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It takes ingenuity and persistence to succeed in today's driveline market.

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Solve the puzzle to enter to win a Kindle Fire.

Contents

14



14 *Automotive Design* Interview

Exhausting Possibilities

A novel herringbone design of exhaust catalyst could be the 'Eureka' moment for emissions reductions, says ACAT Global's CEO Joseph W Moch. Ian Adcock tries to unravel the story behind it

18 Concept car design

A right royal performance

An interior influenced by the Jubilee celebrations? James Brewer finds out more

20



20 Cover Story

Virtually, the real deal

OEMs want faster time to market, reduced development costs and ever more sophisticated testing. Ian Adcock reports

24 Emissions mission: 2020 vision

Weighing up the benefits

In the battle to achieve peak efficiency and reach the mandatory CO₂ emissions levels by 2020, shedding vehicle weight is one of the top priorities, as Tony Lewin reveals

24



28 Structures

Braced for success

Bolt-on chassis braces increase stiffness for better steering response and NVH, with less weight than a similarly strong, unbraced frame, writes Dan Carney

31 Design software

Distraction not required

2013 ATS underpinned GM's new approach to improving driver visibility. Lindsay Brooke explains

28



32 Question Time

Spark of Life

Sandro Pino, Federal Mogul's European application engineering manager, ignition products, explains to Ian Adcock the challenges that the humble spark plug is facing

4 Comment

6 News

- TRW external side airbag
- Johnson Controls' Synergy Seat Gen 3
- Delphi 'MyFi' to cut driver distraction
- Peugeot's new platform is 70Kgs lighter

17 The Columnist

Technology to the fore

Kevin Jost, SAE International Editorial Director

34 60 second interview

Prof Dr Thomas Weber, member of the board of management Daimler, responsible for group research and Mercedes-Benz cars development

Lost Time Is Lost Money

Radiated Immunity Testing Reduced From Days To Hours...



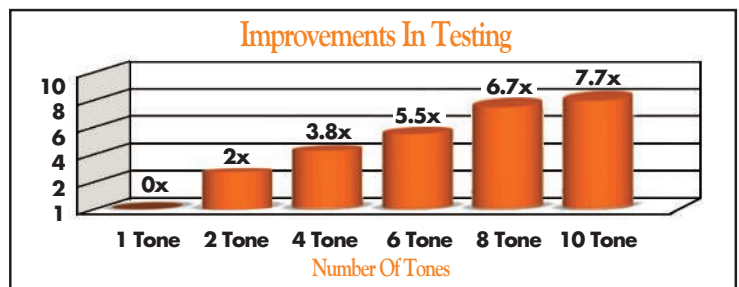
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Frankfurt IAA: confidence comes surging back



What a difference two years makes. Back in 2011, the atmosphere at the world's biggest motor show, the Frankfurt IAA, was cautious, to say the least, with the world economies teetering and the Euro zone crises in full swing.

Well, the latter might still be wavering, but it didn't feel like that in the vast halls and exhibition spaces of the Messe where the

organisers claimed there were a staggering 159 world premiers.

Two themes seemed to dominate the show: first, autonomous driving, which was extensively covered in the last issue of *Automotive Design*, but given added impetus at the show, with news that the take-up rate for Mercedes-Benz's new intelligent driver package for the latest 'S' Class is "60-70%", according to the company's top engineer Professor Dr Thomas Weber. However, he warned that three hurdles still have to be cleared before it becomes universally accepted. "We have to convince the regulators; we need more powerful computers on board; and more precise maps for driving."

Moreover, the prevailing message was that it's going to take longer than the 2020 date Nissan has announced as its target for an autonomous car. "We have to change the Vienna Convention for a start," one sceptical engineer told me, "and that took decades to achieve in the first place."

Theme 2 centred on the rush towards vehicle electrification, which is increasingly seen as niche products, rather than mainstream. What is likely to transpire is a growing electrification of accessories and add-on motors to help manufacturers achieve 2025 emission levels.

Tony Lewin's feature on lightweight strategy (page 24) came at just the right time, with Jaguar previewing its new aluminium structure under the C-X17 crossover concept. Meanwhile, Cruden's impressive vehicle simulators (page 20) show the way forward for future product development and underline only too well why I would never make an F1 driver, with a three-plus minute lap of a simulated Spa-Francorchamps race track!

Ian Adcock, Editor in Chief

First external side airbag goes on show

TRW has revealed the world's first external side airbag, which it expects to go into series production with a German premium manufacturer before the end of the decade.

"Side crashes are still one of the highest accident rates, accounting for 37-40% of accidents," said TRW's vice president and general manager lifecycle management, Norbert Kagerer.

Work started on the system more than three years ago as part of an EU-funded project involving Spanish car maker Seat and other companies to develop technologies that would reduce injuries caused by side impacts.

"There've been tremendous improvements in frontal impacts, but even cars with EuroNCAP 5* ratings can have problems with side impacts," said Kagerer.

The main problem is the comparative lack of space between the occupants and the doors; and, even with sophisticated inner door airbags and seats that move towards the centre of the

car, occupants can still suffer from broken shoulders, arms, ribs and abdominal injuries.

SWIFT INFLATION

TRW's new airbag is mounted in the rocker panel beneath the doors and is deployed rotationally upwards towards the car's belt line; typically, the 200-litre bag measures 15-20cms deep, 70cms high and 200cms long, enabling it to cover both front and rear doors. To ensure a swift (20-30 millisecond) inflation, and even deployment, two inflators are used.

To ensure a stiffer bag, TRW has patented a unique inner structure to provide a cell-like assembly within the bag, while the pressure in the bag itself depends on the OEM's own needs. "Pressure in the airbag depends very much on the design the OEM wants, with several design strategies available," explained Kagerer. "You can have a bigger bag, with less pressure, or a thinner bag with higher pressure, depending on the OEM's strategy."

While the airbag itself is proven technology, TRW faces the challenge of determining when to deploy it. "Side impacts are strange physics, because both objects are starting to move some way. So, when you have a bigger car, there's a higher mass and inertia, so intrusion is worse. There needs to be further improvements in exterior radar and camera sensors and algorithms to inflate the bag well in advance of impact. The challenge is to track and vector the impact gradually, escalating the risk assessment, similar to frontal impact, and, when an impact is unavoidable, trigger inflation.

"The firing strategy is the issue. There needs to be a high confidence level before we're able to fire a non-reversible device, prior to impact," stated Kagerer, who pointed out that it would be very difficult to detect pedestrians, cyclists or motorcyclists, adding: "You have to target the most likely scenarios and highest percentages."

New dual clutch transmissions unveiled by Getrag

Getrag has unveiled two new dual clutch transmissions: the PowerShift 6DCT150 and its first hybrid gearbox, the HybridDrive 7HDT300.

The PowerShift 6DCT150 is intended for front-transverse applications and torques up to 170 Nm. Getrag claims it is the most compact dual-clutch transmission in the market, extending the field for this technology into the small car segment. The wet clutches are actuated electro-hydraulically and the gears are shifted electromechanically, via shift drums. A new gear wheel concept makes this

transmission extremely compact and therefore ideal for cramped installations. The Chinese market will be the first to receive the 6DCT150.

Meanwhile, the HybridDrive 7HDT300 is the hybrid version of Getrag's dual-clutch transmission 7DCT300, complemented by an electric traction motor that is integrated axially, parallel to the shafts. By using tailor-made motors, this modular and cost-efficient approach allows for a scalable hybridisation. A mild hybrid with 15 kW motor support is possible, as well as a full hybrid, adding 40 kW, or a plug-in hybrid, adding 75 kW or more. The battery voltage varies from 48 V for a mild hybrid to 360 V for a plug-in hybrid. Depending on the amount of hybridisation, 15-80% fuel savings can be expected, compared to a conventional drivetrain.

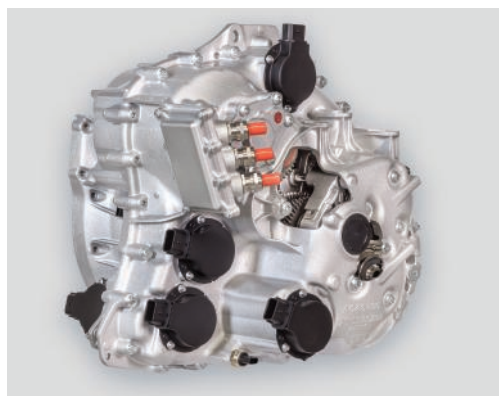
Range Rover's hybrid SUV delivers unexpected windfall

Range Rover has applied for more than 20 patents for the software programme controlling the hybrid diesel-electric powertrain of its newly-launched hybrid SUV.

"The real trick is blending the electric motor and diesel engine," said Peter Richings, Jaguar Land Rover's director hybrids and electrification. "We decided we would do that in-house. Our 'Vehicle Supervisory Controller' software sits above the engine and transmission controllers, and controls the hybrid system. It's embedded into one of the Bosch ECUs and has over 20 patents filed on it. It's that which makes the vehicle stand out as a Range Rover.

"Being an off-roader, it brought us some challenges and unexpected windfalls as well; the windfall was, the first time we took them off road, our specialists told us it was better than the standard car, because of the low speed controllability and torque the electric motor delivers. I wasn't expecting that."

Richings added that, while the car's certified fuel consumption figure is 44.1 mpg (6.4l/100kms), they are regularly seeing 40mpg (7.0l/100Kms) in real-world driving.





Death of diesel greatly exaggerated

"Three to four years ago, a lot of people were saying diesel would disappear completely in favour of hybrid and petrol, with new emission limits putting too many constraints on diesel. The reality is different. I still see the same balance between petrol and diesel in the future to 2020," Pierpaolo Antonioli, managing director and global diesel sector director, GM Powertrain Europe, told *Automotive Design* at Frankfurt IAA

And he added: "If you want one engine for efficiency, to achieve 95 g/kms, it's diesel. OK, so it's more expensive, but the efficiency and CO₂ levels are better than other standard technologies. Hybrids are more CO₂ efficient than diesel, but more expensive. Diesel will still play a key role in CO₂ levels to 2020 and beyond."

Nor does Antonioli see the trend for mega-powerful diesels growing in all but

niche sectors. "If we look to the future, lower-powered engines will be the trend, but better torque at low rpm, because with that we can get better managed long gear sets for improved CO₂. And, if you don't have such high power density, you don't need higher line pressures. So I don't see the need to go up from 2,000 or 2,200 bar, especially if we adopt this strategy to limit engine power."

Meanwhile, his colleague on the petrol engine side, Dr Thomas Johnen, says GM is looking to take out 27% powertrain friction between now and 2020 to improve mechanical efficiencies.

