proActive
ISSUE 48 - SPRING 2013

MATERIAL TRENDS

RECENT TRENDS IN LIGHTWEIGHT MATERIALS

SPRING 2013

LOOKING AT THE STATE OF THE AUTOMOTIVE INDUSTRY

INDUSTRY INTERVIEW

JON SHAW, BOMBARDIER TRANSPORTATION

Automotive news, articles and interviews from Lotus Engineering and just-auto.com

JUST A **TICK**

THE NEW **EVORA SPORTS RACER**

Stunning power and performance. **Tick**.
Motorsport derived design and engineering. **Tick**.
Award winning. **Tick**.
Unique colour scheme and styling. **Tick**.
Fully loaded options. Tick.

EVORA SR 280PS FROM **£57,900**
EVORA S SR 350PS FROM **£65,900**

CONTACT US TO FIND OUT MORE OR TO ARRANGE A TEST DRIVE

Model shown is Evora S Sports Racer with manual transmission at £66,850 on-the-road (OTR price inc. VAT, delivery, 12 months Road Fund Licence and first registration fee). Standard specification includes Tech Pack, Sport Pack, 2+2 seating, Powerfold Mirrors, Reversing Camera and Premium Sport Plus interior trim.

LOTUS

LOTUSCARS.COM

Official fuel consumption, Lotus Evora range in mpg (l/100km): Urban 19.6 - 21.5 (14.4 - 13.2), Extra Urban 37.7 - 42.8 (7.5 - 6.6), Combined 28.7 - 31.4 (9.9 - 9.0). CO_2 emissions: 229 - 210 g/km.

HYDROGEN PROPULSION
Utilising and storing hydrogen in an automotive powertrain

INDUSTRY INTERVIEW
JON SHAW

just-auto's Dave Leggett interviews Project Director Aventra & Divisional Head of Engineering at Bombardier Transportation

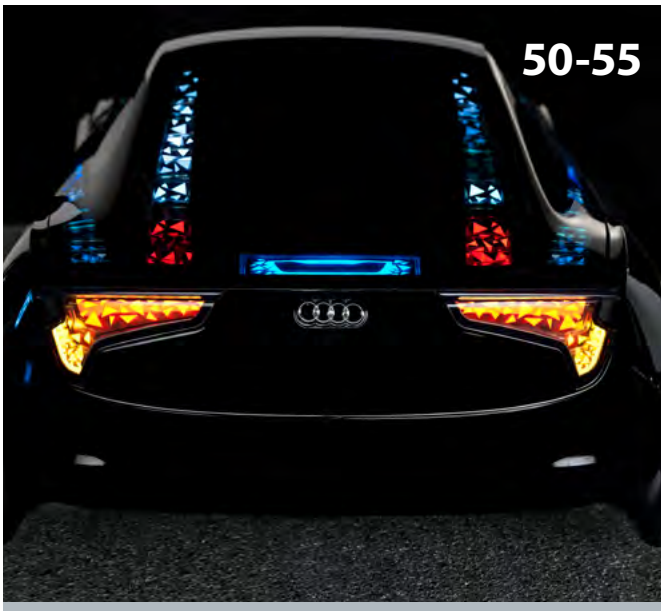
34-43

INSIDE LOTUS
NATHAN LEEMING

just-auto editor Dave Leggett interviews Lotus Cars' Head of Quality

56-65

Contents



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GROSJEAN
LOTUS


LOTUS

Kimi takes first place at Australian GP

Lotus fans around the world celebrated, as Kimi Räikkönen took the chequered flag, racing to victory during the FIA 2013 World Championship in Melbourne, Australia, securing his 20th Grand Prix win, equalling the tally of compatriot Mika Häkkinen.

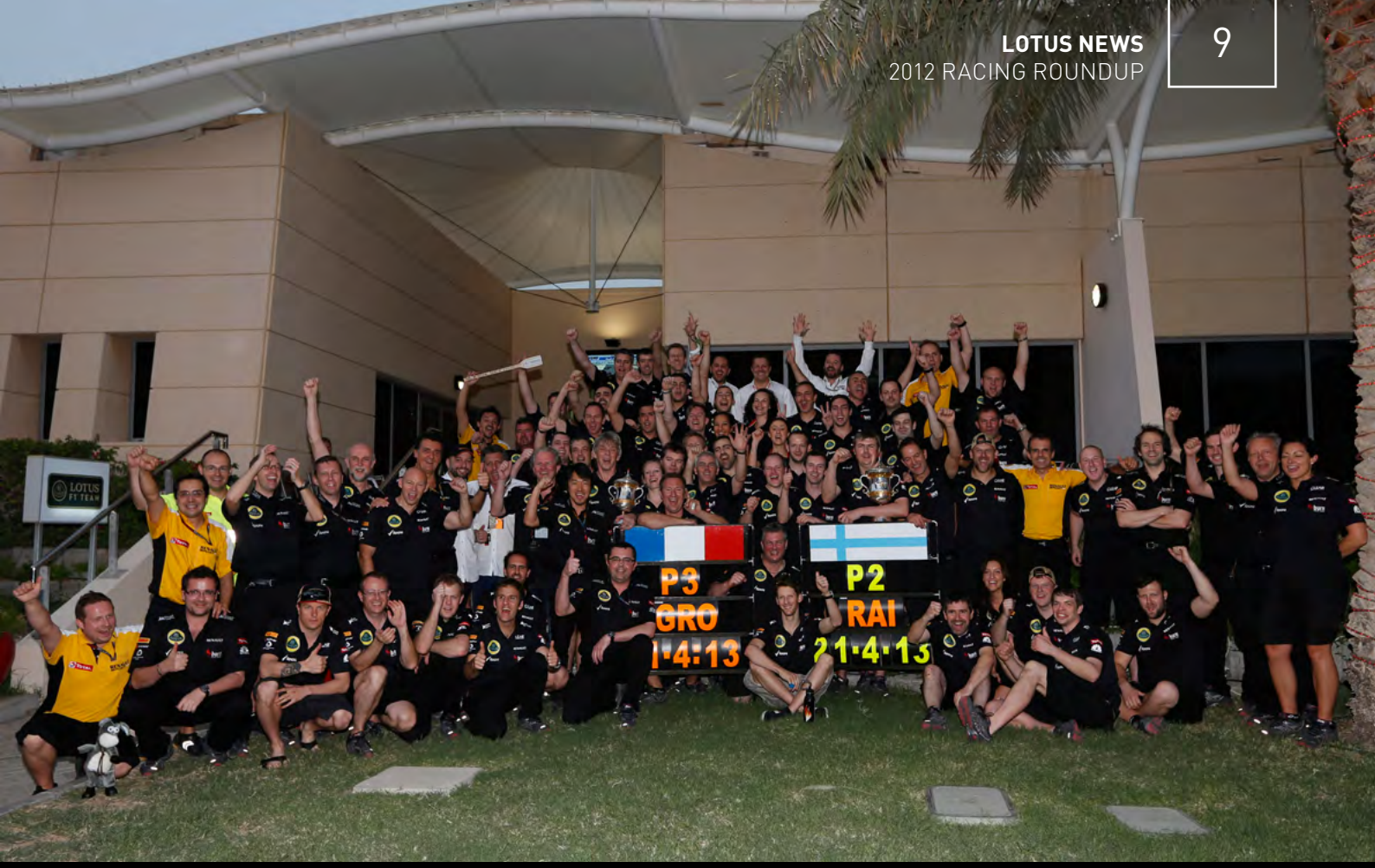
The E21 showed its prowess, with a race pace that was nothing less than impressive with the fastest lap of the race at 1:29.274. Romain Grosjean came home in tenth position after a difficult race.

P6 and P7 in Malaysian GP

The second round of the 2013 FIA F1 championship took place at the Sepang International Grand Prix circuit, Kuala Lumpur, Malaysia. Lotus gained vital early-season points in a race that finished with Romain Grosjean in sixth and iceman Kimi Räikkönen in seventh place.

Kimi takes second place in Chinese GP

Kimi Räikkönen took his second podium finish of the season with a strong second place in the Chinese Grand Prix. Despite a rearranged nose and front wing (courtesy of contact with Sergio Perez's McLaren) Kimi fought back after a poor start from the front row of the grid.



Deja Vu for Lotus F1 Team at Bahrain

Kimi Räikkönen took his third podium finish of the season and Romain Grosjean his first after a superb second and third place result in the 2013 Bahrain Grand Prix.

After emulating the same 2-3 result as last year, Lotus F1 Team returns to second position in the Constructors' Championship with Kimi leading the chase of leader Sebastian Vettel from second in the Drivers' standings.

- Kimi started from P8 with used medium tyres, changing to new hard tyres on laps 16 and 34
- Romain started from P11 on new hard tyres, changing to new hard tyres on lap 8, then new mediums on laps 27 and 42
- Romain's first pit stop was earlier than anticipated due to track debris in the form of a McLaren front wing end-plate being scooped up by his right hand side radiator intake

ABOVE: Lotus F1 Team celebrate a double podium finish

RIGHT: Romain Grosjean delighted with third place and his first podium finish of the season

Lotus Engineering wins SAE Congress Tech Award 2013 with Evora 414E Hybrid

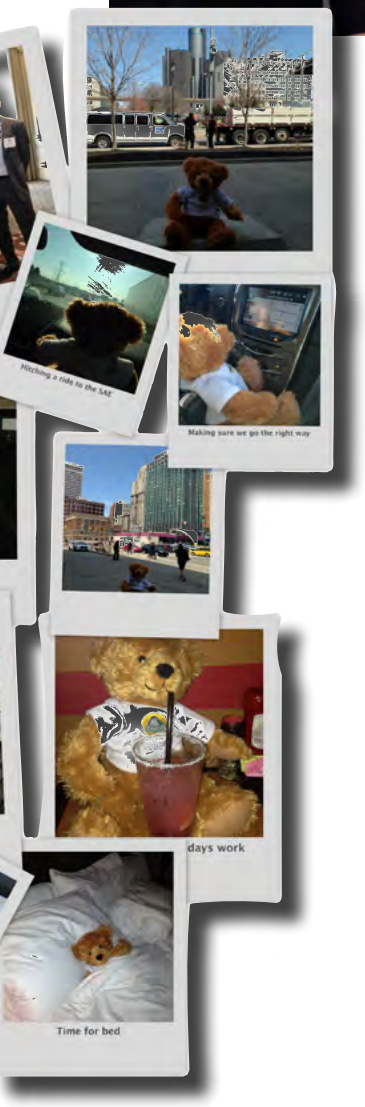
The Lotus Evora 414E Hybrid concept car was chosen by the Editors of the SAE's Automotive Engineering International Magazine, for its design and engineering innovation, uniqueness, potential for 'real-world' production application, and potential benefit for industry customers and end user.

