule is simple: vanity projects are out, as is costly fundamental research, pushing the scientific envelope just for the sake of it. Instead, the focus is firmly on the level-headed selection of sensible technologies that deliver maximum value for millions of customers. The prime example of this, and the foundation for TRW’s rise to its current prominence, is electric power steering (EPS): it’s more effective to save a couple of grams of CO\textsubscript{2} across a 2-million unit platform, argues Roney, than to halve – at great engineering cost – the emissions of a luxury limousine that only a handful of people will be able to afford.

While acknowledging the importance of what he describes as TRW’s “massive push” to improve fuel efficiency, he prefers to hold back and evaluate before putting TRW’s name to every initiative that comes along. Take electric rear axles, for instance, currently in vogue as a handy way of turning a front-drive model into an eco-friendly, all-wheel drive hybrid.

“It’s interesting, from a technology standpoint,” he notes, “and it includes many things that we are good at, such as electromechanical, and electro-hydraulic actuation and control systems. But we’re not an axle or differential or gearset manufacturer, and the volumes and fitment rates of those technologies are still fairly small. They’re niche-type applications – as opposed to the 75% of the world’s vehicles which have EPS or the 80% that have electronic brake controls.”

Indeed, the percentage test is a theme that crops up at regular intervals in conversation with Roney – nowhere more so than in braking, the area that, alongside EPS, forms the core of TRW’s business with the world’s automakers. TRW developed the electro-hydraulic braking system that allows the Chevrolet Volt to blend regenerative electric braking with conventional friction brakes. “This Slip Control Boost system [for the Volt] was our first excursion into the market,” he says. “It was designed for a full hybrid system – a vehicle that’s capable of running on an electric motor alone. The real challenge for the future is that not all hybrids are the same: they range from stop-start micro hybrids, all the way up to a plug-in hybrid or EV.”

The dilemma, he explains, is how to engage with a model range that is, say, 90% internal combustion engine and 10% hybrid. “How do you approach the technology application on that vehicle? Do you design something unique for the 10% or do you have something that works across all of it?”

An added complication in the mix is that not all IC engines are the same either. Gasoline direct injection, for instance, does not provide a handy source of vacuum to power the brake booster.

“There’s a tipping point coming in the next five or 10 years,” Roney predicts. “This is where we will see a crossover, when these low vacuum and no-vacuum engines (such as those with stop-start) will begin to exceed the volume of the traditional multi-point injection engines in the market. That tipping point will coincide with a next step, in terms of technology solutions, that will be affordable enough to cover that range of volumes.

“To put the electro-hydraulic system onto the 90% of the vehicles that don’t need it is very cost prohibitive,” he continues. “But, if you can develop a solution that’s cost effective enough for the majority of that 90%, as well as working for the 10% – now you’ve got a value proposition that works.”

Roney is understandably coy.
Educated at Cornell, Harvard and Purdue, Matt Roney is vice president for product planning and business development at TRW, with responsibility for all of TRW’s product lines, its product strategy and roadmap. His biz-dev brief also includes responsibility for M&A (mergers and acquisitions) and alliances. Prior to joining TRW in 2008, he worked at supplier Siegel-Robert Automotive from 2005, consultants McKinsey & Co (2002-2005), and Ford Motor Co (1996-2001). Roney is married, with one son.
Automotive Design Interview

about divulging details of what is clearly a highly significant development. "What we’re focusing on is future-proofed and hybrid and low-vacuum proofed solutions that allow you the opportunity to run without vacuum, with or without regen, to develop a base system architecture that works across the range," he says. "We’ve got it."

Electric parking brakes are another technology that TRW did much to establish in the last few years, and have become a familiar fitment on D and E segment European vehicles. Now, states Roney, the focus is on increasing their breadth of application, moving them downwards into the C and B segments and capitalising on an as-yet unexploited advantage – that of low weight.

"In the current climate of weight reduction, we see good potential to push this not just in the smaller car arena, where EPB can save around 5kg, but on bigger SUVs where the saving can be as much as 15kg."

A third area where the EPB is attractive is that of residual drag reduction, with a motor on the caliper (made of aluminium) actively retracting the pads from the brake rotor after each park brake application. Every little improvement such as this helps fuel efficiency, he notes.

While the world of foundation brakes is on the verge of its revolution, that revolution has already taken place in the arena of steering. The transformation brought about by EPS has been both sudden – from a handful of applications in the B segment a decade ago to today’s position of dominance – and far reaching. EPS has opened the door to a host of safety and convenience technologies that would have been impossible with traditional hydraulic systems. Perhaps the best known of these convenience functions is that of auto park, where the driver only has to operate the accelerator and brake in a reverse-park manoeuvre, leaving the steering to computer control. Now, however, with TRW into its next generation of EPS, the possibilities of other types of intervention in the steering have expanded exponentially.

"Already in production is the Lancia Delta, with our lane-keeping system. The camera detects the lane markings and our EPS system provides the torque overlay to keep the vehicle in its lane."

Beyond that, there is the capability for more dynamic functions, such as oversteer control, blending stability control through ESP with steering control, with oversteer and torque steer compensation. "All that suite of features has been done. We have systems that can completely steer the vehicle in its lane, but the Fiat application is a bit more subtle and works well, in terms of driver acceptance."

TRW’s most sophisticated EPS to date is the belt-drive system on the new Ford Focus family of platforms. Still more features are built into the second and third-generation EPS systems, which, he says, have been sold to other manufacturers and will appear within the next year or two.

Among the new functions are automatic wind drift compensation, ‘nibble’ compensation to deal with out-of-balance tyres, and torque and angle sensors that can detect when the driver is becoming drowsy, sounding warnings or applying a vibration to the steering wheel to restore his attention.

In theory, full collision avoidance is also possible through intervention in the EPS. Yet, says Roney, concerns about consumer acceptance and reliability mean these “dramatic” uses of torque overlay are unlikely to become reality. "All the building blocks are there, right the way up to fully autonomous driving. But I don’t expect autonomous vehicles any time in our lifetimes. What I would expect is a gradual journey towards more semi-autonomy for the vehicle: freeway driving, for example, could be almost entirely autonomous."

Next-generation versions of today’s technologies will almost allow drivers to take a nap while the vehicle runs on the motorway. "It will keep you in the lane, it will keep you a safe distance from the vehicle in front, it will bring you to a full stop, if needed. But in urban driving, the number of variables is such that the driver’s attention is required."