"There's a trend for more ratios and we're looking into different options for gear boxes: CVTs, 8-speed, potentially 10-speed automatics. We're trying to find the best solutions and you will see those things coming."

Webasto roofing systems could slash engine emissions

German roof supplier Webasto launched two new roofing systems at Frankfurt: the Eco Innovation solar roof and the Multi Option Roof System concept.

Webasto pioneered solar roofs to recharge car batteries in 1989, and its latest version has the potential to reduce petrol engine emissions by 2.6 g/km CO₂ and a diesel by around 1.8 g/km when a solar roof is charging the battery.

The roof is assembled from mono-crystalline, high-performance cells, with 20% efficiency delivering p100 Wp and an active cell surface of 0.5 m².

"The idea of the 'Multi Optional Roof System' is that many different roof variants can fit one vehicle interface. This means that different

roof systems can be put on one car body variant," said Matthias Arleth, member of the management board of Webasto's roof and components division, explaining the concept. The vehicle is always planned such that the roof is integrated into the vehicle as a distinct unit. As a result, the manufacturer doesn't have to decide early on in the design phase which roof system should be integrated into the car in later models.

All roof variants can be installed on one production line, including lightweight fixed roof elements made of PU composite, folding roofs, panorama roofs with fixed polycarbonate or glass panels, openable panorama roofs, as well as solar roofs with the possibility of on-board electricity generation.



First Bentley SUV to be 'intelligent material' blend



Bentley's first SUV, due in 2016, will feature a blend of steel and aluminium structures to keep weight down to a minimum, reveals Rolf Frech, member of the board for engineering, Bentley.

"I am not a fan of a full aluminium car, because, in some areas, you have to bring in so much aluminium, it doesn't make sense to use it as, in the end, it's heavier.

"I am a fan of intelligent material mix, where you need the stiffness and strong materials you put in, even if it's steel; and, where you don't need

that, you use aluminium, composites or magnesium.

"I think the right route is intelligent material usage. If you look at Audi, they are coming from a full aluminium car to hybrid materials and, with our SUV, we're going with Audi, so we can use all these technologies on the platform. We will go for a multi-mix structure."

Frech also confirmed that Bentley's venerable 6.75-litre V8 will continue in production for the foreseeable future, despite the ever-tightening CO₂ limits.

He also revealed that production engineers had been seconded to the Continental GT3 programme to learn about more lightweight materials and how they could be applied to

Bentley's future road cars, without being detrimental to quality and refinement.

This process is already underway, said Stephen Davies, project leader for the new Flying Spur (above), which is 50Kgs lighter than its predecessor. The front fenders are superformed from 5083SPF aluminium by Autolaunch, while the bonnet is TL094 Dry Lube and the boot lid formed from composite material.

Bentley worked with Maucher to develop undersheet material for the front wheel arches. It is the first time that Seeberlite has been used for wheel arch liners, and offers the added benefits of light weight, thermal stability, stiffness and acoustics over other traditional textile parts and hard plastic components.



Safety and comfort to fore in Synergy Seat Gen 3

The latest Synergy Seat Gen 3 from Johnson Controls features a number of new elements that are in production or near production ready. The main innovation is an exposed organo sheet fibre reinforced back frame that is 10-15% lighter than normal and, because it has an 'A' class finish, is uncovered, releasing some additional rear leg room.

It can integrate features such as tubes and guides for head rests, now with a 4-way

head restraint (up, down, fore and aft) with manual and powered options, with the electric motors located in the head restraint for improved packaging. Johnson Controls is investigating a pre-crash situation from the rear where, by putting a high voltage to the motors for quicker reaction, it would bring the restraint closer to the head, preventing whiplash.

The seat also features natural coconut fibres that are thinner and act as carriers for components such as fans, dual density seating foams, with a more compliant upper surface for immediate comfort and a firmer lower strata for long-distance comfort, upholstered in electro-welded fabric elements.

Micro hybrid battery aims for 15% fuel saving



Johnson Controls has revealed its first 48-volt Lithium-ion micro hybrid battery, combined with a 12-volt starter battery, that has the potential to save up to 15% fuel consumption. It will be available for testing from December this year and Ray Shemanski, vice president and general manager, global original equipment business power solutions, predicts early adoption of the system by 2016, while Johnson Controls' own research suggests that, by 2020, 25% of the market for new cars could be fitted with batteries.

According to in-house modelling, the complete installation would cost between €750-€900, with a payback time of two years for a motorist covering 15,000Kms a year.

The 48-volt battery is designed with the capacity to capture energy quickly from braking and can support higher loads, such as air-conditioning and active chassis technologies. The 12-volt battery will continue to provide power to the vehicle starter, interior and exterior lights, and entertainment systems, such as radios and DVD players.

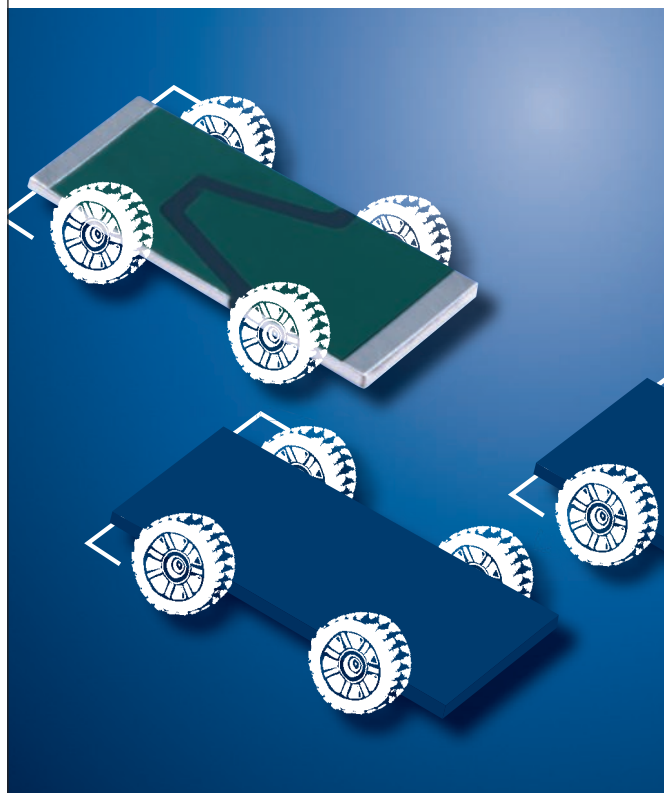
"Each customer has their own challenges, because each is closer or further from achieving those CO₂ requirements, according to their model line-up," said Shemanski, adding that these battery hybrids are more likely to feature on premium, large saloons, rather than small or compact cars.

Isolite's silica fibre xp – originally developed for aerospace application – is an integral liner with aluminium foil that can be moulded into any shape for insulating exhausts or bulkheads. It gains its insulating properties the first time the engine is started; reaching 850°C, the material expands into a 'popcorn' like structure, which it maintains even when cooled down. Sound insulation properties result in a 30% reduction in dBa.

Isolite is working with both VAG and BMW on future applications.



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Latest Mazda 3 central display screen seeks to deliver the magic

The latest Mazda 3 features a high-tech central display screen, based on the work of the late George Miller, the psychologist who came up with 'The Magical Number Seven, Plus or Minus Two', which claims an average limit of seven for

human short-term memory capacity. "A lot of the European drivers are used to this 'Commander' system, but the American market is very much a touch panel market, so it's difficult for them to familiarise themselves with

the Commander," explained Mazda 3 programme manager Ken Saruwatari. "They don't want to go through any complex functions, so it had to be intuitive to use."

Each display is limited to seven lines in total, five of which are the contents, plus two lines for the menu page's title. To determine the font size – 5.8 mm – and line spacing – 0.84mm – Mazda measured eye movement to the screen, which is a coefficient of the number of degrees the eye traverses, multiplied by the number of times the eye moves vertically.

This, combined with discovering that the human eye can comfortably take in 5°, or 24 minutes, determined that only a seven-inch screen was needed.

Using its SkyActiv philosophy, Mazda has pared 68Kgs from the car, including 8Kgs from the seats alone. "The second part of this engineering process is the 'Monosukuri' ('making something') innovation, focused on the supply chain and manufacturing, and getting them on board from the start," explained Saruwatari.



Toyota driven by 'sustainable mobility' vision

"The quoted \$50,000 (€37,600) selling price for our hybrid isn't accurate," says Toyota's fuel cell development director Katsuhiko Hirose, continuing: "We haven't set a price yet, but, in the longer term, it will be similar to a conventional gasoline-powered car."

Toyota will introduce its first-generation hydrogen-powered car in 2015, with the second generation at the end of this decade, followed by a third generation in 10 years' time.

Reducing the amount of precious metals used has been a big contributor in cost reduction, states Hirose. And with power now approaching 3kW/litre, he claims the best way to bring down costs is the continual improvement in power outputs, plus upgrading the cooling system.

"By redesigning the complete system, we have been able to eliminate the humidifier. That has saved costs.

"Our goal is enabling every person in the world to enjoy mobility. If you have a sustainable fuel like hydrogen, it means that everyone can enjoy our vision. Our goal is people with sustainable mobility."

GKN Multi-Mode eTransmission debuts on Mitsubishi Outlander PHEV

GKN's Multi-Mode eTransmission has debuted on the Mitsubishi Outlander PHEV, hailed as the first Twin Motor 4WD plug-in hybrid electric vehicle.

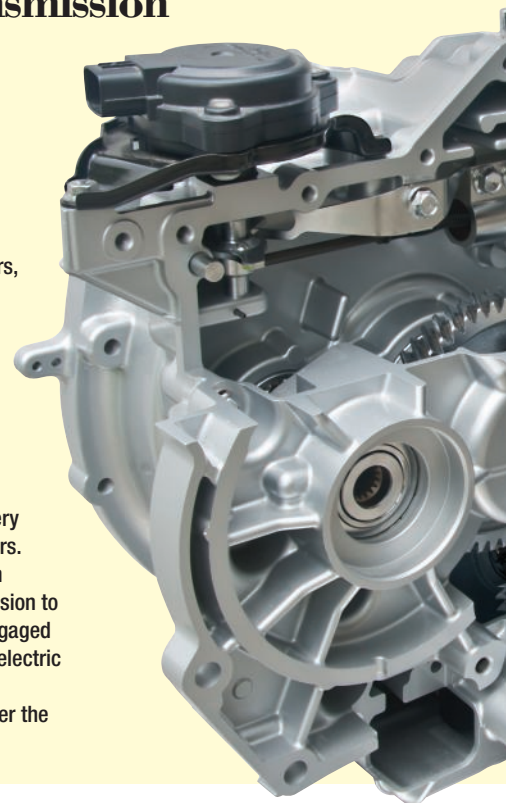
The crossover is powered by twin 60kW electric motors, one in the front and one in the rear, fed by a large capacity 300v, 12kW lithium-ion battery.