Kevin Jost, Editorial Director of Automotive Engineering International Magazine said, *"The Lotus Evora 414E was chosen for the AEI Tech Award for its unique combination of a multimode virtual seven-speed shift, torque-vectoring stability control, and energy and power management optimisation schemes."*

Aslam Farikullah, Chief Operating Officer for Lotus said, *"The Lotus Evora 414E Hybrid encompasses all the key areas of Lotus Engineering's expertise, and doesn't just demonstrate the high level of technological advancements in our products, but is also relevant to the motor industry and applicable to the long term future of the car. We are delighted that the SAE have recognised this with such an important and prestigious award."*

Every year, the editors of Automotive Engineering International select, from among SAE World Congress exhibitors, the technologies they judge worthy of an AEI SAE 2013 Tech Award. Judging is based on level of design and engineering innovation, uniqueness, potential for 'real world' production application, and potential benefit for industry customers and end user. The Evora 414E Hybrid has been designed to highlight Lotus' innovative electric and hybrid vehicle technology without distracting from the pure sportscar character of the Evora.

LEFT to RIGHT: Scott Lindberg, Tom Reedy, Lori Cybulski, Kett, Alice Arnott, Gary Haddon and Lee Jeffcoat



Lotus Engineering wins best stand at SAE Congress

Lotus Engineering were very proud to receive the Best 10 x 20 Booth award at this years SAE World Congress, which took place at the Cobo Center in Detroit, Michigan in April.

Presented to the team by Joe Guertin, Director for Powertrain Budget, Cost Engineering, and Methodologies & International Operations at Chrysler during the last day of the congress, the award is recognition for having an engaging technology display that showcases excellence and high performance within the engineering industry and is voted for by the conference delegates.

Over the three days of the congress, the 414E Hybrid Evora cutaway exhibit attracted a great deal of attention and was one of the stars of the show.

Also in attendance was Lotus Engineering's new mascot Kett, who will be accompanying the team to various events; the next one being the JSAE conference and exhibition in Yokohama in May. After that, he will travel to Stuttgart for Testing Expo on 4-6 June.

His travels can be followed on Twitter with #LotusKett @grouplotusplc and on our Facebook page.


automotive ENGINEERING 2013 tech awards

Lotus shows lightweight hybrid sports car

ACHIEVING EFFICIENCY SAE 2013

Industry News

JAPAN: Toyota sells five million hybrid vehicles

Toyota has now sold 5m hybrid vehicles worldwide and almost 2m (1,951,243) Toyota and Lexus hybrid vehicles have been sold in the United States, significantly reducing CO_2 emissions and fuel consumption.

Toyota has now sold five million hybrid vehicles worldwide and almost two million (1,951,243) Toyota and Lexus hybrid vehicles have been sold in the United States, significantly reducing CO_2 emissions and fuel consumption.

The company said it took just eleven months to sell the latest million, bringing the total to 5,125,600 at the end of March.

After releasing its first hybrid vehicles in Japan in 1997, Toyota took almost 10 years to reach one million sales.

Since then, consumers have been buying hybrids at an ever increasing rate. The second million was posted in two years and three months; the third million took 18 months and the fourth million 14 months.

Last year, hybrid vehicles accounted for 14% of TMC's global vehicle sales and 40% of its sales in Japan.

Prius is the world's best selling hybrid vehicle with more than 2.9 million sales. In Australia, where 50,000 Toyota hybrids have been sold, the locally built Camry Hybrid has recently overtaken the Prius to become the top seller.

Toyota estimated its global fleet of nearly 20 hybrid vehicles has resulted in approximately 34 million fewer tons of CO_2 emissions than those emitted by petrol-powered vehicles.

In addition, Toyota estimates its hybrids have saved their owners over three billion gallons of petrol compared to petrol-only powered vehicles.

"*With more than fifty hybrid vehicle models from various manufacturers available in the US today, hybrids on the road are saving nearly 500 million gallons of petroleum annually in this country,*" said Tony Markel, senior engineer with the US Department of Energy's (DOE) National Renewable Energy Laboratory

ABOVE: Toyota sells 12 hybrid vehicles worldwide.

(NREL), in Golden, Colorado.

He recalled that DOE and NREL's collaborative research with the auto industry, which started 20 years ago, spurred the development of hybrid electric technology for the mainstream market to help reduce the country's dependence on petroleum.

"With millions of hybrid vehicles on the road today, hybrid powertrains are mainstream market reality," Markel concluded.

Toyota and Lexus hybrid vehicles make up 70% of the US auto industry's total hybrid sales, while they account for 16% of overall Toyota/Lexus sales, both globally and locally. Total industry hybrid sales are roughly 3% of the nation's car market.

Toyota and Lexus sell 19 hybrid models and one plug-in hybrid in 80 countries and regions around the world.

Twelve of the models are available in the United States, including seven from Toyota and five from Lexus. They are Prius Liftback, Prius v, Prius c [as the Aqua, the top selling car in Japan], Prius Plug-in, Camry Hybrid, Avalon Hybrid, Highlander Hybrid, Lexus CT 200h, ES 300h, GS 450h, LS 600h and RX 450h.

Of the twelve US models, Camry Hybrid, Avalon Hybrid and RX 450h are manufactured in North America with a fourth model, Highlander Hybrid, planned.

Between now and the end of 2015, Toyota will introduce 18 new hybrid models and expects global sales of its hybrids to be at least one million units a year in the same period. TMS forecasts that about one-third of those will be sold in the United States.

"The first Prius was a surprising success and we never imagined the market would become as vast as it has for the hybrid powertrain," said Bob Carter, TMS senior vice president of automotive operations.

Toyota's hybrid vehicle sales in the United States began in July 2000 with the first-generation Prius and it provided consumers excellent fuel economy and reduced emissions using a precursor to Toyota's advanced Hybrid Synergy Drive System.

The high-technology nature and environmental benefits offered by this early Prius helped it appeal to a small but passionate following of early adopters.

With just 5,562 sold in the first six months, the Prius would eventually find favour with consumers helping it become the recognised symbol of hybrid technology. As a result, it has inspired the development of hybrid vehicles by competitors, with more than fifty models on the market today.

The first Prius has evolved into a modern family of vehicles, while leading to the development of a wide range of additional Toyota and Lexus hybrid models.

The company sells hybrid vehicles in approximately 80 countries and regions around the world and is committed to expanding its hybrid line-up and sales destinations.

TMC vice chairman Takeshi Uchiyamada, who was responsible for development of the first-generation Prius, welcomed the widespread adoption of hybrid vehicles by consumers.

"*We developed the first-generation Prius with the aim of making it a car for the 21st century and as an indication of Toyota's response to environmental issues,*" Uchiyamada said.

"*We had to develop a hybrid system from scratch, making our task extremely difficult; nevertheless, we took on the challenge.*

The launch of the first generation Prius had effects beyond our expectations, with the vehicle increasing consumer environmental awareness and raising hybrid vehicle expectations."

He said Toyota has positioned hybrid and the components needed to develop ultra-low or zero-emission cars as core environmental technologies.

Toyota plans to continue working to further raise performance, reduce costs and expand its line-up of hybrid and non-hybrid vehicles that reduce the impact on the environment.

US: Chevrolet Corvette gets lighter with 'smart material'

General Motors has revealed the weight-saving benefits from the use of so-called 'smart materials' in the latest Chevrolet Corvette.

The new model is the first vehicle to use a General Motors' developed lightweight shape memory alloy wire in place of a heavier motorised actuator to open and close the hatch vent that releases air from the trunk. GM says this allows the trunk lid to close more easily than on the previous models where trapped air could make the lid harder to close.

GM maintains that there are about 200 motorised movable parts on the typical vehicle that could be replaced with lightweight smart materials. The company says it is looking at significant mass reduction going forward.

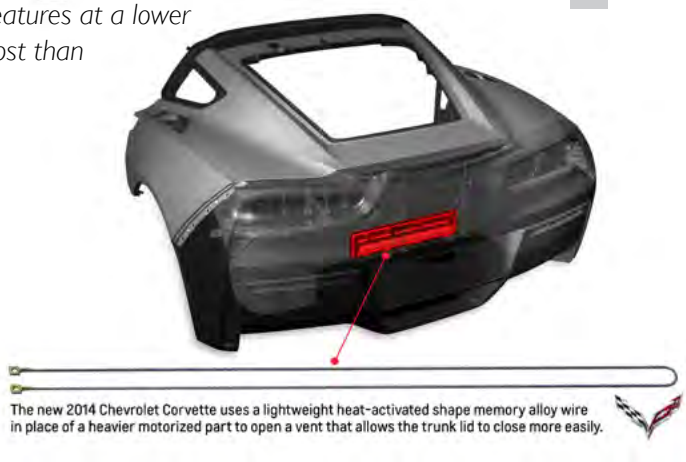
Shape memory alloys, typically made of copper-aluminium-nickel or nickel-titanium, are smart materials that can change their shape, strength, and/or stiffness when activated by heat, stress, a magnetic field or electrical voltage. Shape memory alloys 'remember' their original shape and return to it when de-activated.

In the new Corvette, a shape memory alloy wire opens the hatch vent whenever the deck lid is opened, using heat from an electrical current in a similar manner to the trunk lights. When activated, the wire contracts and moves a lever arm to open the vent, allowing the trunk lid to close. Once the trunk lid is closed, the electrical current switches off, allowing the wire to cool and return to its normal shape, which closes the vent to maintain cabin temperature.

"*Smart materials like shape memory alloys offer new possibilities for many movable vehicle features,*" said Jon Lauckner, GM's chief technology officer. "*These new materials enable innovative designs and new and improved features at a lower cost than traditional motors and actuators.*"

Shape memory alloy also helps remove unwanted mass, which can help improve vehicle performance and fuel economy. The wire actuator used on the new Corvette is approximately 0.5 kg lighter than a conventional motorised system.

"*The shape memory alloy used on the new Corvette represents nearly five years of research and development work on smart materials for which GM has earned 247 patents,*" said Paul Alexander, GM smart materials and structures researcher. "*And it is just the beginning. We have many more smart material applications in the pipeline that will bring even more improvements to our vehicles going forward.*"



The new 2014 Chevrolet Corvette uses a lightweight heat-activated shape memory alloy wire in place of a heavier motorized part to open a vent that allows the trunk lid to close more easily.

SOUTH KOREA: Hyundai's ix35 fuel cell vehicle rolls off assembly line

A white ix35 fuel cell vehicle rolled off the assembly line at the company's Ulsan manufacturing complex as Hyundai claimed to have become the world's first car manufacturer to begin assembly line production of zero emissions, hydrogen-powered vehicles for fleet use.

"*With the ix35 Fuel Cell vehicle, Hyundai is leading the way into the zero-emissions future,*" Hyundai Motor vice chairman, Eok Jo Kim said at a ceremony. "*The ix35 Fuel Cell is the most eco-friendly vehicle in the auto industry and proves that hydrogen fuel cell technology in daily driving is no longer a dream.*"

There are seventeen ix35 fuel cell vehicles destined for fleet customers in Copenhagen, Denmark and Skåne, Sweden. Copenhagen, as part of its initiative to be carbon free by 2025, will be supplied with 15 for fleet use, according to an agreement announced in September 2012. Two will be supplied to Skåne.