Asked why TRW appears to be less proactive when it comes to the technologies of electrification and hybridisation currently commanding so much attention in the industry, he says he is keeping a watching brief. Electric corner modules, drive motors and axles all face significant hurdles, he points out, and are still too niche to figure large on the TRW radar. "Our focus is the majority of vehicles," he reiterates, hinting at the same time that this is a gap in the corporate portfolio and that collaboration with other companies could be a solution.

"We’ve got our eye on a couple of interesting applications," he reveals somewhat enigmatically, not saying whether he is alluding to individual technical developments or complete companies.

A case, perhaps, for Roney to flip his business card over to reveal the second, and no less important, title in his job description – business development director, responsible for corporate mergers and acquisitions, joint ventures and alliances.
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ocial media, and the technology associated with this, are reshaping and revolutionising the way people put forth and accept information. Status pages are updated instantly and bits of information are shared for the world to see.

It’s no different at SAE International. With pages on Facebook, Twitter and LinkedIn, SAE International is embracing this ever-changing communication technology. Team members from customer service, marketing and corporate communications are regularly posting updates and information about all of SAE International’s programmes, products and services.

But it goes beyond that. Last year, SAE International launched its new ‘EngineerXchange’ website. EngineerXchange – http://engineerxchange.sae.org – is an online professional network for SAE International members. The site gives members exclusive access to powerful networking tools, career counselling and management tools, and advance access to SAE International’s vast repository of technical content.

EngineerXchange, along with the social media pages that SAE International has developed and populates, are just one part of our overall commitment to the new way of information delivery.

In addition to the digital versions of SAE International’s award-winning magazines—Automotive Engineering International, Aerospace Engineering and SAE Off-Highway Engineering—which launched last year, our publications team now offers all books in e-book format, allowing customers to purchase individual chapters, as well as the entire title. SAE International’s existing library of titles is being transferred over to the e-book format as well.

The electronic initiative continues with our vast repository of technical papers. In the past 12 months, we have converted more than 20,000 technical papers written between 1906 and 1979 to downloadable PDF documents. This means that SAE International’s entire library of 88,000 documents is now available electronically.

More recently, we began implementing a new content management system that will give more options to customers in how and when they get and access information. New subscription-based product packages are being created for both SAE International’s technical papers and standards; the result is more options, more flexibility and more ways to access relevant information.

These programmes and initiatives are just the beginning of SAE International’s commitment to embracing new technology. Whether it is social media or a new electronic content delivery method, we will continue SAE International’s tradition of not just staying ahead of the curve of innovation, but helping to define that curve.

SAE International has a long and well documented history. Many of the tried and true practices that helped build this organisation will continue to work into the future. But staying on top of what is new, and what is yet to be discovered, is key to success; and SAE International always will strive to be a leader.

“In the past 12 months, we have converted more than 20,000 technical papers written between 1906 and 1979 to downloadable PDF documents”

David Schutt, The Columnist
SAE International Chief Executive Officer

March/April 2011
www.automotivedesign.eu.com
One day in the future, cars could weigh half of what they do today, emit less carbon dioxide and be easier to recycle. Most of this will be down to one material: carbon fibre (CF).

Until now, this material – used as a reinforcement to make components with very high strength-to-weight ratio – has been largely restricted to the aerospace industry. The only things with four wheels that use it are racing cars and a small number of ‘supercars’.

But several fundamental changes have combined to move it into the mainstream. Changes to the supply chain, and advances in both automation and materials technology, are helping to make it more available and affordable – pointing to a true carbon future for the industry.

“The mass-market carbon fibre
where once McLaren could expect an output of one monocoque per week, it now has its sights set on twenty per day. “It’s about taking carbon fibre out of the autoclave,” he says.

Traditionally, monocoques were made from pre-pregs: carbon fibre, impregnated with epoxy resin, was laid up by hand, put in a vacuum bag and cured in an autoclave. Using RTM, Austrian company CarboTech has supplied monocoques to McLaren for the last 18 months, but has only been in “series production” since the end of last year. It has recently built a complete new plant, employing 100 people.

Accelerating problem
According to Karl Wagner, CarboTech’s ceo: “We have a daily shipment to the UK, but won’t reach maximum daily production until August.” At that point, he expects to be making 20 monocoques per day across two plants. “All of our customers make sports cars or luxury cars – but the McLaren project is the most demanding: it’s a very complex part, made at high volume,” he says.

Changes to the supply chain are also helping to boost the use of carbon fibre. BMW recently formed a joint venture with carbon fibre producer SGL, in order to guarantee supply of material.

In the past, the start of a new aerospace project would see carbon fibre supply shut off to the automotive industry. This is now changing, says Santoni. Automotive companies are dealing directly with fibre suppliers, rather than leaving this task to their moulders. “This gives us a guaranteed price and a good supply for the next 15 years,” he says.

Paolo Feraboli, director of the Automobili Lamborghini Advanced Composite Structures Laboratory (ACSL) at the University of Washington, says that the specialised nature of carbon fibre makes it a ‘strategic technology’. “When you make a part, you make the material at the same time. Material and structure are one,” he states. “Companies like BMW will need a stable supply of carbon fibre and that’s why they’ve invested in their plant. When did you ever hear of a car maker opening a foundry for steel or aluminium?”

The big push
For its part, Lamborghini has introduced two new cars – one concept, one a full production car – that promise to push carbon fibre farther into the mainstream.

The Sesto Elemento, launched last year, is a concept car that uses the company’s new ‘forged composite’ material. In March, it unveiled its production car – the Aventador. A production rate of around four monocoques per week, using liquid resin infusion, will lead to an expected volume of 5,000 cars in total. “We’ve decreased the manufacturing cost of a single monocoque by an order of magnitude – from $150,000 to $15,000,” says Feraboli. He believes that ongoing cost reduction will eventually allow carbon fibre to compete on price with aluminium – and replace it in cars such as the Audi A6 or A8. (Audi is the owner of Lamborghini.)

Viable business model
“The fundamental goal is always to reduce weight, while saving cost by increasing production rate,” he says. “The time of ‘performance gain at all costs’ is gone: in the new business environment, you must have a viable business model – even for a supercar. The technology must be cost effective.”

It’s true that many engineering challenges still stand in the way of
There are many steps to overcome, if carbon fibre is to become a true mass production automotive technology. If even high-end cars are to use carbon fibre, many problems remain to be solved.

mass-produced carbon fibre cars. But with production rates soaring and supply chains settled, car historians of the future may look back and identify 2011 as the year when the carbon fibre revolution began.

Steps to success
There are many steps to overcome, if carbon fibre is to become a true mass-production automotive technology. If even high-end cars are to use carbon fibre, many problems remain to be solved.