The GKN Multi-Mode eTransmission fitted to the front axle offers three driving modes from two different power sources. These are pure electric vehicle (EV) mode, with both axles driven by the electric motors.

Secondly series hybrid mode, with the 87kW petrol engine driving a generator to charge the traction battery on the go, with the car driven by its twin electric motors.

And, thirdly, parallel hybrid mode, with the combustion engine's torque feeding through to the GKN eTransmission to the front wheels via a hydraulic clutch, which is disengaged in the other modes. This is supplemented by the twin electric motors and the battery is also charged.

Mitsubishi is claiming CO₂ emissions of 44 g/kms under the European Driver Cycle.



Volvo takes powertrain strategy into its own hands

Volvo has rationalised its powertrain line-up around a two-litre block, with 91 mm bore centres for both its petrol and diesel engines, featuring common head configurations, bed plates, oil and water pumps.

"We had a lot of complexity, with some Ford engines, some of our own, lots of different fuel tanks and exhaust systems," said Derek Crabb, Volvo's vice president power train engineering.

"There was no customer value and it was costing a fortune, so complexity was killing us and stopping technical development, and fuel consumption was going to be a big challenge for us."

Volvo wanted to control its own powertrain strategy and have access to fuel economy technology that it can be in command of itself. "It was a massive challenge for us to develop eight engines, and the best way we could do that was to simplify and modularise as much of them as possible."

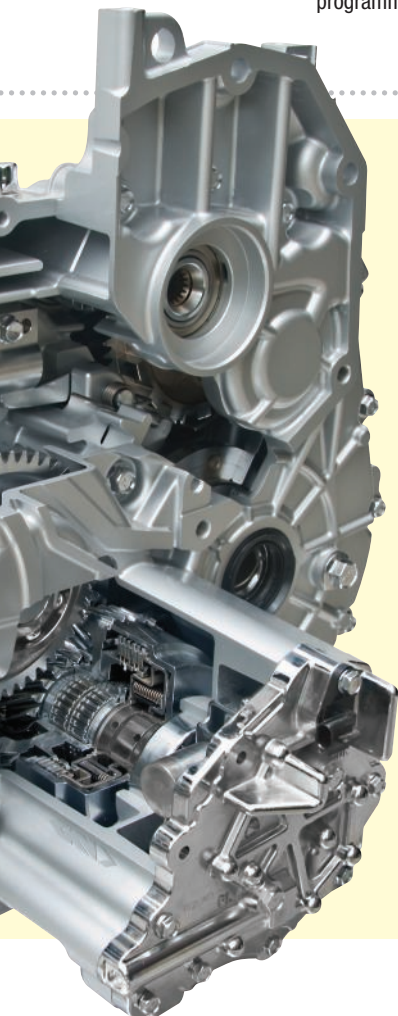
To this end, Denso supplies the base engine management system, which is then programmed for each

application. Likewise, Volvo employs just Aisin automatic gear boxes – a 6- and an 8-speed.

"Whether it's diesel or petrol, we have modularised the engine, so all the catalyst systems come out looking the same: there's a Euro gas, North American gas, a diesel with a lean NOx trap and particulate filter to make it as

easy as possible." While Volvo has used compound charging in its most powerful petrol engine, Crabb admits to looking at electrical supercharging as well.

"But it didn't quite work for us, although I wouldn't say we will never use it, as it's very promising technology."



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News in brief

Continental and IBM join forces

Continental and IBM have announced a collaboration agreement that will see the companies jointly develop fully connected mobile vehicle solutions for car manufacturers around the world.

Central to the agreement is the development of a highly scalable cloud platform that will enable OEMs to deliver a range of new mobile in-car services. It will, state the companies, allow software updates and vehicle control device functionality to be delivered over the Internet, removing costly and inconvenient workshop visits, giving OEMs the opportunity to offer their customers a vast array of new features.

Advanced Diesel Electric Powertrain

Controlled Power Technologies' SpeedStart micro-mild hybrid and Tigers energy recovery systems will be incorporated into Ricardo's Advanced Diesel Electric Powertrain (ADEPT) project.

The Adept project aims to apply the low-voltage concept of 'intelligent electrification' for the first time to a diesel car in a project supported by the UK's innovation agency, the Technology Strategy Board. Keeping the voltage to nominal 48 volt technologies applied to a Ford Focus, it aims to deliver a breakthrough in diesel engine fuel efficiency and CO₂ demonstrating full hybrid equivalent fuel economy and performance, with less than 70g/km CO₂ emissions, but at significantly lower cost.

The combination of various technologies and engine downsizing from the baseline 1.6-litre diesel engine is expected to deliver significant synergy and cost-effective benefits, without compromising vehicle performance.

The Proving Factory

Magnomatics, a manufacturer of energy-efficient products based on ground-breaking magnetic gear technology, has been announced as the sixth technology developer to join The Proving Factory.

The Proving Factory is a unique organisation in the UK automotive industry, bridging the market gap between technology developers making innovative, low-carbon proof-of-concept prototypes and the need to develop vehicle manufacturers' confidence in the new technology by providing volume supply.

Johnson Controls' 'Bespoke' concept interior follows three themes: Does the interior fit me? Does it allow me to organise myself with all the things we carry around? And finally comes the everyday escape – the car being the 'third place' after home and work.

The concept interior features high grade artificial leather that is now cascading down to the 'C' segment and a new take on a suspended cloth

panel in the door, which compresses up against the fascia, eliminating unsightly gap lines. It also has the advantage of increasing the fascia's length by one centimetre at both ends, creating more space for glove box volume and air vents.

A central moveable arm rest has a USB charging port and there are also charging points in each door rest, and a wireless charger in the centre console.

Perhaps the most interesting feature is a removable bin surrounding the centre console for catching loose coins that fall out of pockets or mobile 'phones, preventing them from going under the seat.

Meanwhile, natural mat door panels with back injection take 3.5Kgs out of the interior, with a further 500 grams out of the instrument panel slush skin, thanks to Johnson Controls' patented air bubble process.



Active grille shutters and engine encapsulation promise big gains

Active grille shutters and engine encapsulation can result in worthwhile reductions in CO₂ levels and noise, vibration and harshness, claims Röchling's manager advanced development, Dr Klaus Pfaffelhuber.

By delaying the cooling of the engine when it's turned off, it is possible to achieve significantly lower CO₂ emissions and less fuel consumption. For better thermal insulation of the engine compartment, Röchling Automotive now offers a new multi-layered encapsulation technology, based on low-weight reinforced thermoplastics (LWRT). This technological approach provides not only optimised thermal management, but also big acoustic advantages.

Testing the 15mm thick encapsulation material 'Isoraloft' on a 1.6 diesel at 12°C resulted in a 40% reduction in warm-up time, 10 Kelvin (K) more heat retention after seven hours and a 2-3 g/kms reduction in CO₂, as well as an 8dBa reduction in sound levels.

Fully encapsulating an engine would add about 1.75Kgs to the car's weight, at a cost of €30-50, which, says Pfaffelhuber, would be quickly recouped in fuel

savings. Although it is difficult to retrofit, Pfaffelhuber predicts that new models appearing in the 2020 timeframe would feature the technology and is best used in conjunction with an Active Grille Shutter, which can result in a 1% fuel saving in the European drive cycle.



Delphi's 'MyFi' promises best of both safety and connectivity

Delphi's 'MyFi Connecting with Safety' is an amalgam of active safety and infotainment technologies, designed to reduce driver distraction during critical situations, yet still allow them to enjoy connectivity and infotainment.

According to the US National Highway Traffic Safety Administration (NHTSA), 76% of accidents are caused by driver inattention and those who text while driving are 23 times more likely to be involved in a crash.

Core to the system is a new workload manager and driver state sensor: the former takes inputs from all the vehicle sensors, including the latest integrated RaCam unit that combines a 76Ghz radar with a 38° camera lens (for the next generation, this will increase to 52° for improved pedestrian detection at low speed), while the driver state sensor tracks both the drivers' eyes and head movements to see if they are paying attention to the current driving situation.

As well as lane monitoring, steering intervention and automated braking, the system monitors the density of road traffic and weather conditions. If, for instance, the driver



receives an email, text or 'phone call, the system will automatically delay it, if it deems the driver workload is too heavy. Moreover, a red light mounted on top of the fascia flashes, if the driver is distracted, to bring their eyes back to the road – or the central TFT screen will be greyed out to prevent the driver from operating it under adverse conditions.

"We know how long the driver is looking away and can warn them or suppress functions on the head unit to prevent touch screen operations," explained Roland Hollemann, chief engineer advanced engineering infotainment and drive interface Europe, who added that the current 1280x480 TFT screen will be replaced by a high resolution 1920 screen in the next-

generation version of 'MyFi'.

The driver or front seat passenger can control the infotainment and navigation system, which is brought into the car via a smart 'phone, through voice control; in this case, it's Cloud based, giving it greater authority and the ability to 'learn' driver preferences.

Meanwhile, the in-vehicle wireless network allows passengers to share data and content seamlessly, and can input navigation and infotainment instructions, without distracting the driver.

Hollemann said the RaCam system goes into production at the end of next year, with the driver state sensor and workload management following in 2016, along with the improved camera technology.

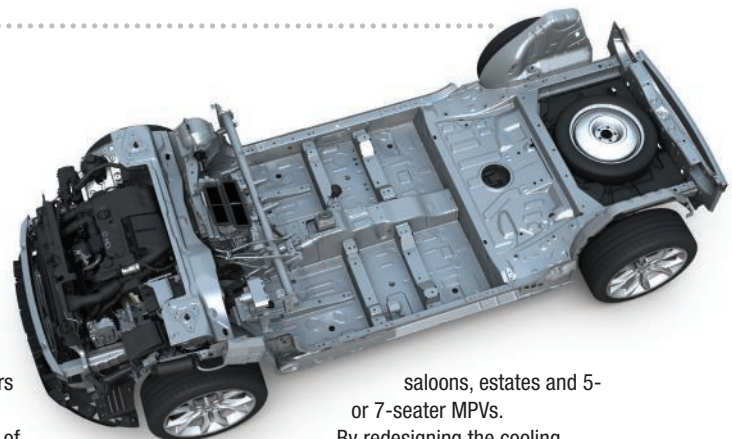
"There are some limiting factors with these systems as we move towards autonomous driving," warned Hollemann. "You need to gather more experience and understand how the system is developed, and it will take time for customers to get used to it – and, if the system detects the driver should be taking control, what that transition should look like."