"*Assembly line production of fuel cell vehicles marks a crucial milestone in the history of the automobile industry not just in Korea, but throughout the world,*" Mang Woo Park, mayor of Ulsan city, said in a congratulatory message. "*By supplying more hydrogen refuelling stations to support the eco-friendly fuel cell vehicles produced, we will make Ulsan the landmark for eco-friendly automobiles.*"

Hyundai plans to build a thousand ix35 fuel cells by 2015 for lease to public and private fleets, primarily in Europe, where the EU has a hydrogen plan and begun construction of hydrogen fuelling stations.

After 2015, with lowered vehicle production costs and further developed hydrogen infrastructure, Hyundai will begin manufacturing fuel cell vehicles for consumer retail sales.

POLAND: GM Europe drives towards mobile connectivity

Drivers in Europe will become better connected on the move within the next two to three years as technology already introduced in the US moves across the Atlantic.

Steve Girsky, president of GM Europe, said, from next year, all of General Motors' new models in the US will be 4G connected via the company's OnStar telematics and communications system.

OnStar has been around for some years and allows drivers to communicate with emergency services and relay problems to GM's dealers. This is now becoming more advanced in terms of connectivity.

Girsky said: "This technology will come to Europe because it is what people are demanding. The way people view cars is starting to change, 16 year old kids in the US are not going into the dealers all starry-eyed anymore. They want more from their mobility, most importantly connectivity."

The car will be less about transport and aspiration and more about staying connected, he added. "Young people are car sharing, renting or hiring cars rather than buying; they want different vehicles depending on what they are doing. GM is moving with the times."

GENEVA: Volvo Cars reveals 'cyclist detection' auto braking

Volvo Cars has revealed a technology that detects and automatically brakes to avoid cyclists swerving out in front of the car.

The new functionality is an enhancement of the present detection and auto brake technology, and the package will be called 'Pedestrian and Cyclist Detection' with full auto brake. All cars equipped with pedestrian detection will also incorporate cyclist detection.

"*As the leader in automotive safety, we have been first in the industry with all detection and auto brake technologies, from the first-generation brake support in 2006 to pedestrian detection with full auto brake in 2010,*" said Doug Speck, Senior Vice President Marketing, Sales and Customer Service at Volvo Car Group.

According to accident data, about fifty percent of all cyclists killed in European traffic have collided with a car.

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

Volvo points out that the car's speed has considerable importance for the outcome of an accident. A lower speed of impact means that the risk of serious injury is significantly reduced.

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

"*Our solutions for avoiding collisions with unprotected road users are unique in the industry. By covering more and more objects and situations, we reinforce our world-leading position within automotive safety. We keep moving towards our long-term vision to design cars that do not crash,*" said Speck.

UK: Porsche says 918 Spyder will emit just 70 g/km CO_2

Speaking to journalists at the UK media preview of the new 918 series Cayman, Porsche GB product manager Jim Willows has said the forthcoming 918 Spyder will have a CO_2 average of just 70 g/km.

This additional model for the Porsche range will be the company's new flagship when it goes on sale in the fourth quarter. The model name refers to both the 18 September 2013 start date for production, as well as the number of cars that will be made at the Zuffenhausen works.

This hybrid supercar will be based upon the 918 Spyder plug-in concept which premiered at the Geneva motor show in March 2010. The prototype was powered by the combination of a 375 kW 3.4 litre mid-mounted V8 and two electric motors. Combined output was stated as more than 530 kW. The 0-100 KPH time was quoted as 3.2 seconds.

The production car's V8 will be a 4.6-litre V8 with dry sump lubrication, the company revealed in September 2012. Total power will be 770 HP thanks to the combination of the 570 HP V8, supplemented by a 90 kW hybrid module on the rear axle and an 80 kW electric motor on the front axle. The range in EV mode will be 25 km.

UK: Aston Martin to race hydrogen Rapide S

Aston Martin is ripping up the record books at the 41st ADAC Zurich 24 Hours of Nürburgring next month as the famous British sports car brand is to race a pioneering hybrid hydrogen car there.

The Hybrid Hydrogen Rapide S (based on Aston Martin's new four door, four-seat sports car) will become the first hydrogen-powered car to compete in an international event as well as the first zero CO_2 emissions vehicle to complete a race pace lap at the Nürburgring 24-hour race.

Working in partnership with hydrogen experts Alset Global, Aston Martin's engineers have developed a prototype twin turbocharged six litre V12 engine that will power the Nürburgring car.

Capable of running on pure gasoline, pure gaseous hydrogen, or a blend of both, the Hybrid Hydrogen race car showcases Aston Martin's commitment to engineering innovation. In pure hydrogen mode, Aston Martin and Alset Global aim to show that a zero CO_2 emissions lap of the Nordschleife is possible whilst emitting virtually only water from the exhaust pipe.

Welcoming the debut of the Hybrid Hydrogen Rapide S, Aston Martin Chief Executive Officer Dr Ulrich Bez said: *"As we celebrate our centenary in 2013 and look back on a century of excitement, innovation and style it's also the perfect time to look to the future with this astonishing race car. Aston Martin has a strong track record of innovation and, with our superb history of competition and testing at the Nürburgring, it is only right that we showcase this amazing new technology at this year's 24-hour race."*

He added: *"Working with Alset Global to unveil this system in such a challenging environment as the 24 Hours of Nürburgring shows once again how confident we are in our cars, our people and our partners."*

The Hybrid Hydrogen system comprises a hydrogen fuel rail, storage tanks and proprietary engine management system. The system enables the driver to run the car on pure gasoline, pure hydrogen or in circumstances where more power or torque is required, the system can automatically blend a small amount of gasoline in with the hydrogen to offer a 'boost' feature.

Safety is paramount, of course, and the system includes four ultra-high strength carbon fibre tanks holding a total of 3.5 kg of hydrogen stored at a pressure of 350 bar, with two tanks housed next to the driver and two in the boot of the car. Meanwhile the entire hydrogen system developed by Alset Global and its partners is approved by German motorsport's governing body, the DMSB.

Aston Martin returns to compete in the ADAC Zurich Nürburgring 24 Hours on May 19-20 for the eighth successive year.

More than 150 cars will start the fearsome 24 hour race, which runs on the daunting 25 km circuit that combines the legendary Nordschleife with the modern Grand Prix track.

US: Jaguar F-TYPE declared 2013 World Car Design of the Year

The Jaguar F-TYPE has been declared the 2013 World Car Design of the Year in New York.

Ian Callum, Director of Design, Jaguar, said: "*No design project has given me greater pleasure than the creation of the F-TYPE. It's a project I've looked forward to from the moment I joined Jaguar, and it's one that's given my team and I great satisfaction. The F-TYPE is a sports car that is true to Jaguar's design values - beauty of line and purity of form - and I'm honoured that the World Car of the Year jury has recognised our work with this award.*"

Some 43 cars were considered for the award, this selection being reduced to a shortlist by an advisory panel of design experts before final consideration by the 66 World Car of the Year jury members.

On the F-TYPE, the advisory panel said: "*The long wheelbase, short overhangs and flared fenders give this car a good stance. The contour in plan view tapered toward the door emphasises the muscular rear fender that houses the driven wheels.*

The F-TYPE exterior maintains Jaguar's own elegance in its horizontal proportion and rounded surfaces, yet it looks very dynamic. But I would like to say the interior design is even more attractive. It is clearly driver-oriented, and a grip bar for the passenger is nicely integrated into the big centre console. The seat design is superb, too."

The award was collected by Adrian Hallmark, Global Brand Director, Jaguar, at the New York International Auto Show. Commenting from the show, he said: "*The F-TYPE is the first full-blooded Jaguar sports car to be launched for more than 50 years. Its architecture and technology are world class, wrapped in an evocative and progressive design that could only be a Jaguar - 'Callum unfiltered', as we call it in-house. It is as dynamic yet refined as any Jaguar sports car should be, and is a unique proposition from a performance and price perspective. This combination of factors has clearly inspired this year's jurors, and we are delighted and honoured to collect this award.*"

OPEL Bochum plant earmarked for closure currently produces the Zafira

Spring 2013

Dave Leggett takes a personal look at the state of the industry

After what has seemed like an unusually long winter in Britain, spring has finally arrived. The birds can nest, the bees can buzz and the human population of this crowded isle can emerge from a kind of hibernation. Spirits are naturally lifted. The great outdoors, to be enjoyed in kinder weather accompanied by a warm sun and days of longer daylight duration, beckons. The cricket season has even begun. A pint of warm beer in a pub garden can't be far away.

Similarly, those of us who have been around a while in the auto industry know that day follows night, however bleak things look just before the dawn. Economic recessions eventually give way to recovery.

But just as each winter is unique, each recession and the changes wrought on industries (including automotive) is different from the last. The current travails for the global economy are bound up in some pretty deep-rooted financial problems, rather than, say, the oil-shocks and inflationary spirals and responses of yesteryear.

We're still very much feeling the aftershocks and knock-on effects of the banking sector crisis that began in earnest in late 2008 (after the 'credit crunch' that commenced around a year earlier). However, the recovery from this recession is, across the world, far from even.

North America and Asia in relatively good shape

From an automotive industry perspective, North America and Asia are in relatively good shape. The US light vehicle market is heading over 15 million units this year.

That's still not quite back where it was pre-crisis, but it's not that far off and it's a big improvement on where it was in the dark days of early 2009 when General Motors went into Chapter 11 and the North American auto industry was staring into an abyss. The slimmed down Detroit 'Big 3' have been on something of a roll, as have North America-based Tier 1 suppliers. Restructuring in North America has meant that higher volumes have quickly translated to higher profits. Leaner and meaner.

Asia, too, remains generally upbeat even if growth in China is not quite as dramatic as it was. China has been delivering strong profitability for Western makers with major joint venture (JV) operations there, most notably Volkswagen Group and General Motors. China's emerging middle-classes are increasingly attracted to

Sergio Marchionne of Fiat has described the West European car market as a '*bloodbath*'.

Western brands. They are seen as better in terms of quality and design. It is the domestic brands who have been struggling.

The German premium brands have also been making hay in China, Chinese buyers tending to want 'specced up' cars that boost profits.

So far this year, China's car market – the world's largest by a considerable margin now (light vehicle sales there this year could top a mind-boggling 21 milion units) - has been growing. That's reassuring. The hope for the global economy has to be that China's population continues to buy goods and services. If Western households are still a little bit reluctant to spend, Chinese consumers could be a rising source of demand for the global economy.

But Asian demand growth is not just about China though. Thailand's vehicle market enjoyed 80 percent growth in 2012. Okay, that was exceptional (it was a bounce-back from the low of 2011 and was also fuelled by incentives) but underlying demand looks strong. Thailand is also developing an industry specialising in 'eco-cars' as well as pick-ups. Other markets in southeast Asia look to have good prospects, also. Indonesia's car market should (on the basis of that country's population size) become the ASEAN's biggest later on this decade and is starting to attract more investment from both OEMs and suppliers.