Cycle times: once resin has been injected over the carbon fibre, it needs to cure. This can be a limiting factor, though companies such as BMW are already talking about cure times of three minutes.

“Curing time is a limiting factor,” says CarboTech’s Karl Wagner. “This is a challenge for the chemists.”

Further automation: RTM automates many parts of the process, but, until production volumes reach several thousand cars per year, it is hard to justify automated lay-up, says body structures function manager at McLaren Automotive, Claudio Santoni.

Mindset: many engineers still design carbon fibre parts as direct replacements for metal. A different approach is needed, in which designers start from scratch.

“Sometimes, it’s engineering inertia; sometimes it would mean changes to the factory floor,” says Paolo Feraboli. “But, just as aluminium took time to take off, so will carbon fibre.”

Price: higher production will help to bring the price down and car makers are securing material supply by setting up carbon fibre production of their own. If carbon fibre is only twice the cost of aluminium, it could justifiably be used to replace it in cars, thinks CarboTech’s Wagner.

Material development: companies are already looking at the prospect of replacing thermosets such as epoxy with thermoplastic resins, as they would be easier to process and recycle. Teijin of Japan recently announced a mass-production technique for making a carbon fibre reinforced thermoplastic.

Lamborghini and Boeing unite
The secrets behind Lamborghini’s featherweight carbon fibre structure for its Aventador supercar lie in its close relationship with Boeing, says VP research and design and chief technical officer, Maurizio Reggiani.

Not only were Lamborghini engineers embedded at Boeing’s Seattle facility, but the Italian manufacturer used the same finite element analysis techniques that the plane maker developed for its 787 Dreamliner. “You must be able to simulate everything and prove it works before having it certified by the Federal Aviation Authority and being allowed to fly,” explains Reggiani.

Following 12 months of simulation, the first chassis was crash tested, “I couldn’t believe that the first crash was exactly in line with what had been predicted,” he recalls.

The entire monocoque weighs only 147.5kgs and, together with the front and rear aluminium frames, features an impressive torsional stiffness of 35,000Nm per degree for a total weight of only 229.5kgs.

Lamborghini established two research centres, the Advanced Composite Research Centre in Sant’Agata to develop materials and new manufacturing techniques, and the ACSL at the University of Washington, to define the mechanical behaviour of the different materials
components, woven using textile industry technology, are used in the rockers – where they are filled with epoxy foam – and also for the ‘A’ and ‘B’ posts, as well as the cant rails.

Further foam was added between the double skinned front and rear firewalls, as well as in the monocoque’s floor and the roof for added stiffening, with the double bonus of noise attenuation, adds Reggiani.

Lamborghini will share its experience and knowledge with other brands within VAG. However, carbon fibre costs must come down, warns Reggiani: “In the car industry, we don’t need the strict regulations that govern aerospace materials, such as expiry dates, strict storage requirements etc. The same goes for resin – we need separate resins and materials for aerospace and automotive.”

**Doubling impact resistance**

Pagani’s new Huyara hypercar uses carbon-titanium reinforced plastic for its main structure. The material’s matting consists of carbon fibres, with a small percentage of titanium fibres interwoven.

This was an original development by Horacio Pagani, the firm’s founder. He has worked with carbon fibre in the Modena area supercar and racing car industry since the 1980s. Pagani says it gives a doubling of impact resistance, compared with standard carbon fibre.

**Quality standards**

The company moulds the parts itself from pre-preg and has an autoclave that can accommodate a full tub. The company says that this is necessary for quality standards. In 2011, it intends to manufacture just one car a month in this very labour-intensive process.

Its cars are well known for the near-perfect accuracy of parts and, in particular, the alignment of the weave of the visible fibres, where much of the material is unpainted. The titanium fibres add an extra glisten to the visual quality.

The absence of paint is an important design theme in the cockpit. Also, many structural components that would usually be upholstered are left bare to save weight. They also play dual roles – for example, to save ducting, all HVAC air is channelled through the structure.

The central tub itself weighs just 96kg. However, the firm says it could still meet global crash regulations with a 60kg tub; the extra meat is to comply with internally set standards. External panels of the car are normal pre-preg carbon fibre, without the titanium content.

However, Pagani chose to make the front and rear subframes, which carry the suspensions and absorb crash energy, from cro-mo steel, “because it is the material with the best stiffness/weight ratio to facilitate repair and minimise costs for customers”. Total dry weight of the car, with its six-litre 522kW, 1000Nm V12, is just 1350kg.
Infineon Technologies is a leading player and pioneer in automotive electronics. Our enduring success in this field is due to a clear strategic focus on automotive applications and standards, the understanding and insights that have emerged from almost 40 years of dedicated experience and our ability to continually innovate this market with a broad portfolio of outstanding quality. Our sensors, microcontrollers and power semiconductors help automotive manufacturers achieve their increasingly challenging safety, affordability and efficiency targets. Above all, we are helping to create more sustainable mobility choices by lowering emissions and fuel consumption.

**Contributing to passive and active safety on the road**

Stakeholders in road traffic worldwide are looking for ways to reduce road fatalities. The automotive industry actively contributes to road safety by developing and evolving technologies that reduce the likelihood or impact of accidents. For example, it is working to improve reactive features such as airbag and stability control systems. Similarly, new active safety features include adaptive cruise control and lane departure warning, where the vehicle acts proactively before a crash happens.

Infineon is continually optimizing the chipsets that enable the safety features designed to reduce the number of road accidents. We lead the field in many safety innovations, including tire pressure sensor systems and radar.

**Paving the way for more sustainable mobility choices**

In an increasingly mobile society, carbon dioxide emissions are rising and fossil fuel reserves are dwindling. The automotive industry faces the challenge of powering today’s mobile lifestyle while simultaneously reducing its carbon footprint. Electronic components play a key role in increasing energy efficiency.

Drivetrain electrification, whether in hybrid electric vehicles or fully electric vehicles, has the advantages of higher energy efficiency and zero tailpipe emissions. As the world leader in automotive and advanced power electronics, with ten years of experience in electromobility, Infineon delivers a broad suite of best-in-class microcontrollers, power semiconductors and sensors that are helping to solve today’s electromobility challenges.

As we transition toward greater electromobility, Infineon is also working with leading car manufacturers and system suppliers to improve the energy efficiency of combustion engines and the various subsystems in today’s vehicles. We offer a range of dedicated products and solutions targeting hotspots such as demand-driven accessories, energy management and electric power distribution. These solutions embody Infineon’s commitment to the exceptional quality and reliability that the world’s leading vehicle manufacturers expect.