Peugeot's flexible friend

PSA Peugeot-Citroën's new Efficient Modular Platform (EMP) 2 is 70Kgs lighter than its predecessor, through the extensive use of high-strength steel and advanced high-strength steel, which comprises 76% of the platform mass, compared to 22% on the previous one; it also makes greater use of laser welding and incorporates a composite boot floor for the first time.

A further 70Kgs is saved in the body mass itself, where the wings and bonnet are formed from aluminium

It has also been designed as a strategic response to underpin mid- and high-range vehicles, explained whole vehicle lead engineer Benjamin Hindsley, and is compatible with high- and low-seating positions for cars and SUVs, and five wheelbases with a variation of 220mm in 55mm steps. This is achieved by



inserting the strips between the 'B' post and heel board. In addition, four different wheel tracks are possible and there is also a quartet of four rear units, compatible with seats and boots for

saloons, estates and 5- or 7-seater MPVs.

By redesigning the cooling system of the new Peugeot 308, said Hindsley, it was possible to reduce the front overhang by 6cms and, since the car is 3 cms shorter than the outgoing model, the 'left over' 3cms has been used to enlarge the boot.

Starting with launches in 2013, group vehicles in the C, D, premium and F segments will be launched on the new EMP2. This will involve three manufacturing sites at the beginning and, ultimately, seven globally.

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





A novel herringbone design of exhaust catalyst could be the ‘Eureka’ moment for emissions reductions, says ACAT Global’s CEO Joseph W Moch. Ian Adcock tries to unravel the story behind it

Exhausting Possibilities

Originally, automotive catalytic convertors, which date back nearly half a century, were of a bead type configuration but these were rapidly overtaken by multi ceramic monoliths typical of what we are familiar with today. Even then, recalls a retired GM and Delphi engineer, who spoke to *Automotive*

Design on grounds of anonymity, the search was on for a more efficient means of cleaning up a vehicle’s exhaust emissions.

“Everyone knew there had to be something better than a ceramic bead convertor. There were multiple paths being looked at during that time...GM was saying ‘OK, let’s look at metallic substrate.’ They tried things like spun wool to barbed wire-

type of looking things; anything that gave you the surface area needed to put a coating and precious metals on.”

The American auto giant also spent 2-3 years developing a variety of alloys that could provide the unique properties a metal internal substrate needs to perform in the catalysts’ environment and with the robustness demanded of the

Joseph A Moch

CV

Moch is an attorney who has been involved in cases in 47 states and written eight books on law. He served as Chairman of the Environmental and Toxic tort section of the American Bar Association, a position which led him into the catalytic converter industry. "I'm obsessed with and driven to make the world's finest catalytic converter," say Moch, which led him and his son, Joe W Moch, to purchase Delphi's catalytic converter division, now known as ACAT (Advanced Clean Air Technologies) Global.

lighter and has this aggressive kind of semi-turbulent flow that it creates as the gases pass through the substrate to give a good tumble, mixing effect and create more advantage to the precious metals, said AD's source, adding:

"The herringbone, first off, has 30% less metal than a given size substrate. So, if you have an 85 cu in (1392 cc) substrate in a standard trapezoidal shell, and you compare it to an 85 cu ins herringbone, it has a third less metal, weighs 33% less, yet will outperform the standard catalyst from a catalytic and sound deadening standpoint, because it has a semi-torturous path. You can't see air through it very well, although

torturous planer flow in each 'A' and 'B' layer. So now you have utilised flow across the whole available plane of surface and not just one little triangular passage. That's where you gain, not only having less material, but better emissions performance, because the actual active surface area that comes as part of the thermodynamic equation when gases are going into it is better than the same-sized triangular passaged product."

GM went so far as to install the catalysts on some Opel Senators in the mid-1990s, supporting a pilot production facility in Michigan, but these cars probably suffered some operational failures, as the catalyst



industry. The original target was to fit the metal catalyst to the now defunct Saturn range that was launched in 1982. As the team quickly realised its original thin form plate construction wasn't the way to go forward but, rather, a new, patented, herringbone construction seemed to offer the right solution, "It uses about a one-third less foil to the substrate for the same performance or even better than the same size or larger form plate. It's

you can see a bit, because gases have to flow through. But because the 'A' and 'B' layers on top of each other match up to the reversals in the opposite direction, what you have might look like a standard triangular cell – because it flows in at 45° and then changes direction by 45° – the real key is that each pair of layers has a planer flow between them. It's not as if you're restricted to one channel through the part, because there is a semi

didn't have a mat-wrapped substrate. This was subsequently cured by using a 3M-developed mat material, now marketed under the Interam brand.

As GM consolidated its various component divisions under the Delphi brand, which it floated in 1999, many patents also passed to the new business, but six years later Delphi was filing for Chapter 11. As part of that process, Delphi consequently divested its exhaust

ACAT's sound reduction

Measured at 6ft, 300kW load, 14L 60 series D.D T-3 decibel reduction			
Octave band centre frequency Hz	Reduction db	Octave band centre frequency Hz	Reduction db
63	10	1k	23
125	25	2k	20
250	30	4k	20
500	30	8k	20

and catalyst divisions to Katcon and Umicore in 2007-8.

Moch and ACAT Global acquired the herringbone technology, patents and assets in 2010. "Included were all the metallic catalytic converter production equipment, all research and development pertaining to the metallic substrate development programme, and access to the engineering team involved in developing the metallic catalytic converter technology," he explains.

The big claim being made by ACAT, which is readying production facilities in Charlevoix, Michigan, and near Budapest, Hungary, is significant improvements in emission levels, especially for diesels. "Right now, we're way beyond Euro5. Even for Euro6 and 7, just based on applications of wash coat, we can solve virtually any European requirements without any problems across the board," claims Moch, adding: "We're in final testing with three different major diesel manufacturers and the only test they've asked for, after reviewing our test data, was the hot shake test to ensure it passes endurance testing on their specific engines.

"We have developed a new foil specifically addressing the needs of the diesel engine after-treatment requirements, as well as the 100 HB, which is ideal for high soot applications and those sensitive to large Diesel Oxidation Catalyst (DOC) pressure drop. The larger channels reduce soot build-up, but the herringbone efficiency still

ensures customers obtain respectable conversion efficiencies with normal precious group metal loadings. The 100 cells per square inch (CPSI) design is also very free-flowing for low pressure drop and we're in the process of developing a 70 CPSI design for some large specialty applications.

"Additionally, depending on the engine, substrate and the wash coat, we have seen 16%-43% reduction in particulate matter (PM), depending on the engine, particle characteristic and wash coat composition.

"Later this year, ACAT plans to investigate applying our substrate technology for use in the SCR portion of diesel after-treatment. The improved light-off time inherent with our technology could offer significant benefits for NOx reduction, as this portion of the after-treatment system is the farthest away from the exhaust manifold. Additionally, since our design allows exhaust gas to pass between channels, it may improve DEF/NH3 mixing within the substrate for increased efficiency

over a traditional straight channel design."

The light-off times for both petrol and diesel applications are also substantially reduced by 15-20% as well, says Moch: "That's due to the lower mass, no dead centre and the linear herringbone construction diffusing heat evenly across the substrate to the outer edges. We have seen improved efficiency of the unit on cold-starts and early in the emissions test cycle. These benefits are more evident in diesel, hybrid, stop-start and turbocharged engines since they all tend to struggle in cold-start or have trouble maintaining converter operating temperatures, especially in urban, low-speed driving."

Because of the tortuous nature of the air paths created by the herringbone design, the exhaust note is considerably quieter, with noise reductions of 15% being measured on 15-litre and larger diesels. Even on production engines, "the ACAT system reduces exhaust noise by approximately equivalent to a standard silencer so, at the very least, OEMs could downsize it and save on weight and cost," he suggests.

ACAT recently passed its ISO certification audit and is currently producing limited volume, with the aim of ramping up production for its first customers in the near future.

If the system proves out ACAT's claims, then it could, indeed, be a game-changer just at the time when stricter emissions regulations are on the horizon.

ACAT passenger vehicle EPA aftermarket catalyst test programme

3.8L Chevy Camaro 1/26/12		Standards – EPA		
		THC EFF	CO EFF	NOx EFF
		70%	70%	30%
OEM unit	ONT24521	97.00%	97.810%	98.07%
XXX leading european 94 cubic inch catalyst	ONT24798	91.24%	95.26%	95.80%
ACAT 74 cubic inch catalyst	ONT24904	95.28%	98.22%	97.70%

Technology to the fore



SAE International just successfully wrapped up another World Congress in Detroit in April. Some of the highlights included more than 10,500 attendees from 46 countries, presentation and publication of 1,364 technical papers, and more than 170 companies exhibiting the latest innovations.

The AEI editors annually review those innovations and dig deeper for the most notable. Judging is based on level of design and engineering innovation, uniqueness, potential for 'real-world' production application, and potential benefit for industry customers and end user. The winning technologies are:

FEV Inc.'s MicroHiL engineering-service solution, shown for the first time at the 2013 SAE World Congress, is believed by FEV to be the first portable HiL unit developed specifically for testing engine components at the system level.

"This unique device will allow FEV to better serve customers by testing, calibrating and validating literally anywhere that is convenient

for the customer. It allows us to complement the service provided by full test cell powertrain evaluation," says Gary Rogers, president and CEO of FEV Inc.

Ergoneers demonstrated its eye-tracking system, called Dikablis, which consists of a head-mounted eye tracker device that, together with the company's proprietary D-Lab software, helps engineers measure, analyse and optimise human-machine interactions for ergonomic design and other purposes. Ergoneers' system has a valuable real-time element. "Many users of our product want to trigger an event or a response in either a simulated or actual environment, based on where a subject is looking, what he is doing, or what a

car or machine is doing in real time. This ability makes our product on the extreme cutting edge," says Anne Storm, president of Ergoneers of North America.

Horiba launched the second of its 'ONE Series' products, the dilute system comprised of CVS-ONE (Constant Volume Sampler) and MEXA-ONE, designed for the measurement of diluted exhaust gas from vehicles and engines. Apart from complying with the latest emissions regulations – Euro 5/6, Euro VI and U.S. EPA regulation 40 CFR Part 1065 – CVS-ONE also supports future regulations such as WLTP (worldwide harmonised light vehicles test procedures) or GTR (global technical regulations) that are currently under consideration.



focus@sae.org



A RIGHT ROYAL

**An interior influenced by the Jubilee celebrations?
James Brewer finds out more**

We all know that car designers, especially when creating free-form concepts, take their inspiration from the most unlikely of sources. But from Queen Elizabeth II's Jubilee celebrations? That has to be a first.