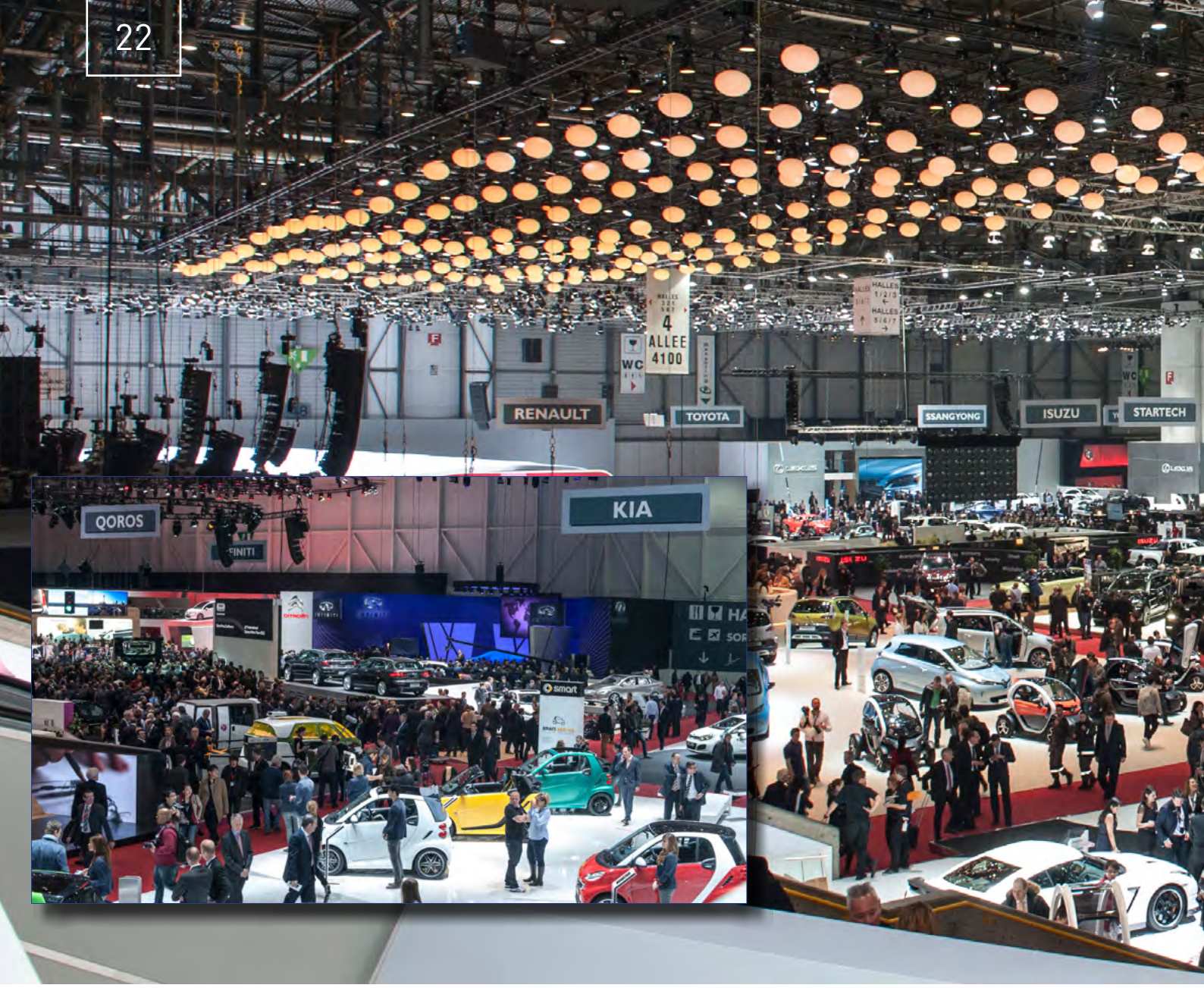
The Japanese carmakers have been through a lot over the last few years, but relief is a prospect in the shape of domestic politics and its currency. Japan's government has moved decisively to bring about a weakening of the yen and that is already supporting bottom lines. Emerging wrangles over the conditions for international trade and proposed free trade agreements will likely rumble on though, with the automotive industry at the heart of that.

Western Europe stands out for its current problems

If there are some bright spots for the auto industry in the Americas and Asia, Western Europe stands out for its current problems. The car market is still shrinking as austerity budgets bite across the region. In 2007 Western Europe's car market was 14.8 million units. This year it will not be much over 11 million units. That's a lot of market volume, demand, taken away. What has it meant for the industry?

Some OEMs have been impacted more than others but it has led to general discounting and very, very low rates of capacity utilisation. Sergio Marchionne of Fiat has described the West European car market as a 'bloodbath'. While there have been some announcements of plant closures, it looks like there is more to do given where plant capacity utilisation rates are – way under what is healthy - and given the prognosis for the European car market, i.e. still going down with a weak economic recovery in prospect, at best, from next year. Industry sources tell me that stock levels have been trending up for some in recent months, something that could make plant capacity utilisation rates look even worse later this year, perhaps in combination with even softer new car prices in the marketplace.

The overall economic situation remains weak. Austerity budgets are biting across the continent, the eurozone crisis may be calmer as the ECB has taken actions to calm the bond markets down, but as we have just seen in Cyprus, it can blow up from time to time. Consumers across Western Europe remain very wary. Even German consumers, who have an economy with unemployment at a 20-year low, are most definitely not in the mood to spend while big uncertainties persist.



ABOVE: Geneva Motorshow 2013. Asians have been capturing a greater share of the market in Europe over the past decade, not just the Japanese, but now the Koreans in the shape of Hyundai and Kia

The 'squeezed middle' gets squeezed further

Who is suffering most? The answer is the European volume makers are all suffering in terms of European operations, but pressures are being felt especially acutely by Fiat, GM, PSA Peugeot-Citroen and Renault. Even Ford, which is in relatively good shape, is expecting to make a USD 2bn loss in Europe this year.

Besides the current unhelpful developments in overall market conditions, there's also a long-term loss of share evident for what some have termed the 'squeezed middle'. These traditional European volume players are being squeezed by more aggressive premiums, guys like BMW and Audi who have added many niche models and moved into smaller car segments. BMW Group's MINI brand, with its small premium cars, is one example.

We have also seen Asians growing share in Europe over the past decade, not just the Japanese, but now the Koreans in the shape of Hyundai and Kia.

The European volume players are all in a tight spot: losing share and money. The big question right now is overcapacity. Capacity can be a complicated thing to measure, but as a rule of thumb, vehicle assembly/production plants should operate at around 80 percent capacity utilisation to break even. Some plants in Europe are at nearer 20 percent. That's a lot of unproductive overhead to carry.

There is still a general reluctance to shut capacity, especially during a severe recession. Opposition can be strong and potentially even more damaging than keeping a plant ticking over for a while longer or until the market picks up. Wait for the tide to come in

and everyone will get some 're-flotation' benefit, the thinking goes.

The big problem is the duration of this slump in Europe. If you are losing money and operating plants at a loss, a big question is how long can you do that if the market recovery is being pushed back further? And if you are losing money and cutting back on new product development to save cost, the competitive implications of that are pretty serious too.

Will tough decisions be fudged?

Will the European players, the 'squeezed middle', shut more plants? Or will they fudge it? Renault, for example, has just done a productivity deal with labour unions in France and said that it will not shut any plants there. That seems like quite a concession from Renault.

There is also talk of making Nissan and maybe some Daimler Group cars in Renault plants. Opel plants might make Chevrolets to soak up some of its unused capacity. And there's also talk of trimming capacity, looking at model-mix and shift patterns, at some plants to avoid outright plant closures.

Many in Europe think things will be fudged, that the capacity surgery that should happen probably won't – at least not to the extent that it should. There is also a cynicism about the role of governments, somehow contriving to keep some plants going. Witness the political furore in France over PSA's plans to shutter the Aulnay plant. Politicians seem to have accepted that as a done deal and a government sponsored report was cooked up that said Aulnay has to close, pinning the blame for PSA's troubles on its strategic governance over past decades.

More difficult decisions on capacity seem to lay ahead, at least while the West European car market languishes in the region of 11 million units. One

About David Leggett

David Leggett has been editor of just-auto since 2000. He has been analysing the auto industry for over 25 years in analyst, forecasting or B2B publishing roles. He is frequently asked for media interviews or to present at industry conferences.

David also plays a leading role in the development of just-auto's expanding research portfolio.

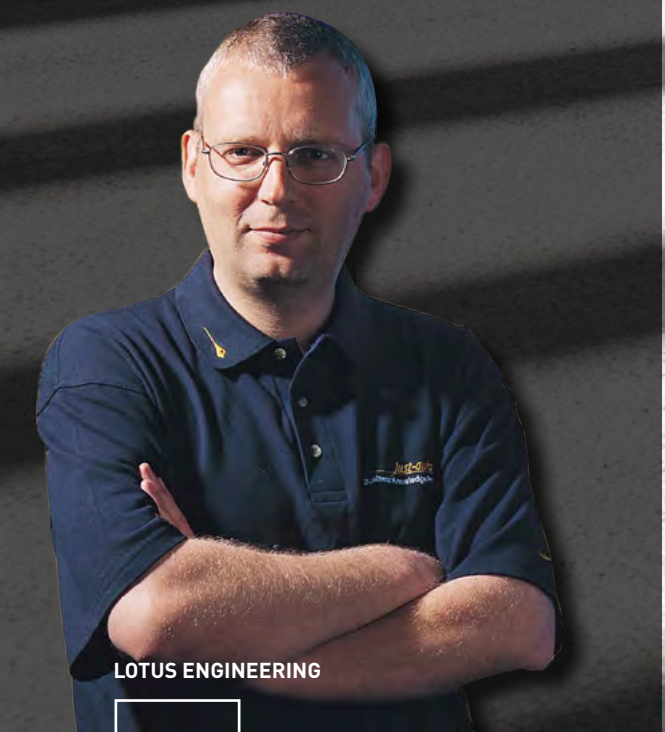
He joined just-auto from the Economist Group's Economist Intelligence Unit (EIU) where, as director of automotive forecasting, he played a key role in the integration and development of forecast-orientated automotive data to the EIU's electronic product portfolio.

Formerly, he was director of forecast services at CSM Europe, the European arm of US-based auto industry analysts CSM Worldwide, where he developed the European Light Vehicle Forecast Service for automotive clients across the world.

Previous appointments include senior associate with Global Insight (then DRI) and senior economist with the UK's automotive trade body, the Society of Motor Manufacturers and Traders (SMMT).

While at Global Insight in the mid-1990s he led the company's expanding analysis of automotive emerging markets, especially in East Asia.