**Meeting increased data security demands**

As system complexity increases in cars, so too does the volume of data to be processed and distributed. Automakers therefore need to ensure that information is processed securely and protected against external access and manipulation (e.g. car tuning, counterfeit spare parts). Furthermore, new payment methods, such as parking fees or road tolls, require a secure flow of transaction data. Infineon can draw on years of expertise in chip card and identification systems to take automotive data security to the next level.

With our components delivering cost-effectiveness, high efficiency and power density, Infineon is driving the future of automotive electronics and paving the way for market-viable and affordable electromobility.
Breakthrough Innovations for Affordable Electromobility

Widespread deployment of electric vehicles depends on an intelligent power supply infrastructure, coupled with advanced electronics to create affordable and dependable electric vehicles.

With more than 40 years of innovation experience in automotive and power electronics, Infineon is applying its industry-leading expertise to the evolution of hybrid and electric vehicles. In addition to increasing overall system efficiency, our intelligent power semiconductors and modules, microcontrollers and sensors make a significant contribution to cost efficiency in both fuel burning and electric drivetrain systems. For example, our active battery-balancing solution extends the capacity, range and life of EV/HEV batteries more than 10%.

Semiconductor solutions also play a key role in the intelligent power supply chain needed for tomorrow’s smart grid infrastructure. Infineon’s technology leadership is the starting point for breakthrough innovations driving the emergence of affordable, market-viable electromobility.

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Safety first

Integrating a 300Kgs battery pack into a family saloon presents body engineers with a unique set of challenges, as Ian Adcock discovers

Carrying more than 100 litres of combustible fuel in a car isn’t questioned these days. With well over a century of development, manufacturers and the suppliers of fuel tanks and fuel delivery systems have come to terms with the challenges that petrol and diesel bring. Vehicle fires are, thankfully, rare occurrences these days and the average driver doesn’t give a second thought to any potential hazard, no matter how remote, that liquid fuels could present.

But can the same be said of the new generation of electric vehicles (EVs) being developed and launched?

Isn’t it somewhat ironic that, according to EuroNCAP’s own statement when performing its first series of EV tests on the Mitsubishi i-MIEV and its Peugeot and Citroën clones earlier this year, “extra precautions were taken before, during and after testing. The tests could only be performed at laboratories with specially trained personnel; service plugs were removed during vehicle preparation and extra fire-fighting measures taken to ensure the safety of laboratory personnel and equipment”.

You can’t simply add 300Kgs to the structural weight of a car, as Volvo has done with its C30 Electric, without it having an effect on the car’s safety performance.

Volvo started working with its battery partner Ener1 at its Californian concept centre in 2006, recalls Ulrik Grape, president of Ener1 Europe, before moving on to the C30 electrification project in 2009. “The biggest challenge for Ener1 was the space available in the central tunnel and fuel tank area where we could install the batteries to give Volvo the range it was demanding.”

Engineers from both companies had working sessions in the early days of the project, but these quickly morphed into full collaboration to deliver a tailor-made system for the C30.

The result, according to Lennart Stegland, president Volvo car special vehicles, is a combination of battery and vehicle structure unique to the C30. “In the future, we can look at the principles we’ve employed here, but each electrified Volvo will have its own engineering solution.”

According to Ener1’s president of transportation Thomas Goesch, Volvo did a “very good job” in the finite element analysis phase of the project that allowed the battery supplier to fully understand how its pack would be integrated into the C30’s structure to form part of its safety system.

The batteries are housed in two fabricated steel modules, tuned to harmonise with the C30’s crash paths, from both the front and rear, as well as the side. Ener1’s task was made more complicated, bearing in mind that its engineers also had to take into account air flow round the batteries, in addition to cross bracing to help withstand side impact.

In a standard C30, explains Stegland, additional side struts running at floor level between the sills and centre tunnel help to resist side impact intrusion. Clearly, the same couldn’t be achieved, if the batteries weren’t to be crushed, so Volvo reinforced the floor and seat structures, allowing the latter to...
move slightly, while maintaining their integrity and avoiding compressing the central tunnel.

Frontal impact proved even more problematic to Stegland’s team. To ensure Volvo’s smallest car had levels of safety equal to its bigger siblings, its engineers had developed a complex web structure to absorb frontal impacts and minimise intrusion into the passenger compartment. Integral, that is, to the powertrain, which acts as part of the crash sequence and energy management. Eliminating that and replacing it with a smaller, and 70-80Kgs lighter, electric motor meant the C30 Electric was losing a significant element within its safety envelope. “With an electric motor, you need to design a structure that does the same job as the powertrain,” states Stegland.

To achieve this, the Volvo team designed a complex double deck subframe, comprising some 100 parts. Currently, it’s fabricated, but Stegland says that production versions will be a single aluminium casting.

The cradle structure sits between the side members, using the original mounting points, with the motor bolted into place and then, on top of that, the electronic controls and ancillaries; in a neat move, the vacuum tank for the brakes is also integrated into the assembly.

“By doing it this way, we’ve been able to pass the pole test with no problems, as well as two rear offset collisions at the mandatory 51mph (82Km/h) demanded by the US authorities,” he explains.

The car shown at Detroit was the seventh of a planned 13 Volvo C30 Electrics to be crashed. It had a fully charged battery when it was tested at Volvo Cars’ crash test laboratory in early December 2010. The crash was an offset collision, in which 40 % of the front hits a barrier at 64Km/h (40 mph).

Both Ener1 and Volvo say they are working hard to bring down the weight of the battery systems, especially the casing. But, as Ener1’s Thomas Goesch points out, steel is both relatively inexpensive and well understood. Composite materials or lighter steels would add both cost and complexity to the system, although Grape does state that they need to look at lighter materials as they move forward. “By 2020, you will see more significant developments in casing materials, the electronics will improve and the cells will change.”

With safety as one of its core strands of DNA, we shouldn’t be surprised perhaps that Volvo was the first OEM to put a crashed EV on display. But what is patently clear is that engineering the safety attributes of future EVs, either from the ground up or modified like the C30, is no easy task.
KING of the ROAD – and off it, too!

The new Range Rover Evoque will offer drivers both on-road excellence and off-road adventure, in a package that addresses the push for lower CO₂ emissions, as Ian Adcock reports.

Four decades have passed since the original Range Rover broke cover. Spen King’s radical four-wheel drive design created a new vehicle sector that has spawned imitators around the world and there are few manufacturers – apart from top-end luxury and supercar brands – that don’t have an SUV within their product portfolio.