Frank Leopold, who engineered the Opel Monza seen at Frankfurt, enlightened me: "You remember the evening concert when they projected images onto the front of Buckingham Palace? Well, they were using light emitting diode (LED) beamer technology and we wondered if we could use that in our next concept car for Frankfurt."

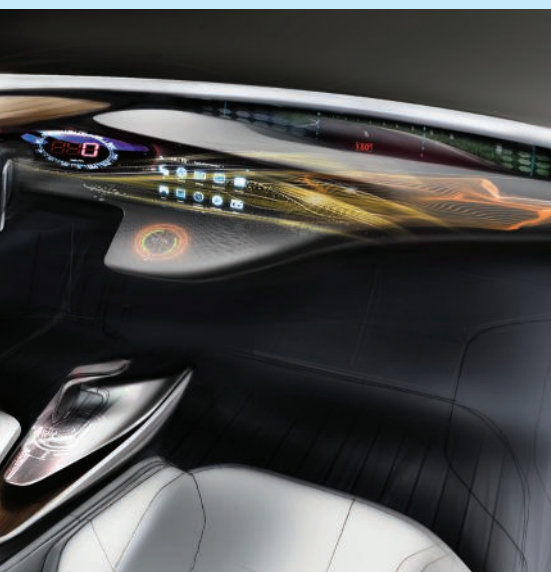
Scaled down for its first, patented, automotive application, the Monza's interior houses no less than 18 LED projectors to illuminate the sweeping curves of the fascia that stretch the width of the car; its surface is a combination of matt and gloss finish to give varying degrees of effect, hiding the beamers that project individual and overlapping images on to the surface to give a 3D display,

"In our front lights, we have up to 70 small LEDs and the beamer technology is not so far off, because it's just started being developed. So our assumption was that in 2020 we will, maybe, have this technology in cars with, perhaps, curved screens. The problem was that we wanted a 3D effect in the car, because, if you have the screen close to the occupants, it's important to have depth and distance for focusing their eyes."

Each beamer projects an individual image, controlled by software, so that they marginally overlap to create the 3D effect. "So we needed to calculate that and map them together, which caused a few headaches," Leopold concedes. Like so many electronic display elements currently under development, the Monza's has benefited from processors being developed for the computer and digital games industry, "They are constantly getting faster, smaller and cheaper, which helps us in these applications," he said, although he wasn't about to divulge who were GM Europe's technical partners in this project, apart from



PERFORMANCE



saying they are “based in Europe”.

But is this technology really feasible for future production cars? Leopold is cautiously confident. “What we wanted was to create this image of Opel-Vauxhall in 2020-22, so we have to go a little bit more than where we are today with Insignia. We have capacitive touch areas and I would say, in 2020, you will have voice control and, if you have that, you don’t need to have big fields of touch areas; only small areas where you want to locate certain functions, but not fixed positions.

“If you say ‘radio’ or ‘heating’ then you go into a deeper menu and, if you want to programme something, you need switches. But for the main function you will have voice control and some push buttons on the steering wheel.

“This means that IT meets automotive; the whole car is a screen, like you have on home entertainment with different programmes. With this assumption, we started to say ‘If IT meets automotive’, there’s a necessity for the OEM to organise the information, because the driver needs focused information for driving with their hands on the steering wheel and the passenger wants entertainment. In between, there’s a kind of

correspondence about navigation, information, where we go, incoming information via the Internet – this all has to be demonstrated. So, how can this all be landscaped? You expect things like this to go into cars around 2020-ish, so you would have one beamer in a cluster in the Adam, Astra maybe two, and in a car without side mirrors four beamers. Just to give you an idea of how this, maybe, comes to realisation.

“This is an industry first, because, if you remember the Saab 9-1X concept from 2008, I wanted to do a laser projection ice block cluster for that car, but we couldn’t find a powerful enough laser and, also, you can’t risk looking at a laser. So we had to look for other things and we found this technology that’s normally used to project onto houses for outdoor events.”

The next step for Leopold and his team is to develop the concept towards production intent: to assess the packaging and heat soak issues, as well as its performance under extreme conditions and durability. If those criteria can be successfully met, then, you never know – by the turn of this decade, we might just be driving an Opel or Vauxhall with instrumentation inspired by the Queen’s Jubilee.

VIRTUALLY, the REAL DEAL

OEMs want faster time to market, reduced development costs and ever more sophisticated testing. One man has had the vision to develop simulation technology to fulfil that goal – operating at the very edge of reality. Ian Adcock reports

Cover story

"We learned valuable lessons from the games industry They had to be robust, work all day, every day, for years and be simple to operate."

Maarten van Donselaar, CEO, Cruden

Walk into Cruden's slightly scruffy and unkempt workshops on the waterside near Amsterdam and you're immediately confronted by six huge actuators towering upwards like some 'Star Wars' robot, complete with a large platform above. This, explains company CEO Maarten van Donselaar, will eventually be an airline cabin simulator, so the crew can be trained in a replicated black-out storm scenario, complete with a bucking and weaving fuselage – although he didn't add if panicking passengers were part of the package.

It's an appropriate introduction to the Dutch company that is, yes, named after an obscure west coast Scottish resort where Bram Stoker holidayed and reputedly wrote parts of 'Dracula' – because it was from the ashes of the defunct Fokker that Cruden eventually emerged.

To cut a long story short, explains van Donselaar, who had his own motor sport simulations consultancy at the time, he, together with Fokker Control Systems (FCS) and a third party specialising in high end interactive TV, decided in 2001 to combine their expertise and build a car simulator at their own expense.

"Increasingly, I came across customers who wanted more powerful results being presented to the management or more interactivity, so they could watch not only tables and graphs, but see the results of our simulation.

BETTER UNDERSTANDING

"Initially, I thought the graph said it all, but that's not true; because, if you look at the car in a well defined animation when cornering, and you see how the car behaves, it gives a better understanding of what the graphs mean."

That original simulator had three screens and a control loader that fed

back steering and pedal forces, a long way from the next generation where the trio modified an FCS customer project with a motion base and six degrees of freedom (6-DoF), a race seat and three screens.

CREATING A NEED

Feedback from potential customers likened it favourably to early large multi-million Euro simulators, like Daimler Benz's Berlin facility. "Our vision was for customers to order them from stock to keep prices down, so board approval wasn't needed to buy one," he adds.

At the time, there was virtually no demand from the automotive industry for simulators. "We had to create a need," says van Donselaar. So the trio turned to the amusement park industry and, in 2005, when a customer bought 18 simulators, it gave them the opportunity to move away from building simulators in their spare time and concentrate fully on motor sport and OEMs. ▶



► had to be robust, work all day, every day, for years and be simple to operate.”

It is those lessons that Cruden now applies to the simulators they regularly supply to OEMs such as Jaguar Land Rover, which has taken delivery of its first model. Vitally, though, the entertainment industry helped put a cap on costs.

“You can easily spend €20m on a simulator, buildings etc, like the big names, Toyota, Mercedes etc do. But I am talking about three simulators for less than €1m each that offer three times the capacity for use, with lower initial investment,” explains van Donselaar, adding: “OEMs are limiting their simulators to fairly narrow and well defined parameters, and that’s a wise thing to do. You’re better off having multiple simulators for numerous applications, rather than trying to build one that could simulate everything you could possibly think of. Then you end up with a huge machine that does everything not very well.”

And while this makes good business sense for Cruden, as they sell more simulators, there’s logic to van Donselaar’s argument when you start to appreciate the breadth of simulation that can be achieved using these machines.

To most, simulators are employed to develop a vehicle’s ride and handling dynamic characteristics that can range from

a Formula One car through to a truck; even tracked vehicles on virtually any type of surface, ranging from the race track to the – under development – soft soil tyre model for 4x4s.

SIMULATING THE FUTURE

“I believe that we’re at the beginning of an exponential curve in the market. I see greater use of even more realistic simulators in the future. OEMs want faster time to market, reduced development costs and testing, and you can do that with simulation technology, not just on the desk top, but also with human-in-the-loop environment.

“Our philosophy is that we provide a working system for the customer and they inject their own knowledge about the vehicle into the simulator’s controlling software.”

The obvious example of that are the F1 teams that close the door to Cruden as soon as the simulator is delivered and functioning to embed their own software. Even so, Cruden prides itself on its programming abilities. Most of its staff are employed developing unique programmes that project 3D virtual environments or translating the results of laser scanning road surfaces – it can take two weeks to create one kilometre of scanned track, I am later told, from data points with x-, y- and z-coordinates every few millimetres. But such

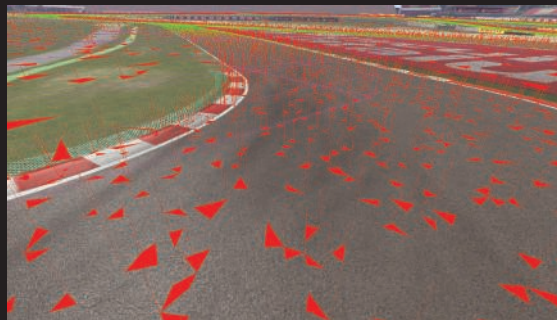
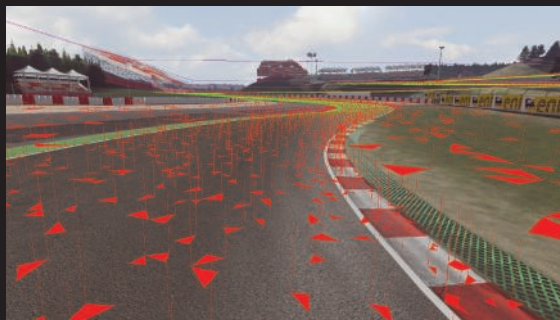


obsessive attention to detail is to be expected, if the simulator is to be accepted by the human vehicle testers, as van Donselaar explains.

ACCEPTANCE FACTOR

“If you want the test drivers to accept the simulator as a useful tool, they have to recognise where they’re driving. If they’re driving their favourite test road, and there’s a bump or a spot with less grip, there has to be exactly the same on the simulator. It has to be accurate and that takes a lot of resources. Most of the people you see working here are on content development.”

Then he recalls an incident that surprised even him. “We were



Laser scanning a racetrack (above) shows the myriad of three-axis points that are plotted to render a realistic simulation



Cruden's CEO Maarten van Donselaar believes simulation is at the start of what will be an exponential curve

working on a simulator with a test driver for an American tyre producer and, changing from summer to winter tyres, he said he could feel the difference. Then we reverted back and he told us we hadn't changed the rear left back to a summer tyre – and he was right! I would never have thought we could get to this level of detail, without using super computers.”