He holds an honours degree in Economics from the University of East Anglia, Norwich, UK.



LOTUS ENGINEERING

consolation: it probably won't go much lower. The first quarter market was around 10 percent down on last year, but the remainder of the year will see the comparison versus last year against a weaker base. At some point, as we have seen in the UK car market ('defying gravity' and still showing some growth), buyers putting off replacement purchases come back to the market. 2014 may well see some pent-up demand in Europe coming back after such a prolonged and deep slump in sales, assuming that the powers that be in Brussels and Frankfurt (home of the European Central Bank) can combine to steady financial markets and keep the European economy in a state of reasonable stability.

As the recent crisis in Cyprus showed, some serious uncertainties remain and the crisis for the eurozone remains far from resolved.

Image: Renault ZOE
©Renault 2013

The global pie is expanding

One point that is worth remembering: the global automotive pie is continuing to grow. Market growth outweighs contraction and global light vehicle sales are forecast to accelerate to over 81 million units in 2013.

There is also much new product and technological innovation to get the pulses racing. For example, I recently drove Renault's Zoe electric vehicle and I was very impressed with the experience as well as the price point. It will find a market niche. As well as being a technological tour de force in its own right, that car and its technical underpinnings are very much the product of that company's highly successful alliance with Nissan. They can share investment costs where appropriate and make big savings on parts procurement and in manufacturing.

Such alliances between automotive companies will become increasingly important in the future.

Carlos Ghosn also made a good point when I met him for breakfast at the launch hotel on the outskirts of Lisbon. Electric cars can make a valid contribution on the environmental front, along with other powertrain technologies, even if battery electric vehicles are not a silver bullet that solves everything immediately. It's a valid step in the right direction.

Renault is a company that faces big challenges, but its situation is far from hopeless while it can innovate and achieve that innovation in the context of a global strategic alliance that, besides Nissan, also involves AvtoVAZ of Russia and some cooperation with Daimler.

While it may seem that the 'automotive spring' is taking its time to appear in some parts of the world, there are plenty of positives. You just have to know where to look.

Writer: David Leggett

△ Editor - just-auto.com

Material Trends

In vehicle lightweighting

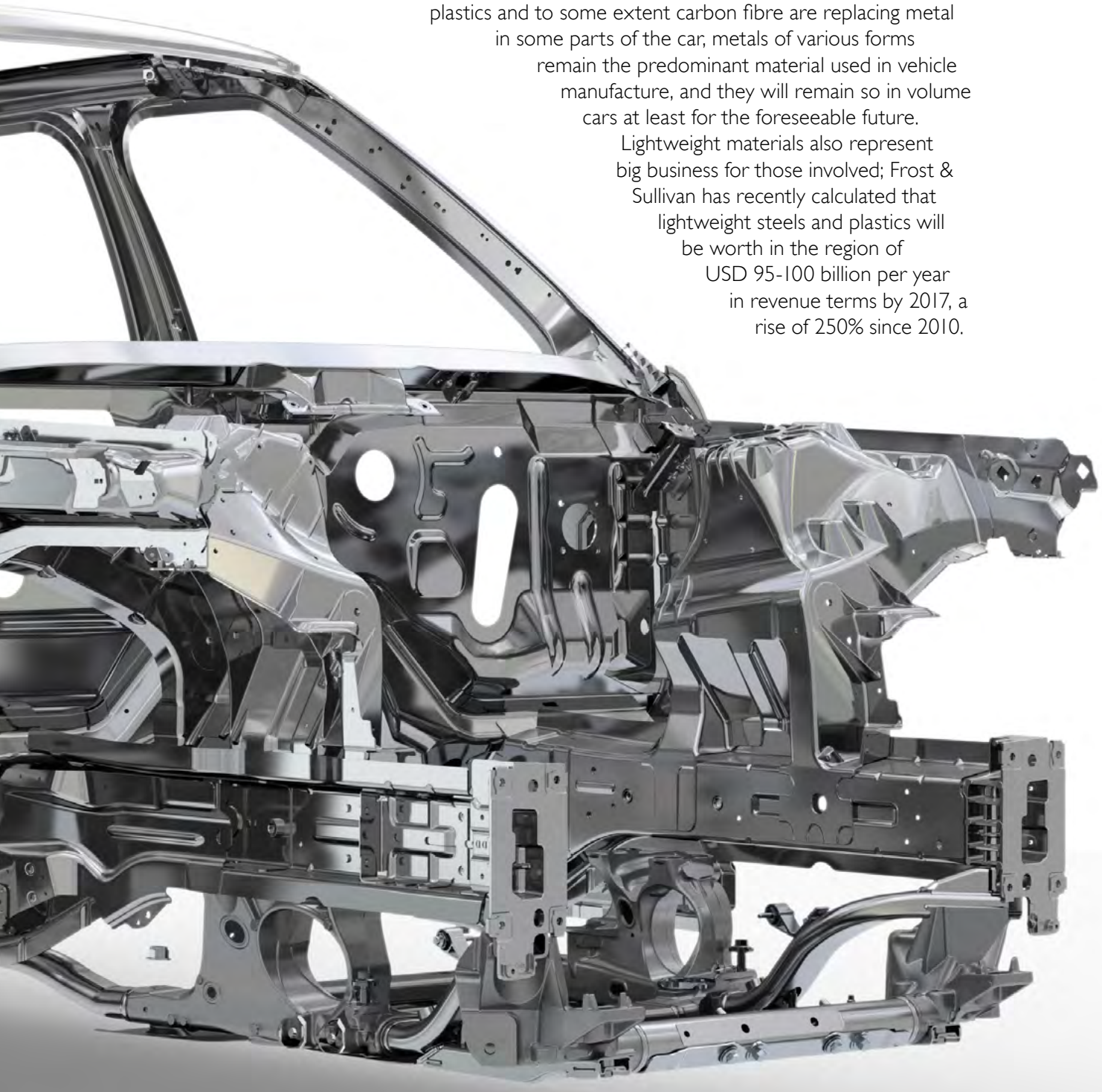
Lighter suspension and braking components, together with the body reduce the weight of the new Range Rover Sport by 420 kg ©Jaguar Land Rover 2013

As the automotive industry comes under increasing pressure to raise energy efficiency and lower CO_2, materials used in vehicle construction are coming under closer scrutiny. Ian Henry considers developments in materials.

Car companies are under constant and rising pressure to reduce fuel consumption and emissions; cleaning up the tailpipe exhaust and making the different components of the engine more efficient clearly have important roles to play, but the main route to cutting consumption and emissions is through reducing vehicle weight.

Weight reduction can be achieved by a number of ways, ie replacing traditional, heavy-duty steels with lighter weight steels, or alternative metals, plastics or carbon fibre, or by designing parts to use less material. Although plastics and to some extent carbon fibre are replacing metal in some parts of the car, metals of various forms remain the predominant material used in vehicle manufacture, and they will remain so in volume cars at least for the foreseeable future.

Lightweight materials also represent big business for those involved; Frost & Sullivan has recently calculated that lightweight steels and plastics will be worth in the region of USD 95-100 billion per year in revenue terms by 2017, a rise of 250% since 2010.



Aluminium is the main metal alternative to steel

Aluminium is the leading alternative lightweight metal to steel. According to AluminumTransportation.org, a reduction of 10% in vehicle weight can result in a direct fuel efficiency gain of between 5-7%; and with this in mind, Ducker, a US research company, has suggested that aluminium use in vehicles will more than double by 2025. All the vehicle manufacturers (VMs) are increasing their use of aluminium, not just the premium brands such as Audi and Jaguar Land Rover who arguably lead the way in the use of aluminium. For example, although aluminium has a low current penetration at GM, it is seen as an integral part of the GM policy to reduce its average vehicle weight by 15%.

The continued growth in aluminium across the automotive industry is quite remarkable, according to aluminium specialist Alcoa. Global aluminium use in 2011 totalled around 11.5 million tonnes and Alcoa expects this to increase to an estimated 24.8 million tonnes by 2025, or put another way this will represent around 250 kg of aluminium per car compared to 155 kg per car at the present time.

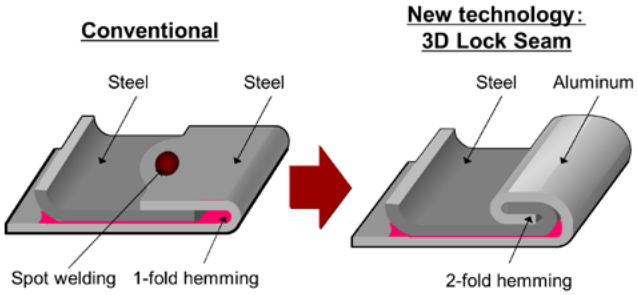
One of the aluminium parts made by Alcoa are forged wheels; and here it is worth noting how a forged aluminium wheel can also save weight over cast aluminium wheels – it is not just the material per se which allows weight savings, but also the means by which the aluminium is processed. For example, while a cast aluminium wheel typically represents a 40% weight saving on a steel wheel, a forged aluminium wheel represents another 20-30% weight saving over a cast aluminium wheel.

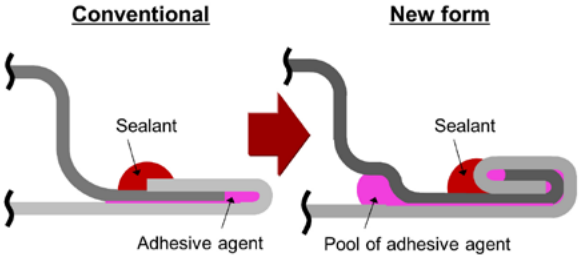
Although most VMs have been using aluminium to a greater or lesser extent in recent times, arguably the leader in terms of the take-up of aluminium has been Audi. Audi first presented its aluminium space frame nearly 20 years ago and has remained at the forefront of aluminium use in vehicle bodies ever since. The benefits of aluminium are well-known in terms of weight saving; as a result of the increased use of aluminium on the current Audi A3, it is at least 80 kg lighter than the previous model.

Audi is now leading the way in terms of sustainable use of aluminium and has joined the 'Aluminium Stewardship' initiative. This organisation is in the process of developing a global sustainability standard by the end of 2014. It will embrace the whole value chain aluminium use, from the extraction of the ore through to its processing into finished parts and onto recycling at the end of vehicle life.