It could be claimed that, while the Land Rover and Range Rover brands have stubbornly clung to their core DNA of engineering vehicles that are peerless off-road performers, rivals have compromised that for on-road superiority. That has changed with the latest generation of Land Rover and Range Rover models. But what has also changed is the drive to reduce CO₂ emissions. Four-wheel drive systems are heavy and consume energy; to be able to compete in the modern world of eco-motoring, both brands have to offer more efficient models.

Land Rover now sells a front-wheel drive Freelander and, in the Evoque, Range Rover is offering its customers a smaller, lighter model that will also be available in front-wheel guise, as well as part-time, all-wheel drive. It will still deliver class-leading, off-road ability, if customers want to do more than simply bump up a kerb when parking in crowded urban streets.

“We wanted a product that was dynamic, fun to drive, but still have the expected Range Rover credentials for off-road ability, refinement and plushness, but make it a sportier, dynamic vehicle. That’s quite a significant departure in engineering for a Range Rover product,” says David Mitchell, chief programme engineer, and the reason why he and his team evaluated cars such as the Audi TT and A3, Mini and BMW X1, which must be a first for a Range Rover product. “We wanted that sporty handling and chuckability, but also the ability to cross a sandy beach or grassy field, and we think we’ve got an excellent balance.”

Evoque features a bonded aluminium roof (above) and new generation of engines (top right)
Range Rover Evoque Special

The easy option would have been to simply reskin Freelander underpinnings, especially as the two products share the same production line at Halewood. However, for numerous reasons, not least styling, this was never going to be an option, as Mitchell explains.

“At least 80% of the car is unique to Evoque, compared to Freelander; there are some small body-in-white panels that are common. The difference in the roofline between the two products drives the occupancy positioning, and the ‘H’ points of the passengers and driver are lower. That then drives the driveline’s location, while the engine position also drives the pedal box and the steering column’s relationship to the driver. If you change that, you change the instrument panel and pack, and then the cross car beam is different.

“In the bulkhead area, a few panels are similar, while the area along the tunnel is subtly different and everything rear of the back seats is new, because we have a unique fuel tank, due to packaging challenges. Although the two cars share some of the electrical harnessing, we have different suppliers between Evoque and Freelander.

“All of a sudden, you’re changing a substantial amount of the vehicle to get the contours, in terms of overall package size and roof height.”

Even when it comes to engines, there’s commonality, although “the diesel is very similar between Freelander and Evoque but, clearly, there’s a lot more refinement to get the Range Rover DNA we wanted and there’s a new petrol engine that’s a four-cylinder, rather than the six-cylinder in Freelander,” he adds.

Laughing, Mitchell says the only communal point he can think of “is the road wheel nuts…”

Evoque first appeared at the 2008 Detroit Show as the LRX Cross-Coupe concept. Range Rover, perhaps stung by the criticism it received over the sensational-looking 2004 Range Stormer concept morphing into the much more conservatively styled Range Rover Sport, has adhered closely to LRX design. “It’s difficult for people to tell the two apart,” Mitchell states. “One thing that’s obvious from LRX to Evoque are the door mirrors; we had some small, sexy ones, almost like an F1 mirror, but legislation, which is driven by the occupants’ ‘H’ point, didn’t allow me to use them.”

Physically, the two cars are very closely aligned. “You wouldn’t believe the amount of effort that went into making the car the right height, the design around the hood and the bottom of the ‘A’ post to comply with pedestrian impact,” states Mitchell. “We kept trying different solutions to the packaging challenges and it was very difficult to get the roof height correct – especially on the three-door.”

The body is a combination of steel, aluminium and thermo-formed plastics: following Range Rover tradition, the bonnet is made from aluminium, as is the roof, the latter laser welded and bonded to the steel body sides, using twin adhesive beads to ensure craftsmanship and rigidity. Body stiffness was a major challenge, especially in those models fitted with the optional one-piece Webasto full-size panoramic roof.

For the first time in a Range Rover, there’s extensive use of thermo-formed panelling, from Plastic Omnium, for the front fenders and a one-piece tailgate that saves six kilograms over a conventional metal one. “Significant engineering went into getting rigidity into the top of the tailgate, because we have powered tailgates on some derivatives,” explains Mitchell, adding: “There’s a lot of webbing in there and we did a great deal of finite element analysis. It wasn’t an easy task, because we’ve also moved the rear wiper assembly from where you would see it on the waistline and hidden it under the rear spoiler. We also put a lot of rigidity into the tailgate to mount the motor and mechanisms and the harness to it. Then we’ve got the power struts for opening and closing the tailgate.”

An additional 30mm rear headroom in the five-door necessitated unique body sides, compared to the three-door with taller ‘C’ posts, although it still retains the same silhouette and floating roof graphic.

Other weight-saving techniques include boron high-strength steel in the ‘A’ posts and magnesium in the steering geometry to take weight out of the ball joints.

“There’s a lot of aluminium in the suspension geometry components, but the frames themselves are high...
tensile steel. We looked at aluminium extrusions, but, by the time you've got the stiffness you want, there's no real weight saving." Mitchell's team also considered aluminium door skins, but concluded that the projected £20 million cost could be spent better elsewhere. "I'd rather spend it on something the customer can see and feel. We ended up doing the rear bumper beam in aluminium, as that saved 3.5kgs, versus doing the doors. Pound for pound, it was a better investment."

So far, all quite conventional, and, as an indication of the way Jaguar and Land Rover are merging their technologies, the Evoque gains the eight-inch TFT dual view screen that debuted in the Jaguar XJ, but with unique graphics. Meanwhile, the rising knob gear shifter on autos is a development of that first used on the XF and then developed for MY11 Range Rovers.

Where it does depart – to score a first in SUVs, as well as the first UK-European application at all – is offering the latest generation of BWI's MagneRide magneto rheological (MR) suspension as an option.

"One of the challenges for off-roading is to make sure we can get maximum bump and rebound," says Mitchell, "and sometimes, with passive dampers, you find that, at extremes, it goes into resistance and you can't get the full articulation. Of course, with MR, depending on how it is set, we don't get any suspension frictions that could restrict the amount of bump and rebound travel. Essentially, we get about an extra 4mm articulation with MR at bump and rebound."

The MR system is also linked in to Range Rover's Terrain Response, which includes a new dynamic response for the first time. Concerns about MR's durability in extreme temperatures that form part of the marque's stringent sign-off procedure were, says Mitchell, unfounded.