Cruden recognises that OEMs know more about the behavioural aspects of their products than they ever will do, so it employs an open software architecture that allows the vehicle producers to embed that data to gain the results they want. While dynamic programmes like Carsim,

“Our philosophy is that we provide a working system for the customer and they inject their own knowledge about the vehicle into the simulator's controlling software”

IPG and Adam don't run in real time, it is possible to feed back results to validate the mostly simpler models that run on simulators. Alternatively, working with VI-Grade that has acquired Adams' real-time initiative is a solution.

Delivery, says van Donselaar, doesn't stop at 6-DoF. “We're working on systems with either a lateral or longitudinal rail, or an additional turntable, so we could yaw more, without compromising the motion envelope in other degrees of freedom.

“Under development is, also, a new platform where the main objective is to create one modular application that can simulate race cars, road cars, traffic and not rely on different applications that communicate with each other.

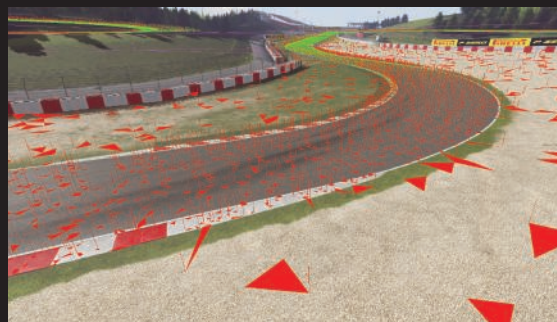
“It's currently a working environment. What we are adding before we can roll that out to customers is the usability aspect, because right now configuring how a pedestrian reacts when they see a car coming has to be programmed manually. Working on making that more accessible, using graphical user interfaces to define the behaviour of objects – and that can be anything –

you have complete freedom inventing new objects and adding behaviour to it. Whilst the next visual step – multi-channel projected images – could be in a cave or in cylindrical set-up, which is better for driving.”

VALIDATION EQUATION

I got the impression that no request would faze van Donselaar, but even he seemed a little taken aback by the customer who asked, in addition to visual, aural and physical feedback, to include olfactory comment. While another, for testing headlights, wanted oncoming rain to be included and, when that was only partially feasible, Cruden went the whole hog to develop a simulator that uses real water and a fan to simulate driving rain.

How much closer can simulation get to the real world? According to van Donselaar, “very, very close”, but he is realistic. “At some point, it begins to look more expensive than building a prototype, so it's not worth trying to reach 99.9%. And, at the end of the day, we always have to validate our results. We can never rely purely on simulation; simulation is only as good as its validation.”





Jaguar's concept C-X17 crossover is based on the company's all-aluminium iQ AI architecture

WEIGHING UP

In the battle to improve achieve peak efficiency and reach the mandatory CO₂ emissions levels by 2020, shedding vehicle weight has become one of the top priorities, as Tony Lewin reports

Reducing vehicle weight is one of the few genuine win-wins in automobile engineering – even though, ironically, the current German-influenced regime for calculating European fleet average CO₂ emissions means that lighter cars actually face tougher individual CO₂ emission targets.

This administrative anomaly aside, however, there is complete consensus that, in the struggle to improve efficiency and reach the mandatory 95g/ km CO₂ emissions by 2020, shedding weight is one of the top priorities. It's a familiar and irrefutably logical argument: with less mass to accelerate and brake, less engine

power is needed; the engine can become smaller, and hence lighter, and these secondary weight savings allow the use of lighter brakes, tyres and chassis components. And so the virtuous circle continues, with a further round of powertrain downsizing becoming possible.

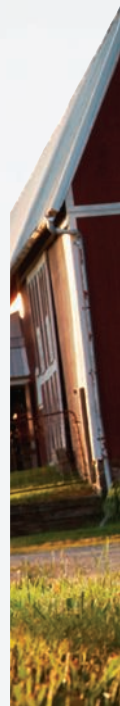
As a rule of thumb, for every 100 kg shaved off the vehicle's overall mass, CO₂ emissions can be expected to drop by some 9 grams per kilometre, in some cases more.

And with CO₂ emissions being squeezed by tightening legislation in all the world's principal markets, every automaker with an R&D budget and the desire to survive is looking seriously at the weight issue; most

have succeeded in slowing, or even halting, the upward weight spiral that took hold in the power-hungry pre-2008-crisis period.

Several have moved from steel to aluminium for hang-on parts, with a typical saving of 40 kg; many are already downsizing engines and transmissions, and others such as Audi and Jaguar have taken the big step to lightweight all-aluminium body structures. These can be up to 140 kg lighter than a standard steel body in white: the new Range Rover boasts a like-for-like weight drop of no less than 420 kg, once the secondary weight savings are taken into account.

Yet, when asked which vehicle best symbolises the beginning of the





Light weighting

new aluminium era, Philippe Meyer, chief technology officer of leading aluminium supplier Aleris, gives a surprising answer: the Ford F150 pickup. Not the Audi A8, the first series production model to use an aluminium spaceframe, nor the Jaguar XJ or XK with their pioneering aluminium monocoque construction; not even the new Range Rover with its state-of-the-art blend of lightweight materials.

"I like the F150, because it's in the US, it's a very high volume product in a traditional sector and a good portion of its body is aluminium," says Meyer. "In fact, there's a lot of aluminium spread throughout the vehicle."

But, for Meyer, the real clincher is

not technical, but industrial. "The F150 will need 350,000 tons of aluminium sheet a year," he explains. "This is roughly the size of the entire worldwide market for automotive sheet aluminium, some 400,000 tons, so it's a dramatic step for the material."

JAGUAR AMONG THE LEADERS

It is clear, too, that this is just the beginning. Jaguar, which by common consent has become the leading authority on aluminium construction, is gearing up for a big push with its new iQ AI architecture, effectively the fourth generation of its lightweight technology. iQ AI will underpin Jaguar's new generation of smaller

THE BENEFITS



High volume Ford F150 pick-up is a major user of aluminium panels

vehicles, including its BMW 3-Series sized sedan, due in 2015; the system's potential is being previewed with the C-X17 sports crossover concept.

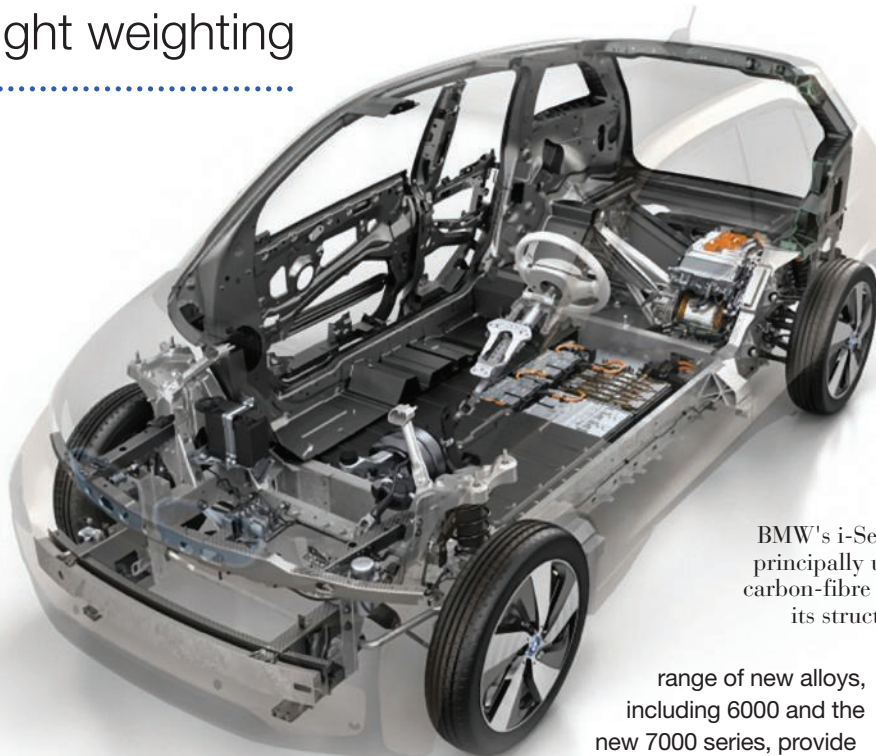
Jaguar Land Rover has significant expertise in lightweight design, says Kevin Stride, vehicle line director for the new model series and responsible for the iQ AI architecture: "No one now matches JLR's expertise in aluminium and now we're taking it a step further," he explained during an exclusive technical briefing at Jaguar's UK design centre.

WORKING FROM A BLANK SHEET

"The architecture is completely new – a blank sheet of paper," he added. "It had to be, in order to achieve the goals we want."

Explaining further, Stride says that the architecture is "a complete toolbox", allowing designers total flexibility to get the proportions they

Light weighting



BMW's i-Series principally uses carbon-fibre for its structure

want. "Each model is made to measure – the core of the architecture is from the front of the car to the middle; the suspension systems are common, but they're all tuneable."

REVOLUTIONARY ARCHITECTURE

While Jaguar is understandably reluctant to give too much detail on iQ AI, prior to its commercial launch in 2015, it is clear from the company's responses that this is a system geared towards volume production. To make aluminium viable, says Stride, "we need higher volumes – so we need all the manufacturing processes to deliver. The sweet spot of our volume engineering capability will be put into these models".

Compared with earlier architectures for much pricier vehicles, the iQ AI system will incorporate more sheet aluminium, and proportionally fewer castings and extrusions; joining technologies represent a further advance and include adhesive bonding, rivet bonding, clinching and welding. These processes are all cleaner, quieter and use far less energy and water than conventional steel build processes, says Stride.

Additionally, he says, a whole

range of new alloys, including 6000 and the new 7000 series, provide much more specific strength and help iQ AI realise excellent stiffness and the unusual ability to achieve both 300 km/h and under 100 g/km CO₂. Philippe Meyer, of Aleris, says that 7000-series aluminium is presently "at the development stage" with customers and that it can provide a 40% weight saving for the same crash resistance as the best current steels; JLR's aluminium partner to date has been Novelis, the global leader in automotive aluminium.

EXOTIC MATERIALS

While the grand projections issued by the aluminium industry might give the impression that this metal is the only solution to creating lighter vehicles, two further materials – magnesium and carbon composites – have been used for some time to reduce the weight of individual components. Magnesium castings, for instance, are regularly specified for the large and complex IP cross members, and the new Range Rover Sport uses a magnesium front carrier to enhance its pedestrian safety performance. Carbon composites in their various forms are also familiar as weight-saving door, bonnet and roof skins on sports derivatives of premium models – and, of course, in the complete monocoque structures of extreme performance sports cars.