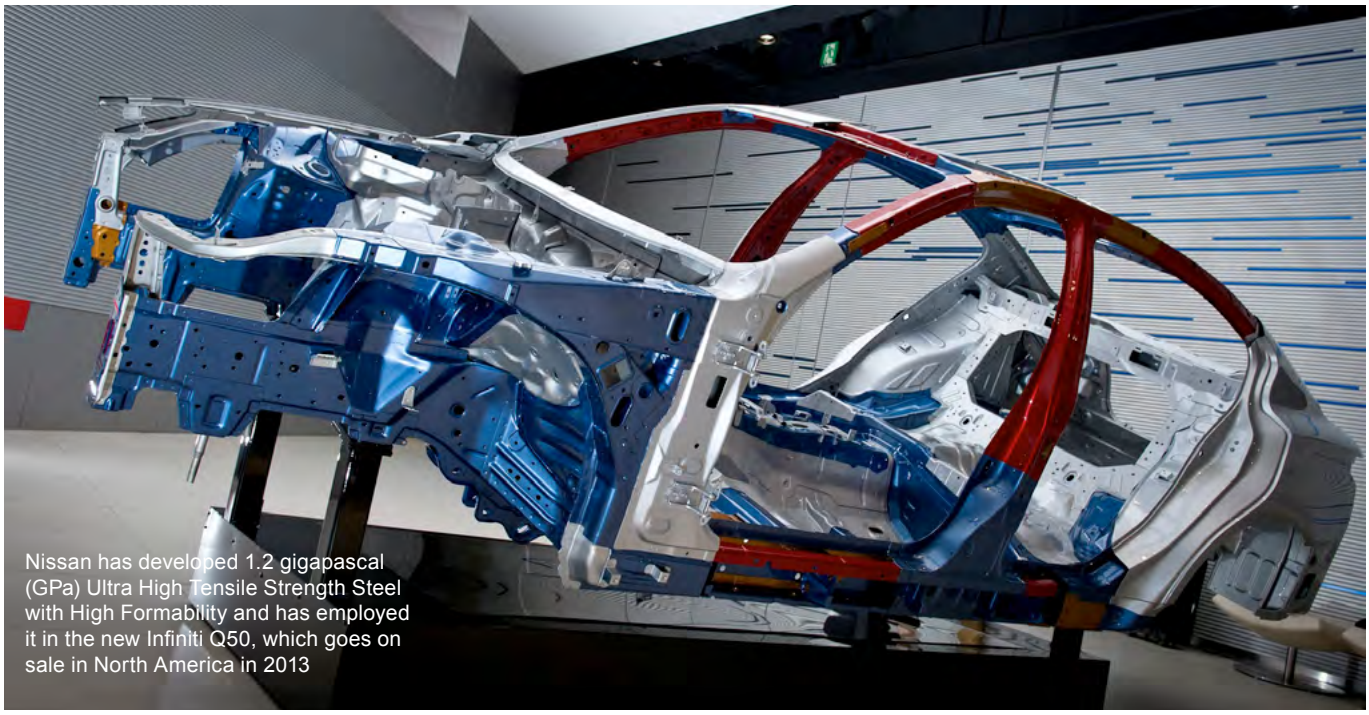
Aluminium's contribution to reducing body weight

The latest version of the Range Rover Sport makes extensive use of aluminium and lightweight technology in general. The aluminium body is around 350 kg lighter than on the preceding model; the lighter body has a direct benefit in terms of allowing the reduced weight of other parts, e.g. lighter suspension and braking components. Together with the body, these reduce the weight of the vehicle by 420 kg. One of the many specific components which has been subject to a major reduction in weight is the rear sub-frame, made by Martinrea Honsel. This part is 15 kg lighter than its steel predecessor.





Honda Motor Co., Ltd. has announced the development of a new technology to join steel and aluminium and further applied this technology to mass production vehicles, initially to the North American version of the all-new Acura RLX but plans to expand its application to other models



Nissan has developed 1.2 gigapascal (GPa) Ultra High Tensile Strength Steel with High Formability and has employed it in the new Infiniti Q50, which goes on sale in North America in 2013

Bodies made from Advanced High Strength Steel (AHSS)

Here we are concerned with the vehicle companies adopting high strength steels which are thinner and much lighter than conventional steels. As a recent example Nissan has revealed plans to increase its use of advanced high strength steel (AHSS) on new models; the use of AHSS will rise by around 25% from 2017, which will result in a weight saving of 15% in body structures. Nissan has developed this new steel in collaboration with Nippon Steel, Kobe Steel and Sumitomo Metal. The first use of the new steel is on the 2013 Infiniti Q50. The use of this metal is integral to Nissan's 'Green Program 2016' which sets out to achieve a 35% improvement in fuel economy across its entire range when compared to 2005 levels.

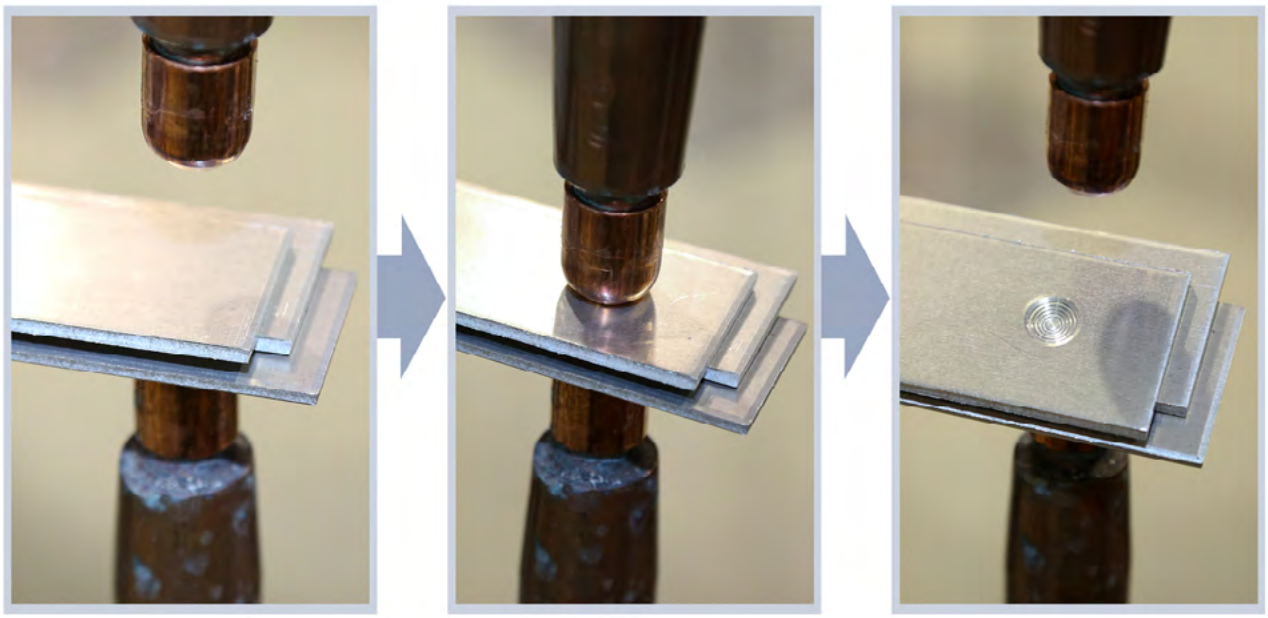
Joining steel and aluminium – Honda achieves a major breakthrough

One of the factors preventing the widespread use of aluminium in car bodies at some VMs has been the problem of how to join, i.e. weld, it to steel. Until now, car bodies have tended to be either steel or aluminium, with mixed material use the exception rather than the rule. In early 2013, Honda announced it had developed a new means to join steel and aluminium and said that it expected this technology to result in a far greater use of aluminium in its cars in the years ahead.

Honda has used this technology on a door for the new Acura RLX which would normally be made of steel. Joining different metals like steel and aluminium requires parallel work in a number of areas, not just the act of successfully joining the two metals, but also preventing electrical corrosion and controlling thermal deformation. While steel and aluminium can be joined together through MIG welding, this process is not without its problems. The new processes developed by Honda overcome these problems, and having done so, Honda can also eliminate spot welding which is normally used in steel door manufacture. This technology has reduced the weight of the door panel by around seventeen percent compared to a steel Door.

There are other benefits too, not just weight saving; this change improves stability by reducing weight on the outside of the vehicle, helping to concentrate the point of gravity towards the centre.

In another development, Honda has begun mass production and use of front sub-frame with a steel-aluminium hybrid structure using a process called friction stir welding (FSW) on the 2013 version of the north American Accord model. FSW works by producing a metal-to-metal bonding between steel and aluminium. This is achieved by putting a rotating tool on top of the aluminium which is lapped over the steel with high pressure. The resultant welding strength is at least the same as that achieved through conventional MIG welding. According to Honda, this process can reduce part weight by 25% when compared to a conventional steel sub-frame.



GM achieves breakthrough in aluminium welding

Although aluminium is not widely used at GM, developments in welding aluminium have not been entirely ignored. In late 2012, GM announced that it had developed a new resistance spot welding technique; this uses a patented process, featuring a multi-ring domed electrode to weld aluminium to aluminium. Smooth electrodes have proven to be unreliable in this process in the past. As a result of perfecting the aluminium-to-aluminium welding process, GM believes it can cut around 1 kg worth of rivets from parts such as bonnets/hoods, tailgates and doors. The process is already used on the bonnet of the Cadillac CTS and the liftgate on the Chevrolet Tahoe/GMC Yukon hybrid pick-up truck. Although other VMs are undoubtedly working on this issue, at least at the time of its announcement, GM believed it had stolen a march on its competitors and expects to be using the process widely in the years ahead.

GM also moves into lightweight steel

Last year, GM – having emerged from Chapter 11 not so long ago – authorised its investment arm, General Motors Ventures, to invest in a company, NanoSteel, which specialises in nanostructure lightweight steel. Specifically, NanoSteel has developed a new category of steel which facilitates weight saving through using ever thinner, but higher strength, steels and at the same time maintaining the structural integrity of the vehicle body which is required to meet safety standards. GM has co-invested in this company with seven other financial investors, citing NanoSteel's technology as a potential 'game-changer' in terms of reducing vehicle weight in the long term.

Significant potential in magnesium

Moving away from steel, GM is also working on lightweight magnesium sheet metal, having developed an industry first, namely a thermal forming process with integral corrosion resistance treatment for magnesium sheets. According to GM magnesium weighs 33% less than aluminium, 60% less than titanium and 75% less than steel, so its weight benefits are clear, although the cost of magnesium somewhat militates against its widespread use.

However, GM is proceeding with the development of magnesium parts and has developed a production-ready component, namely a magnesium rear decklid inner panel. This has survived rigorous testing, including over 75,000 robotic slams and a 250 kg impact drop. In a series production environment, GM claims it can save 1 kg over an equivalent part made in aluminium. Assuming adequate and cost competitive supplies of magnesium are available, the US Automotive Materials Partnership believes that 350 pounds (160 kg) of magnesium can replace 500 pounds (227 kg) of steel and 130 pounds (59 kg) of aluminium per vehicle, achieving a 15% reduction in weight and a fuel saving of around 9-12% depending on driving cycles and styles.

ABOVE: GM's new resistance spot welding process uses a proprietary multi-ring domed electrode

And aluminium potential in particular areas

The 2014 Corvette uses an aluminium body frame which reduces weight by 99 pounds or just under 45 kilos, but it is also at the opposite end, at the level of small individual components that GM is saving weight. For example the new Corvette will be the first to use a lightweight heat-activated shape memory alloy wire (rather than a motorised actuator) to close the hatch vent which is used to release air from the trunk. This component saves just over 0.5 kg in weight.