Using ZF's electric power-assisted steering has resulted in a 2% CO₂ improvement and given Mitchell's team the opportunity to develop Park4You parallel parking ability that will squeeze an Evoque into a slot just 1.2 times the car's length. More importantly, peripheral sensors detect kerbs, allowing the Evoque to park within 100mm, while preventing expensive alloy wheels from being scuffed.

"Clearly, refinement was key," comments Mitchell, "and we spent a lot of time refining the aerodynamics to reduce wind noise," as well as eliminating pathways through the bulkhead. "We've redesigned the lower steering column seal at the bulkhead, not just because of the EPAS, but we stiffened the bulkhead in that area to get the right sealing. In terms of air paths, the 'A' and 'B' pillars either side of the front and rear door edges have been re-engineered to close gaps down and include more sealing."

The Evoque is a long way from Spen King's vision for Range Rover, but it's clear that it shares the same DNA. But there's more to Evoque than a new interpretation of that DNA; it also heralds a new direction in powertrain strategy.

Smaller, leaner, lighter engines
Evoque shares its diesel engine with the new XF (see page 6), albeit in a different state of tune, as Gary Reid, senior manager diesels explains. "The peak 420Nm torque met the character we needed for Evoque; we didn't need the overboost with the calibration optimised for the performance and driveability you'd expect from a Jaguar."

"Range Rover is geared more towards low end torque, trailer towing capability and off-roading performance. So, whereas the curve on the Jaguar will get peak torque of 450Nm at 1750-2000rpm and then it tails off, in the Evoque peak torque is a lot flatter all the way through to 3000+rpm."

The Evoque’s engine went through the same acoustic camera analysis that the Jaguar version did, with largely the same results. Common componentry, such as
sound deadening socks around the injectors and sound deadening material around the starter motor, is shared. Differences include a bung in the lower pulley that was developed for, but not needed on, the XF, whereas the transverse location of the Evoque’s engine brought the pulley closer to the driver and front seat passenger, so the bung was used to damp unwanted sound. Likewise, a sheath round the fuel pump is used on Evoque, but not on XF, due to packaging constraints.

One of the big challenges for any Range Rover engine is to meet the brand’s unique off-roading requirements. “We didn’t want to tool up for a new oil pan,” says Reid, “and we knew from Freelander the engine’s capabilities, so it will tolerate fore and aft movement of ±30° and ±27° lateral. From a DNA perspective, it would have been nice to get 45°, but the cost to achieve that would have been prohibitive and, anyway, people wouldn’t take the car to those extremes.”

The other major test is sealing the engine, but, as Land Rover-Range Rover had specified their sealing requirements with Ford and PSA at the start of the engine’s development programme and, based on market experience since 2007, Reid and his colleagues were confident it would withstand off-road abuse.

However, says assembly set engineer Rob Carvell, the new two-litre GTDi petrol engine was a bigger challenge. Effectively, this is Range Rover’s take on Ford’s new EcoBoost engine that produces 176kW at 5500rpm and 340Nm from 1750rpm through to 4000rpm.

“The torque curve,” Carvell comments, “suits Range Rover characteristics and the way the turbo selection went was to choose the minimum size necessary to achieve headline power figures that gave us the right characteristics for off-roading, which is, basically, low speed.

“The benefit of a small-sized Borg Warner KO3 turbo is time to torque characteristic, or lag, which is hugely reduced. “We were looking for 6-cylinder performance from a 2-litre turbo, with exceptional flexibility, thanks to its wide torque band.

Class leading

“The big message for GTDI is sustainability, with reduced friction and pumping losses, and state-of-the-art Direct Injection from Ford. But the way we have tailored its calibration and the emissions work in-house are class leading,” claims Carvell.

Development of the engine started back in 2007 when Land Rover/Range Rover was still part of the Ford family. So, from the beginning, the off-roaders’ prerequisites for oil, dirt and slurry ingress were engineered into the engine, as was its ability to withstand 45° angle of tilt fore and aft, as well as lateral, for five seconds. “Evoque was considered the worst-case scenario for this engine,” says Carvell, “although meeting the 600mm deep water wading proved a challenge. We got round that by using a semi-sealed Denso starter motor.”

Range Rovers are put through some brutal tests, including a ditch drop which puts excessive stress on engine mounts. To meet that, Carvell and his colleagues insisted on a four stud layout at the front of the engine, which has been carried over to the EcoBoost range. As with the diesel, special attention was paid to sealing, including a labyrinth seal for the front crankcase to survive the slurry test, as well as optimising belt drive for mud resistance and a plastic cover for the tensioner.

While twin balancer shafts smooth out the four cylinder engine, there were some NVH issues created by the DI systems injectors. “The injector itself has isolators that help to seal it against the cylinder head structure. There’s also a ‘rag and fluff’ cover on the fuel rail that further reduces the tick. The pump body is exposed on an east-west engine, as it’s driven off the exhaust cam, so it is sheathed in high density foam, reducing tick to an acceptable level for us. There’s an acoustic engine cover as well.”

Being an all-aluminium structure helps to keep weight down to 138Kgs shipped to Range Rover, but Carvell is particularly pleased with the plastic cam cover and intake manifold with honeycomb stiffening ribs, and fabricated exhaust manifold produced from pressed and welded sheet with hydroformed outer shells, and four internal runners going into a single collector that not only saves weight over a cast manifold, but also accelerates quick light off the catalyst.

Four decades on, and Range Rover is setting a new challenge to its rivals – Spen King would approve.
Fuelling a brighter future

With oil prices now moving well above the $100 a barrel mark, fuel economy is growing ever more important. Andrew English caught up with VW’s Dr Ing Harald Ludanek to unearth the technology that lies behind the XL1 experimental car.
Volkswagen’s super economy car, the XL1, is the third such experimental vehicle in this series. Although VW has been looking at cigar-tube eco cars since its 1980 ARVW concept, the first car in this particular research program was initially ordered in 1998 by Dr Ferdinand Piëch.

At the 2009 Frankfurt Show, VW presented the L1, which swapped the one litre’s noisy single-cylinder diesel engine for a two-cylinder, 800cc TDI engine, with electric motor assistance to give a 160 Km/h (100mph) top speed and 1.49 l/100km (189mpg). Development continued, but, for this XL1, its antecedents’ tandem seats were rejected as impractical and board member responsible for R&D, Dr Ulrich Hackenberg, ordered a side-by-side arrangement, staggered to limit the inevitable width increase. With its drag coefficient of Cd 0.186, the XL1 is one of the world’s most aerodynamic cars. Other weight and energy-saving innovations include: light-emitting diode lamps, television cameras to replace wing mirrors, narrow-gauge wiring with electrical fuses, radiator louvres, electrical air conditioning and a fully faired underbody.