For BMW, even a fully aluminium structure would not have been light enough for its new-generation i3 and i8 electric cars: the company realised that only a predominantly carbon fibre construction would provide the ultra-light platform needed to compensate for the extra mass of the batteries, and endow the models with a good power to weight ratio and thus acceptable driving range.

BMW's i-series models will be watched very closely by the industry – not just for their electric traction, but also in order to see how the hitherto thorny carbon fibre issues of slow manufacture, high cost and problematic end-of-life recycling are handled.

WHAT THE FUTURE HOLDS

Pressed as to what the material composition of a very high volume model such as the VW Golf might be in 2030, Philippe Meyer says that the design of the vehicle would be critical. "Perhaps 50% of the shell would be aluminium," he speculates, "with maybe 10 to 20% being castings and extrusions." The European Aluminium Association, for its part, anticipates that by 2020 the typical car will contain between 160 and 180 kg of aluminium, up from today's 140 kg.

An important step will be marked once there is a critical mass of aluminium cars in circulation and beginning to enter the recycling process. This will further boost the sustainability of the material, saving 95% of the energy used in the production of new aluminium; the metal is ideal for recycling, agree experts.

But whatever the eventual split between automotive materials proves to be, and whether or not a viable second use for carbon is developed, one thing is certain: tomorrow's cars will be an order of magnitude lighter than the models we know now. They cannot afford to be anything else.

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BRACED FOR

Bolt-on chassis braces increase stiffness for better steering response and NVH, with less weight than a similarly strong, unbraced frame, writes Dan Carney

A bolt-on reinforcing brace may look like an afterthought or a patched-on solution, but, in fact, a variety of chassis braces are increasingly, giving new cars, especially high-performance models, superior levels of rigidity.

That translates into corresponding benefits in steering response, control of wheel movement over bumps and, counter-intuitively, noise, vibration and harshness (NVH). That's because appropriate rigidity at suspension pickup points on the frame allows use of compliant bushings that reduce NVH transmitted to the driver.

Advances in tyre technology contribute to the need, as larger-diameter wheels, fitted with low-profile tyres, have less compliance than smaller wheels with taller sidewall tyres, which increases

the sharpness of impacts to the chassis.

Meanwhile, the increased grip of those same tyres raises the chassis-bending loads the tyres can apply to the car. That's why existing chassis designs need reinforcement, and existing reinforcements are seen as too flimsy for the job and are being replaced with monstrous bridge trusses meant to banish unwanted flex.

BOLT-ON BRACES

Bolt-on braces are used primarily in four different applications, reports Dave Marler, group chief engineer for computer-aided engineer and development at Lotus Engineering. Lotus subsidiary Lotus Lightweight Structures supplies such braces for OEM customers.

The four applications, states Marler, are: front suspension shock

tower braces, including shock tower braces that triangulate with the firewall bulkhead; transmission mount braces; ones that directly connect suspension mounting points to one another; and rear suspension shock tower braces. There is also some limited use of bracing to augment crash protection, but that is a rare application of the technology, he adds.


Why install braces? "They are used because a straight line between two load points is an efficient way to join those points." It is possible to achieve similar stiffness by simply adding material to existing chassis parts, but it is not an efficient solution. "It would be considerably more mass required than by linking those two together."

The problem is, the path for a direct connection isn't always clear. "You can't necessarily join them up as directly as you'd like," Marler notes.

Structures

Why install braces?

“They are used because a straight line between two load points is an efficient way to join those points.” It is possible to achieve similar stiffness by simply adding material to existing chassis parts, but it is not an efficient solution. “It would be considerably more mass required than by linking those two together”



The optional Plasan Carbon Composites brace on the SRT Viper cuts the 6 lb (2.7 kg) weight of the aluminium brace in half, but costs an eye-popping 27 times as much as the metal part

The popular shock-tower-to-shock tower connection is the most obvious. “You’ve got an engine in the way.”

Arching the brace over the top of the engine seems a reasonable workaround, but doing that saps the brace of its strength, he explains. A 10% eccentricity from straight reduces the brace’s strength by a factor of four.

A solution is to triangulate the brace on the firewall bulkhead, a solution seen on the Aston Martin Vanquish, which uses a Lotus Lightweight Solutions-supplied brace.

“Stiffness is improved 25% versus the DBS,” reports product manager Andy Haslam. “That is predominantly through the engine bay bracing. The weakest area was around the front end.” The old car used a single, untriangulated brace between the towers. “The strength in the [new] part is in the triangulation of the load.”


The benefit to drivers is improved steering feel and response. “That is what is needed to achieve that steering feel,” Haslam points out. “You need to take all the noise out of the system.”

ATTACHMENT THERAPY

Just as important as the triangulation of the load, the Vanquish brace mounts to the shock towers with an elaborate bracket that connects to the brace with a pair of bolts on each tower.

“It is no good having very stiff bracing and a weak connection,” Marler states. “By having a two-bolt connection, it gives moment fixity. If you had a ball joint, for example, at each end, it could move like a parallelogram.”

Rather than a triangle, the 2013 Chrysler SRT Viper uses an enormous X-brace across the engine bay. The standard part is cast aluminium, while a carbon fibre unit is available as an option. The stiffness of both is equivalent, according to head of SRT motorsports engineering Russ Ruedisueli, with the benefit being that the Magna International-supplied aluminium brace weighs 6 lb (2.7 kg) and the Plasan Carbon Composites-sourced carbon fibre brace weighs half that. “There is,” he states, “a 50% improvement in torsional stiffness that



The Mini Cooper John Cooper Works GP edition features a steel rear shock tower brace

Structures



Aston Martin product manager Andy Haslam points out the Lotus Lightweight Structures-supplied shock tower brace, which contributes to the 25% increase in stiffness for the new Vanquish

makes it easier to tune the Viper's handling." "It improves turn-in and makes it more predictable."

Another challenge in installing a brace over the engine is the need to leave space above the brace for the bonnet to crush, for pedestrian protection. Tesla Motors is better known for its efforts to innovate in the electric drive space, but the company has also filed a patent for a cast aluminium shock tower design with exposed, external control arms, for the purpose of lowering the height of the towers and the cross-brace connecting them.

PEDESTRIAN SAFETY

The January 2012 patent filing (number 13/344,383) explains: "Shock towers and the corresponding upper control arms have been designed to allow a very low hood profile, while still providing sufficient gap (on the order of 70-75 mm) between the control arm/tower assembly and the inner surface of the hood to meet head impact requirements and insure [sic] pedestrian safety in the event of a vehicle/pedestrian collision."

Since the shock tower brace mounts at the control arm attachment points, rather than the top of the tower itself, Tesla's design allows for the

brace to be even lower than the tops of the towers – a benefit that's made possible by the absence of an internal combustion engine between the towers.

OUT OF SIGHT

Rear shock tower braces can also provide benefits for performance models, as illustrated by the bar installed in the Mini Cooper John Cooper Works GP edition.

The Mercedes-Benz SLS AMG uses four braces between its suspension attachment points to reinforce those mounts. As such braces are underneath the car and

out of sight, they don't have the decorative aspect that under-bonnet braces can have, Marler points out.

Such parts can also usually be straight, like the Mini's rear brace and, like it, they can be made of steel rolled into a rod and mounted by the ends.

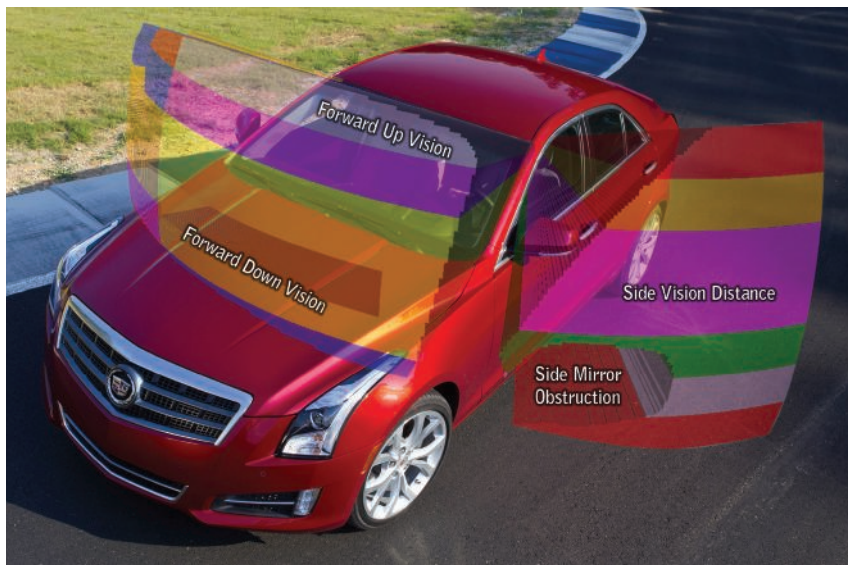
Aluminium is preferable in those applications where a casting is needed to create a shape that fits the available space. Since castings demand a wall thickness of at least 3mm, steel would be very heavy, so aluminium or magnesium are commonly used.

Dashboard instrument panel beams are another area where cast aluminium and magnesium are employed. While much more expensive than stamped steel, a casting can incorporate all of the mounting bracketry needed for the steering column, HVAC devices and air bags into one piece, reducing assembly costs to partially offset its higher price. The SRT Viper and Mercedes-Benz SL roadster both use cast IP panel beams to provide maximum stiffness and minimum weight. The Mercedes part is provided by Magna's Cosma International subsidiary.

"Very big cast parts reduce complexity by integration," notes Gunter Fischer, SL-class programme manager for Mercedes. "Everything is integrated into one part."



The Mini Cooper also has a conventional straight tower-to-tower brace



Distraction not required

2013 ATS led GM's new approach to improving driver visibility, as Lindsay Brooke explains

In developing the body architecture and active safety-systems array in the 2013 Cadillac ATS, General Motors engineers used new approaches to measuring and evaluating driver visibility beyond the typical subjective metrics.

"Conducting clinics in Europe, as well as the US, provided invaluable insight into the needs of drivers who use demanding roads like the autobahn," reveals Raj Mehta, the company's vehicle architecture engineering group manager.

From the customer-visibility input, his team focused on optimising exterior mirror and A-pillar area size, seat height, and forward

and side vision distance. They also worked to minimise or eliminate intrusive objects in windows – such as rear headrests and the interior rear-view mirror.

GM engineers have been keen to find new methodologies in this key safety area, given the evolution of vehicle structures – including thicker-section roof pillars, needed to accommodate airbags and support new rollover requirements; lower roof heights, required to decrease frontal area for improved aerodynamics; and raised boot lid heights, aimed at increased cargo capacity – that create visibility challenges.