Shape memory alloys are seen as especially useful tools in the manufacture of moving parts; they can reduce part mass (i.e. weight), leading to a direct improvement in fuel economy, but making individual, small improvements like these take time and involve an awful lot of work. For example, GM took nearly five years to perfect use of the shape memory alloy for this part, albeit as part of a wider programme of R&D in the use of smart materials, for which GM has registered in the region of 250 patents.

The role played by component suppliers should not be forgotten

While the car companies themselves lead the way in looking for opportunities to cut weight and implement the ideas they develop, the role played by suppliers should not be overlooked:

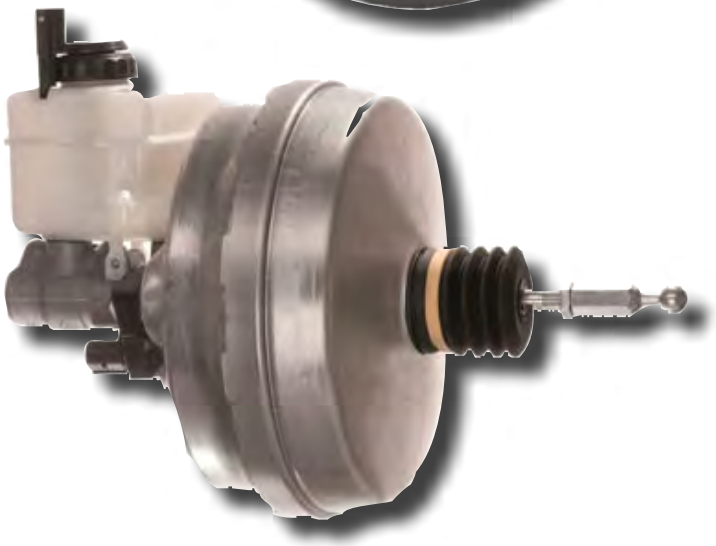
Continental – lightweight brake boosters

The latest generation of brake boosters developed by Continental are made entirely of aluminium, the first time this has been achieved; the use of aluminium and various improvements to its design has reduced the weight of the new part by around 50%, i.e. 1.7 kg, compared to the previous generation design. In addition, the new boosters are slightly shorter, with the reduced weight and optimised shape of the part having been achieved through the use of thinner metal and improvements to internal design of the part. The thickness of the metal has been reduced by 50%, from 2.4 mm to 1.2 mm, and this has been done without compromising on service life.

TRW's lightweight airbag inflators

Another example of small scale weight reduction comes from the airbag world, in this case the inflator. In 2012, TRW launched the DI10 1G45 inflator, its lightest and smallest inflator yet. This has been developed for use in micro-airbag modules and will go into

TOP to BOTTOM: TRW's lightweight airbag inflator; Continental's lightweight brake booster; Johnson Control's door panel



Carbon Fibre?

Actual use of carbon fibre will be highly specific…

In terms of the main opportunities and applications for carbon fibre in mass produced cars, Gary White, engineering manager at Prodrive Composites believes that cosmetic enhancements are an obvious opportunity. In these instances, the customer would be willing to spend an additional amount to upgrade the vehicle with clearly differentiated interior and external trim components. Prodrive says that advanced composite components can now be produced in a range of deep-lustre colours to the highest quality standards required for luxury products across a wide range of industries.

"It's a substantial step beyond conventional carbon trim finishes, offering something very special for exclusive vehicle options and other luxury products."

He added: *"In addition, OEMs are looking at the weight saving advantages of carbon fibre for suspension components and body panels, using press and thermosetting technologies to make the processing cost element cheaper, with higher volume capability."*

Terry Graham, managing director of Zircotec, agrees that cosmetic parts currently show the greatest opportunity. *"As a supplier of coatings to enable the use of composites in harsh environments, Zircotec is receiving a growing number of enquiries from OEMs and Tier Ones. A number of these requests revolve around the protection of 'decorative' carbon trim parts that are tightly packaged close to heat sources and need to be protected. However, our first application was to coat an under bonnet carbon composite inlet manifold."*

Recycling carbon fibre still a major challenge

It appears that processes to manufacture carbon fibre have moved faster than those for recycling it. *"Recyclability is still a potential stumbling block," says White. "However there are a number of people looking into effective ways of recycling carbon and I am sure that as was the case with tyres an effective solution will be found."*

Indeed, a team of researchers at Nottingham University, led by Professor Steve Pickering, Professor of Mechanical Engineering, are developing processes to recycle carbon fibre composite materials, including developing applications for use of the recycled carbon fibre.

The team worked closely with Boeing yet Pickering points out that the prospects for transferring this technology to the automotive industry are good. *"The technology that we are working on with Boeing would generally be applicable to recycling carbon fibre from any industry and so could be applied to the automotive industry if viable applications were identified.*

Carbon fibre has unique structural properties that mean that it can be used to make the lightest structural materials. So it has the potential to make very lightweight cars that could help to reduce fuel consumption and carbon emissions. There are great opportunities to use it in the vehicle structure."

production from 2014, with a weight saving of 25% compared to the previous version.

Johnson Controls (JCI): saving weight in door panel trim

While the VMs are using lightweight metals to reduce metal outer door panel weight, suppliers are doing the same with door panel interiors. An example in this regard is the work done by JCI for BMW on door panels. The door panels on the latest 3 Series have been made of a combination of natural fibres and plastics which are said to save 20% weight compared to previous generation components. Seat structure weight has been saved by around 3-4 kg.

The non-visible door panel elements on the 3 Series is made of wood fibre, with the carrier, made of natural fibres, moulded together with plastic. The combined production process is said to reduce the weight, with additional weight being saved through the novel way of laminating the fabric or leather trim to the door panel. This saves an intermediate component and therefore additional weight.

Beyond metal, will carbon fibre make it as a mainstream vehicle body material?

Carbon fibre is well known for being used in Formula 1 racing cars in particular but until now it has been used rarely in volume vehicles. This is beginning to change however. The strength-to-weight ratio of carbon fibre is well-known (it is five times as strong as steel and twice as stiff), but it achieves this while weighing just one third of steel on a part-for-part basis.

Road going high performance sports cars have been the initial users of this material, with McLaren, Ferrari and Lamborghini the main adopters. However, BMW has settled on carbon fibre as a means to achieve a major weight saving on its new *"i"* range of electric drive vehicles. It has established a joint venture with SGL Automotive Carbon Fibres, based in Washington State in the US.

The carbon fibres for the i3 and i8 are made in the US and shipped to Germany for transformation into body parts.

Will legislation be required to reduce weight even further?

The car companies and their major suppliers have become remarkably adept in recent years at finding ways of reducing fuel consumption and emissions from traditional engines. The death of the conventional internal combustion engine has been predicted on many occasions but it survives and is going to be with us for many years to come as weight reduction and mechanical efficiency improvements will mean the car companies can meet the next round of fuel efficiency targets which the regulators throw in their path.

According to a recent review by Frost & Sullivan, if governments really want to make significant further inroads into fuel consumption and emissions levels, then the only way to do this is to set tough weight limits for cars.

F&S have suggested that limiting all city cars to a maximum weight of 500 kg would have a dramatic effect on emissions and this is what the authorities should do if they really want to address emissions and congestion in urban environments. If they did this, and taking the figures quoted by F&S at face value, then the resultant changes would indeed be dramatic.

For example a 500 kg petrol engined car (something around the size of a Renault Twizy for example) would, according to F&S emit less CO_2 in its lifecycle than the new, all-electric Renault Zoe which weighs around 1,400 kg. Small, ultra-light vehicles already exist, such as the Aixam or Ligier micro-vehicles sold in France, but persuading governments to mandate their use and indeed forcing consumers to use them on a large scale is unlikely, in the short-term at least.

The Japanese, with their kei-car segment, have managed to create sustained demand for very small cars, so it is possible, but in reality, consumer pressure and the persuasive powers of the major car companies are likely to prevent such a switch in vehicle types on the scale suggested by F&S, at least in the foreseeable future.

Writer: Ian Henry

△ just-auto.com


TYPE 8 F0
TYPE 3
TYPE 2 F0
TYPE 5 F0

Jon Shaw

Project Director Aventra & Divisional Head of Engineering for Bombardier interviewed by Dave Leggett

Headquartered in Montreal, Canada, Bombardier is split into two main divisions: Aerospace and Transportation. With 64 production and engineering sites in 26 countries and 19 service centres at customer premises across the world, Bombardier Transportation is a global leader in the rail industry. The company covers the full spectrum of rail solutions, ranging from complete trains to sub-systems, maintenance services, system integration and signalling. Dave Leggett caught up with Jon Shaw, a senior director with Bombardier Transportation.

What are the main areas of activity for Bombardier's Transportation division and can you describe your responsibilities?

In the rail sector, we have been the number one by sales in the world for a number of years. I am the senior director of engineering for a division of the transportation group which is called 'Rolling Stock Atlantic and Services Division'. Essentially that encompasses the new build trains which are manufactured in the UK and other parts of Europe and globally it embraces what we call 'services' which is the through life support of the trains maintenance, overhaul and the upgrade of Bombardier's trains worldwide.

PREVIOUS PAGE: Bombardier factory in Derby, UK and Jon Shaw (INSET)

And what about the UK unit/operations? How much is design and how much is manufactured here?

We manufacture and design all the trains we supply in the UK here in the UK. There is one manufacturing facility in Derby (the last rolling stock manufacturing facility in the UK). We're going strong despite the news coverage a couple of years ago when we lost the Thameslink contract [to a consortium led by Siemens].

We are also a world class centre of excellence in engineering and design for trains all around the world. For example, we're doing double-deckers in Switzerland, designs for a monorail in Sao Paulo and also designs for very high speed trains for China and Italy.

So we were actually recruiting throughout that period when there was the adverse publicity surrounding the Thameslink decision,

which surprised a few people.

As well as the one manufacturing facility and the design here in the UK, we also have around twenty service centres spread throughout the UK, looking after the trains in service.

If we take the London Olympics for example, over half the people who travelled to the Olympic stadium, by whatever means, travelled on a Bombardier train and their performance was outstanding – something we are very proud of. We do London Underground trains, airport express trains (London-Stansted, for example). We cover a lot.

How many people does that activity employ?

The factory in Derby, which has been here for 137 years and has a terrific history, employs around 1,500 people, including around 350 people who are involved in design work. The service centres throughout the country employ around 1,700, so it's a grand total of around 3,200 people.

How is the business growing?

What we have seen in the last five years is more demand for rail globally. We are seeing a lot of increase in urban demand. Demand for rail is being driven by clogged up roads, more people moving to cities, the high price of oil, more interest in sustainability and efficiency in transport.

Rail has the advantage of higher speed and an enhanced passenger environment – with things like wifi on trains. It's an environment where people can be productive and that's provided a big opportunity for us.