“The XL1 is a genuine Volkswagen, which could come into small series production in 2013,” says Martin Winterkorn, VW chairman. He says that, if the EU target to limit global temperature rises to just two degrees centigrade by 2050, “the average fuel consumption of the world’s car fleet will need to be about 0.9/100km (313mpg) by then”, Dr Piëch, now chairman of the supervisory board, says the XL1 should be “built in reasonable numbers” and “affordable”. Expect prices to be in excess of €35,000.

We caught up with Dr Ing Harald Ludanek, VW’s head of vehicle engineering, to ask what lessons have been learned and which of the XL1’s technologies is likely to transfer to mass-produced Volkswagen models. “The basis of this XL1 project came out of a 2007 shareholders’ meeting. We wanted to know if it was possible to build a small series production model out of the One Litre car and, in 2009, we exhibited the L1,” Ludanek states.

“We have researched construction materials suitable for a small-series production, with higher speeds and legal crash performance. We soon realised a plug-in hybrid configuration could give us the one litre consumption we sought, but we also need the hybrid system, because the electric motor increases the driving torque to acceptable levels. In fact, the XL1’s consumption with the engine alone is about 2l/100km (141mpg).”

“The drive line is one half of a Polo’s 1.6 litre turbodiesel, produced in aluminium, with plasma-sprayed liners and a balance shaft to reduce vibrations. This 800cc parallel twin produces 35kW and 120Nm, and is supported by a 20kW/100Nm electric motor with a plug-in hybrid system, using a narrow motor/starter and a 60kg, 5kWh lithium-ion Sanyo battery. This unit will be used in this year’s Up Space, where it will deliver CO2 emissions of around 74g/km.

“The XL1’s carbon-fibre tub is produced by Carbo Tech Composites in Austria and is an advanced resin transfer moulding. We are working with German universities and research centres on this technology, where we use separate moulds to lay up the carbon fibres, then take them to the resin-transfer machine where they spend half an hour curing. We can then remove them and separate the tub elsewhere. This means we don’t lose time cleaning and preparing the machine, and we can produce a tub every hour, which gives us the capacity of about 6,000 tubs a year.

“This is a lighthouse project where we are experimenting with the technology, but it’s still very expensive: some 80 to 100 times more expensive than stamping steel. And, if we had chosen to do this car in aluminium, it would have resulted in a 20% increase in weight, but would have been 40 times less expensive.

“What we are learning is how to increase the carbon-fibre content in mass production models, as demands for better fuel consumption increase. Weight is the enemy of fuel consumption and a rule of thumb for the current generation of cars is that each additional 100kg increases consumption by an order of 0.2l/100km.”

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“The 2020 EU requirements are for average carbon dioxide levels of 95g/km and we are already able to reach as low as 85g/km on some concept cars, and will be able to reach 70 to 75g/km eventually. The current mix of materials in mass-produced cars is about 60-70% metals, with 20% polymers. I can see the metal content reducing to about 40-50% in the future, with resulting increases in polymers.

“The next development in carbon fibre is to reduce the cost of the fibres and the processes, and increase the speed of production.”

March/April 2011
At General Motors, 2011 will largely be remembered as the year of the Volt. With a host of 2011 Car of the Year awards already in hand, and Chevrolet Volt deliveries expected across most of the USA by year’s end, GM has taken a huge step forward in its effort to “redefine the DNA of the automobile”.

As Karl-Friedrich Stracke, GM’s vice president of global vehicle engineering and SAE 2011 World Congress general chairman, points out: “We are right now in a very significant time phase where we are reinventing the automobile; the DNA of the automobile is basically being redefined.”

GM acknowledges that switching from an automotive landscape that is mechanically driven, energised by petroleum and powered by internal-combustion engines, to one that is electrically driven, energised by electricity and hydrogen, and powered by electric motors, is not something the automaker can do on its own and will require a great deal of cooperation. Under the theme, ‘Charging Forward Together’, the GM-hosted SAE 2011 World Congress, to be held from 12-14 April at Detroit’s Cobo Center, serves as an excellent opportunity for the automotive community to come together, and share strategies and perspectives on the automotive landscape, moving forward.

“‘Charging’ creates automatically a relationship to electric cars and I think it’s the right time to talk more about electrification in society,” Stracke adds. “But then, with ‘Charging Together’, it’s really a society effort. It’s a team effort—everybody: the utility companies, different suppliers, the automotive industry—so a big industry effort is required to get the right solutions out on the road to the customer.”

Steps towards solutions

The collaborative atmosphere and many networking opportunities provided by the SAE World Congress can go a long way towards finding those right solutions and sparking creativity for future developments.

“There are many reasons why the World Congress makes a lot of sense,” Stracke comments. “You discuss and share technical solutions, you share your strategies, you share your perspective on the automobile going forward. I am seeing this congress defining a great deal about the automobile. The SAE conference is a perfect platform actually to discuss and debate that.”
SAE Preview

TOGETHER

While stressing the importance of collaboration to future technology development, Stracke understands the concern some in the industry may have about being too collaborative.

“The challenge is, we are competitors, but, at the same time, we need to work together to provide the right technical solutions to the customers. At the end of the day, I think we are dependent on each other to develop the right solution. It’s a big society issue, getting away from fuel-dependent propulsion systems. It’s a unique industry challenge and the better we work together on those challenges, the better solutions we get. But there are some standardised solutions you can work on together.

“That’s the opportunity, to discuss those things at the SAE Congress. Those days will be a huge benefit for the society, for the automotive industry and for the suppliers to provide some clear guidance. Also the supplier who needs to be invested in the business wants to have some clear direction, going forward, and wants to understand that and anticipate what direction the automotive industry is heading in. It’s a unique platform – to standardise, to discuss, and then go from there.”

As an example of successful collaboration, Stracke points to the relationship between GM and the SAE 2011 World Congress Tier One Strategic Partner LG Chem, which is supplying the battery cells for the Volt.

“We have an excellent relationship with LG that we have developed over the last few years. I remember three years ago, when we decided [to proceed with] the Volt, there was no battery cell, there was no chemistry, there was nothing whatsoever. So we received cells around that time from LG Chem; we tested them and we found that the biggest opportunity was to go with LG Chem. We have developed an excellent battery, performance wise, and have not seen any big hiccoughs during the development phase. They have supported us all the way through in an excellent way. We are very fortunate to have them here with us.”