Mehta's team used a new GM visibility evaluation technique to help

characterise the 3D aspect of A-pillar sightlines. The technique, which involves 'hedgehog' visualisation (familiar to design engineers and so nicknamed by its spikey computer plots), enables designers to study quickly how changes in windshield angle or pillar cross-section affect the driver's ability to see targeted areas. These areas are derived from careful evaluation of performance driving scenarios, such as those regularly used at GM's Milford Proving Ground in the USA.

These findings were validated and used to create a Driver Visibility Calculator. The ATS development team employed the data to keep the car's bonnet low and A-pillars relatively slender through the use of high-strength steel. The resulting body architecture achieved a "very good" internal score for forward visibility. The A-pillars are positioned wide to allow a broad field of view and angled toward the driver to require minimal head movement when peering around.

The designers also created a narrow support structure for the ATS's exterior mirrors, which also resulted in a "very good" internal score on cornering visibility through turns.

Aiding the car's basic structural geometries is the available rear-vision camera with dynamic guidelines. The camera provides a natural view of objects directly behind the ATS in the centre stack display. Dynamic guidelines laid over the video image assist in parking manoeuvres by showing the vehicle's path and available space. Onboard radar and ultrasonic sensors are also used in conjunction with the camera to help enhance driver vision.

Executive chief engineer Dave Leone notes: "Our ability to execute good visibility, based on robust scientific methods, will be an important tool in the development of Cadillacs to come."

SPARK of LIFE

Sandro Pino, Federal Mogul's European application engineering manager, ignition products, explains to Ian Adcock the challenges the humble spark plug is facing

“The trend with spark plugs over the past 15-20 years has been for them to get ever smaller. Fifteen years ago, it was typically M14 that was the spark plug of choice, but the majority of requests, particularly from European OEMs, are for M12 designs.”

“We’ve had requests from one Asian OEM and two European ones of going down to M10 where, effectively, you create more space in the combustion chamber for valves and greater freedom for positioning the injector. It can help with cylinder head cooling, which allows the engine to be driven harder before knock sets in. So there are benefits, from an engine efficiency point of view, but there can be durability issues,” he states.

The problems are two-fold: because the plug is smaller, there’s less ceramic wall thickness and the OEMs are also demanding higher voltages, up from 38kV to 42kV and even beyond that, towards the latter half of this decade. “Pushing the plug size down is putting even more stress on the ceramics, which is why we have developed new materials for Surefire Plus and Surefire Two, which has a production date set for 2017, with a ceramic that’s so dense, it’s almost translucent.”

Even so, Pino suggests that OEMs will have to be prepared for shorter plug life in the proliferating number of downsized, high-powered, direct-injection turbocharged petrol engines from 100,000Kms to

60,000Kms. “Turbo direct injection engines have very high pressure waves, which come across and effectively hit the core nose of the plug, causing a bending moment which can fracture the ceramic, if the force is high enough; and, once it’s cracked, the plug is finished.

“We’re also developing different firing end configurations, with different corner profiles, and looking to increase the mechanical strength in the high stress regions. Redesigning the internal seat profile, and also the radius and the angle at which the transition between the major diameter and the corner happens, by smoothing this out, gives greater mechanical strength and improved resistance to these mega knock events that can cause mechanical failures in the ceramics.”

There’s also a step-change in reducing operating temperatures to help prevent the mega knock events: “The farther projected into the chamber the spark plug is, the farther you are away from the cylinder head, so there are no issues with quenching of the flame front. But, because you’re farther into the chamber, the ground electrode is a lot longer and then it runs a lot hotter – in the region of 900°C – which leads to issues with ground oxidation of the electrode and, potentially, it breaking. Similarly, when the central electrode and core nose is projected farther into the chamber, mega knock will cause a lot

more issues on the core nose.”

Skirted designs, where some of the steel shell is further projected into the chamber to reduce the length of the ground electrode and also cover the core nose, helps to protect it from this very high pressure wave.

The electrodes need to be made as small



as possible, but there’s a fine balance, according to Pino, between size and wear resistance, “In turbo applications, you need to make sure the platinum is well protected, in terms of how it’s attached to the ground electrode and that there

aren't any issues with oxidation forcing its way under the weld boundary.

"We're looking at double fine wires solutions, with double iridium designs and straight grab electrodes. Effectively, that means having a ground electrode that's short, straight and relatively cool, compared to a 'J' gap design, which allows the combustion to start as efficiently as possible, without absorbing any of the energy during the initial phase of combustion.

"Although we're not seeing any requirement for these yet from European OEMs, some of our rivals have them in production today and they are very good, in terms of ignitability.

"However, if we can demonstrate a reliable design with ideal thermal management of the electrode temperatures, then benefits can be derived from them. There's also a new design away from 'J' gap, through to a straight ground electrode with side fire; instead of the spark firing vertically from the ground electrode, the ground electrode is to one side and the spark fires 90° between a pair of fine wires."

The field between the ignition coil and the ceramic is very important as well, if 'flashover' is to be prevented. "As voltages increase, the distance between the top of the terminal and the shell is such that it's too short when firing at 40-42kV or higher, causing the voltage to 'flashover'.

"In other words, instead of sparking between the electrodes, and because the pressure in the chamber is too high, the charge will look for an easy path – and that might be from the terminal and come on the outside of the ceramic, down to the shell. To prevent that, we've shortened the terminal and made the ceramic longer."



"Pushing the plug size down is putting even more stress on the ceramics, which is why we have developed new materials for Surefire Plus and Surefire Two, which has a production date set for 2017, with a ceramic that's so dense, it's almost translucent"

– Sandro Pino

Prof Dr Thomas Weber, member of the board of management Daimler, responsible for group research and Mercedes-Benz cars development

Still a future for the combustion engine

Doom-mongers might have been enthusiastically predicting the demise of the internal combustion engine, but it's not a scenario that Prof Dr Thomas Weber, head of research for the company that gave the world its first car back in 1885, recognises.

"I think it's clear that the combustion engine, based on all we know about fuel, oil etc, will stay for a long time. We definitely have enough oil and it will remain cheap; the only driver that could change the game is climate discussion, if we really see a dramatic increase in bad weather. It will be a long path to these new technologies, like hybrids and other forms of combustion engines. But it will always be an internal combustion engine plus.

"Independent research has shown in three future scenarios that 80%, 90% or 98% of all vehicles will still have a combustion engine on board. But that's linked to what is the manufacturer's key message.

"Electrification will take place, but, without a combustion engine, that will take another 10-30 years, because a plug-in range extender or a hybrid will be based on efficient, downsized, down-speeded engines, with an electric motor in addition.

"The only thing that will decrease in numbers is the pure internal combustion engine. The only question is: 'How fast will that decline be?'

"Electrification will be necessary on the way to the 2025 regulations; the question will be: 'What's necessary for large cars?' The plug-in concept will be crucial for 'C' class upwards and full hybrids, whilst small cars like smart will be full electric vehicles (EVs).

"We need downsized, efficient engines and better aerodynamics; that's the first lane. In the second lane, there's hybridisation, full hybrids, plus plug-in hybrids. And, in the third lane, EVs and fuel cells.

"We need all these technologies around the world and then, with a clever architecture strategy, we can combine them, for a specific country, to get the right powertrain."

Like many in his field, Weber is already looking towards alternatives to oil-based fuels and, for him, the key question is how successful will natural gas be and will there be enough infrastructure to support it in the future?

Taking the long view, he maintains the "best technology" will be electrification, based on the fuel cell, "as range will no longer be a topic". And he welcomed Honda's and Toyota's commitment to fuel cell development, emphasising that, with support from Ford, Nissan and themselves, this will help to give the supplier base confidence in the technology, driving up volume, while reducing cost.



"I think it's clear that the combustion engine, based on all we know about fuel, oil etc, will stay for a long time."



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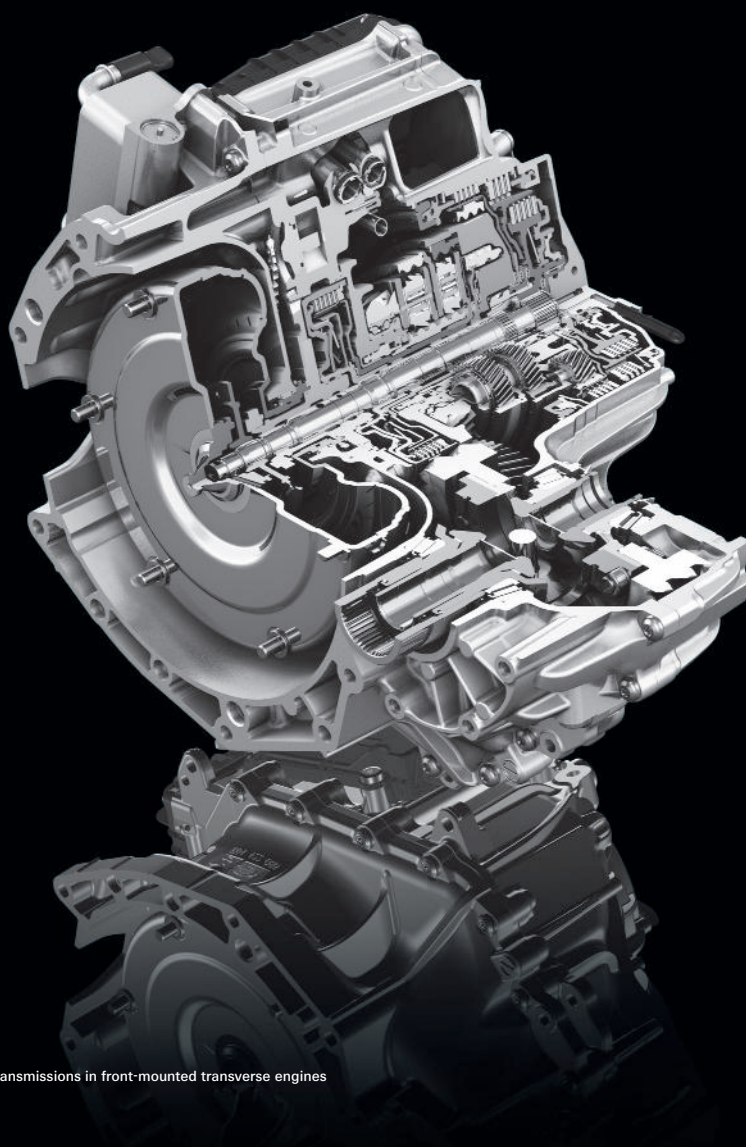
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- In-Vehicle Networks and Software, 2011 SAE Paper Collections (Online, 2011, COLL-TP-00127)
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