Innovation in mind

The conference itself will carry over many of the changes instituted last year, maintaining a three-day format, as opposed to the traditional four, and only featuring the most innovative technologies on the show floor. “We want to focus this year again on having the right technology out there on the floor,” states Stracke.

Once again, to participate in the event as an exhibitor, companies had to submit an application detailing the noteworthy technologies to be displayed and then have that application reviewed by a panel of OEM engineers and executives, who selected only the most innovative solutions to be present on the show floor. A total of 74 companies had received approval for exhibition at time of publication, up from 42 exhibiting companies in 2010.

The access to technology and innovation at the SAE World Congress, and the opportunity to talk directly to the suppliers in one convenient place, is a unique benefit and one that Stracke stressed to his employees and colleagues.

“We said we want to have staff meetings here. I agreed with Bob Socia on the purchasing side that we have staff meetings on the floor. We will have a very interactive activity over that time frame. We will interact more with the suppliers,” he comments. “When you are a supplier and put money into your booth, you want to see something in return. Therefore, I committed with the other...
SAE Preview

OEMs that we are on the floor with them; that we share ideas. It should be a win-win for everybody.”

Along with the value to be gained from attending the SAE World Congress, exhibitors will have the opportunity to hear from industry experts and leaders discuss automotive technology trends during presentations and panel discussions held at the AVL Technology Leadership Center and the FEV Powertrain Innovation Forum.

The World Congress begins on 12 April with the grand opening at the AVL Technology Leadership Center, featuring keynote speaker Ray Lane, managing partner, Kleiner Perkins Caulfield & Byers (KPCB) and non-executive chairman, Hewlett-Packard Co.

At KPCB, Lane is focused on helping entrepreneurs with technological and market insight, organisational development, team building, selling and managing growth. In his time with the firm, Lane has sponsored investments in clean and alternative energy, including vehicle manufacturers Fisker Automotive (plug-in hybrid) and Think NA (electric).

Additionally, Helmut List, chairman and CEO, AVL Powertrain Engineering, and Mircea Gradu, director, Transmission and Driveline Engineering, head virtual analysis, Chrysler Group and SAE Automotive vice president, will be part of the ceremony.

Keynote addresses at the AVL Technology Leadership Center on 13 and 14 April will feature Cathy Zoi, acting under-secretary for energy, US Department of Energy, and Rodney O’Neal, CEO and president, Delphi, respectively.

Panel discussions in the two theatres will be centred on the topics: future powertrain strategies, petroleum alternatives, global collaboration, electrification for personal mobility, ensuring safety, compressed natural gas, and transmission, electrification, and off-roading technologies. Meanwhile, the technical programme at the World Congress will feature more than 175 sessions. These will embrace nearly 1,300 technical papers, presented by engineers, which showcase applied technology, innovation and product leadership. Technical sessions, which will each begin with a keynote address, are grouped in seven technology topics: electronics, emissions/environment/sustainability, integrated design and manufacturing, management and marketplace, materials, propulsion/powertrain, and safety/testing.

Paper trail

Nearly half of the papers have come from outside North America, including 305 from Asia and 270 from Europe, both being increases from 2010. Papers submitted by OEMs have increased by 82%, compared to 2010, to reach 398 in total.

Apart from using the intervals between technical sessions to discuss challenges and ideas, attendees can also take part in the many designated networking opportunities offered at the SAE World Congress.

Several annual events held in conjunction with the World Congress will offer pre- or post-event receptions, including the SAE Awards Ceremony on 12 April and the SAE Detroit Section meeting on 13 April, which will feature a presentation by the Chevrolet Volt development team. The World Congress Annual Banquet will be held on 14 April and feature an address by Daniel F. Akerson, chief executive officer, General Motors.

The popular ‘Chats with the Experts’ sessions, introduced at the SAE 2010 World Congress, will return this year, discussing topics such as recyclability, diesel emissions, composites, motorsports and supply chain. Technology-focused lounges will also be open to all attendees throughout the day, located near the session rooms.

Whether engaging the World Congress through the management programme, technical sessions, exhibition or any of the special events, Stracke believes attendees will come away from the event with valuable experience they can apply to their specific field.

And he concludes: “The benefit of this event is to show the future technology, to reveal what’s coming next and to demonstrate how all the partners can be engaged here – to have greater success for the industry, at the end of the day.”

Electrification and batteries will be one of the main topics of discussion at the World Congress. Tier One Strategic Partner LG Chem is supplying the battery cells for the Chevrolet Volt.
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Making all the right noises...

When I first started, the approach to the noise reduction business was relatively simple. We did basic measurements on prototype vehicles looking for smooth transitions, and eliminating booms, vibrations and excessive volume. Dealing with these as they occurred late in the programme, though, could be very expensive and time consuming.

“We've now got noise levels down to a level where they are all in an acceptable area. In fact, in some vehicles the sound deadening can be almost too good; ever wondered why it’s so difficult to have a conversation between the front and rear seats in some cars?

“Manufacturers want to tailor their vehicles’ sounds to satisfy or match their brand identities, but new pressures have emerged to do with technology, vehicle development and legislation. Hybrid and electric cars have thrown a spotlight on noise reduction and sound tailoring in several ways. First, we need to design electric vehicle sounds that give the driver information about speed and progress in a way the engine does today. We need to recover the driver feedback that’s so good in a combustion-engined car.

“There’s also the requirement to warn pedestrians of a vehicle’s approach, especially in urban areas. Some of the ideas, such as simply replicating a petrol engine, are over-simplistic. I like to think of the way that computers have taken the noise of an old-fashioned office, such as a file cabinet opening, and modified them for similar on-screen functions. We need a similar transition from where we are today to something that’s acceptable and instinctive.

“There are also issues emerging from the engine ancillaries and new developments, such as electric power steering or direct-injection fuel pumps. Some sounds are more noticeable in the quieter environment of an electric car, so, in some senses, we’ve gone back to the drawing board here. One of the things we can do is to test these noises in our driving simulator, where they can be heard against a background of real driving sounds to check they aren’t being magnified or, in the case of warning sounds such as indicators, drowned out.

“There are also combustion engine developments, such as tightening emissions standards (Euro VI diesel standards, for example) and the adoption of two-cylinder engines, which can adversely affect NVH and need a lot of work to solve.

“What we like to do is be involved in the earliest stages of the project, so that we address noise transmitters, booms, bulkhead transmission and powertrain noise before press tools are made. But, in the end, it’s still all about fine-tuning of the whole vehicle just before sign-off.”
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