You believe, then, that the railways, often thought of as having their heyday following the industrial revolution, are very well placed to address some of the challenges facing transportation in general?

Most definitely. And there's a parallel with automotive in where the technologies are heading, for example in trying to reduce pollution and enhance efficiency. If we take the traditional diesel train, we can move to electrification solutions or energy storage on the trains, so that they can be independently powered but without the diesel engine running.

In the UK, there is plenty of investment in electrification infrastructure for rail, for example London to South Wales and what is called the 'northern hub' which is Liverpool, Manchester and across to Leeds. It's a pretty big financial commitment.

The trend is most definitely away from diesel locomotives on passenger trains. All new railways, these days, are being built on electrified infrastructure.

So, while there is that up-front infrastructure investment which can be considerable, that comes with a payback in terms of reduced operating costs. And the higher price of diesel oil, alongside the perception that it will get more scarce and expensive in the future, is also helping to reinforce the electrification trend in rail.

I guess a diesel locomotive pulling a train is a thirsty machine...

It certainly is. It's not just the need to be able to pull the considerable mass involved, but there is also the stopping and accelerating from stations to consider, which has a big impact on running efficiency.

But the electrification infrastructure installation is sometimes not straightforward?

There can be challenges, certainly. We manufacture trams also, the Croydon trams for example. And if you are running that through a city centre there are challenges associated with setting up the electrification infrastructure, managing the electric currents, safety hazards and so on. But the lower operating costs are increasingly seen as worth that initial investment.

What other parallels can you see between automotive and rail?

There a number of areas where we share similar experiences. For example, like automotive, we have implemented something like stop-start. So if a diesel train is stationary for a period, it will switch off a number of the engines automatically.

There are some areas where automotive is leading that also apply to us in the rail sector – areas like energy storage, light-weighting, new materials being used in passenger environments. And that's why we are working with Lotus, looking to see what technologies we can draw on that might give us some competitive advantage.

What areas of the rail market, in global terms, are particularly hot right now?

I would pick out the emerging economies, they are driving massive growth in rail at the moment. China, for example, has been a combination of both metro, urban rail and also high-speed trains to connect the cities. Brazil, China and India have seen massive growth and Bombardier has manufacturing facilities in each of those countries to support that growth.

Local manufacturing is an important part of the picture?

Yes, that's our strategy, which is a little different to some of our competitors, who have a much more centralised production structure and export from there. Our thrust is to have a local facility to provide a local level of service.

Is it cheaper to produce locally?

It depends. There can be lower labour rates in emerging markets, but obviously, if you go down the centralised route you can really sweat your assets. Decentralising means that you run the risk of having a multitude of factories with some operating below their optimal or efficient scale.

But we feel that there are some countries that want to buy locally. In some, like China, it is a requirement.

It is also part of our philosophy to have that global footprint. It works for us and, we believe, keeps us at number one in the world.

We do also like to have a global supply chain.

Is there much automation?

You don't see robots in the way that you do on an automotive production line. It is relatively labour intensive, given the nature of the work and the batch quantities being produced.

If we consider India, is the investment in rail to replace and renew old systems and stock?

Yes, it is not as high as in China and it takes longer to come through, but we are seeing it now. The aspiration to modernise is there, but it takes longer for the contracts to come through.

We have a factory in India and an off-shore design facility where we undertake non-core design activities, around 15-20% of our total design effort.

Given the very different railway operating conditions around the world, how does rolling stock design address that? Are there common standards in design or are things highly customised for different operating conditions?

There are certainly significant differences in operating environments, air temperatures and things like dust, which can get into propulsion systems, steep gradients in some places, different track gauges and so on. The UK, for example, is an old Victorian railway with some very narrow tunnels. We're the first company to add London Underground trains with air-conditioning.

But we are trying to look at whether there are modules that we can bring in for a degree of standardisation, it's perhaps similar to the platform type approach used in the automotive industry. That can enable us to save on cost. The cost of rail is something that could hold rail back, so we are interested in any areas where we can reduce cost.

How are things in the UK rail business?

It is growing. The UK, historically, has been a difficult market from a feast and famine point of view, with government cycles on procurement. But there is plenty of growth in the UK at the moment. We have just put some new trains on the London Underground and there is quite a lot going on there. There is also the big London Crossrail tender, which will be announced later on this year, which we have been short-listed for.

And we are working with people at High Speed 2 (HS2) to understand the energy and infrastructure requirements that those high speed trains will need. We have the experience with high speed trains for Italy and China that we can use as a model for what might be used in the UK. But the UK planning timeline is still early, with the trains not actually running until the middle of the next decade for the first phase. Typically our cycle is five years or a little less. The new trains that we have just done for the London-Brighton route are the shortest cycle we have done; we have a train on the test track at the moment. The contract was awarded on Christmas Eve 2011 and we'd built the first one by December 2012. Typically that

period would be about two years and then 1-2 years to build them all, followed by testing and passenger operation. So, it's usually up to five years to design, build the fleet and have passenger operation.

And the same companies tend to be going for those big contracts?

Yes, pretty much. It is Siemens from Germany, Hitachi from Japan and CAF from Spain. But we are beginning to get stiffer competition from companies in China – where there are two state-owned organisations, China Southern and China Northern – who are increasingly starting to compete overseas as the Chinese domestic rail market starts to peak.

How do you manage the big peaks and troughs in terms of manufacturing and capacity?

Feast and famine with big government procurement cycles is an issue, not just for us but also our supply chain (more than half of our suppliers are in the UK). If we are in a 'feast' phase, they have to get the capability to supply us, but when we are dropping into famine, they may end up leaving the market.

Our Derby factory was producing about 25 carriages a week two years ago when we experienced our last peak. That can go right down. A global spread of work can help to mitigate the big swings.

How long are the replacement cycles for rolling stock?

Very long! We are talking about a typical train life of 35 years. Two years ago we had five different fleet operators wanting new trains. And then the new contracts dried up. You can imagine what that does to us, but also the supply chain, we are talking maybe 60,000 different parts on a typical train. We had a million parts arriving per week. And then the famine hits, suppliers go out of business or are able to enter other markets.

How does Bombardier Transportation's workload break down in terms of metro type rail systems and the long distance high-speed stuff?

The big focus is on inner-city and commuter type transport. It is around an 80:20 split on the two broad types of applications.

Is Bombardier involved with the freight rail side of things?

We do manufacture some freight rail locomotives but not the freight wagons.

You have already mentioned the widespread adoption of electrification, but are there other technical or technological changes impacting rail at the moment?

Speed is a big area of attention. There is a desire to develop faster trains that can start to compete with air on short-haul flights, move people at speed from city centre to city centre. The latest Bombardier trains that meet this express market and that we are designing can do 350 km/h, for Italy and for China. In the UK we have High Speed 2. The technical challenge is to get to that speed and not consume vast amounts of energy. And that is where we can get some support from Lotus, in weight reduction, energy efficiency.

Lotus can also help us with noise reduction. That is important in metro rail going through highly populated areas. Even electrified trains, propulsion and aerodynamics and vibration are factors that impact noise levels as speeds increase. We can also look at the suspension set-up to help minimise noise and also wear and tear on the rail.

On weight reduction can we look at different materials? We build our trains with a lot of aluminium. Can we start to look at composite materials? Can we start to take weight out of the really heavy steel structures, the bogies underneath the passenger compartment?

Also, can we brake electrically, put the motors back into reverse when braking, put electricity back into the network, regeneratively?

We are also looking at control systems that can take control of the train and drive it in the most energy efficient way.

Like the intelligent transport systems being looked at to optimise vehicle traffic flows?

That's right. If we look at urban metros, the majority of them are electrified and capable of operating perfectly well without drivers, like the Docklands Light Railway in London. Even some of the newer London Underground signalling systems going in have the capability to operate without drivers. In places like Hong Kong, driverless trains are normal.

And energy storage can extend the reach of electrification?

Yes. If we can put some energy storage on the trains, then they might only have a little way to travel to outlying communities on the back of a bigger electrification network. So we need to look at what we can get out of different types of batteries. There are some things we can learn from hybridisation in the automotive industry. And there are things like flywheels and super-capacitors that we can look at.

In this energy storage area we are looking to do a trial in one of our UK trains later this year. We want to see how far a train might realistically be able to travel using on-board energy storage.

I guess it will have to be a pretty big and heavy battery?

Yes, to some extent, but they are getting smaller and the performance better. We have looked at lithium-ion, but we are now looking at other types, such as lithium ferrous-phosphate and others. The battery technologies are advancing so this is getting increasingly feasible.

And what sort of range are you looking at?

The intention would be to run for 50 or 100 miles. So these might be able to run to more rural areas and replace diesel trains that would currently be used.

Are there any synergies with the aerospace side of the Bombardier business?

Reliability is one area. Rail operators frequently face penalties for unreliability and reliability in operation is something for us to consider, certainly. There are some interesting differences and there are some things that we have learned from them in terms of what they would call an 'iron bird' – a plane without wings and you look to test all the systems work properly before you even start manufacturing the plane itself. We have borrowed from that and have an iron bird equivalent for a train.

How do rules and regulations impact the rail sector?

There are multitudes of standards and regulations for new trains that the engineers have to comply with. There are independent organisations called 'notified bodies' which assess the trains in terms of compliance to standards and safety, risk assessments for each component. We also use the MIRA test facility with crash test dummies – a similar process to that used by the automotive sector. Fire safety is also a big area, lots of testing on smoke and toxicity of materials. That is probably more rigorous than automotive and restricts us in the materials we can use.

And active safety as well, systems that make collisions 'impossible'?

That's right, yes. There are the new driverless systems, for example on London Crossrail that we are bidding for. There are computers talking to each other, monitoring separation distances, speeds, so that the trains can be controlled automatically. And there are systems in the UK now that mean if it looks like the train is going to go through a red light, the brakes will be deployed automatically.

So passenger rail travel is constantly getting safer?

Yes. When accidents occur these days, it is due to vandalism or perhaps negligence related to maintenance, rather than the trains whacking in to each other, that hasn't happened in the UK for a long time.

Writer: David Leggett

△ Editor - just-auto.com

Hydrogen Propulsion

Utilising and storing hydrogen in an automotive powertrain

The Hyundai ix35 fuel cell electric vehicle

A vehicle can be propelled by hydrogen fuel in a number of ways. Hydrogen can be used as a rocket fuel although this is more applicable for the space industry rather than automotive.

Hydrogen combustion

Perhaps the most obvious automotive use is to combust hydrogen in a spark ignition engine. Relatively few modifications are required to the actual engine and in many cases, the control system allows switching between burning gasoline and burning hydrogen. A dual-fuel system such as this decreases any anxiety regarding the ability to refuel with hydrogen until there is a hydrogen infrastructure in place. In addition to an either/or state, it is also possible to co-burn hydrogen and gasoline with the benefit of lowering harmful emissions, fuel consumption and tailpipe CO_2.

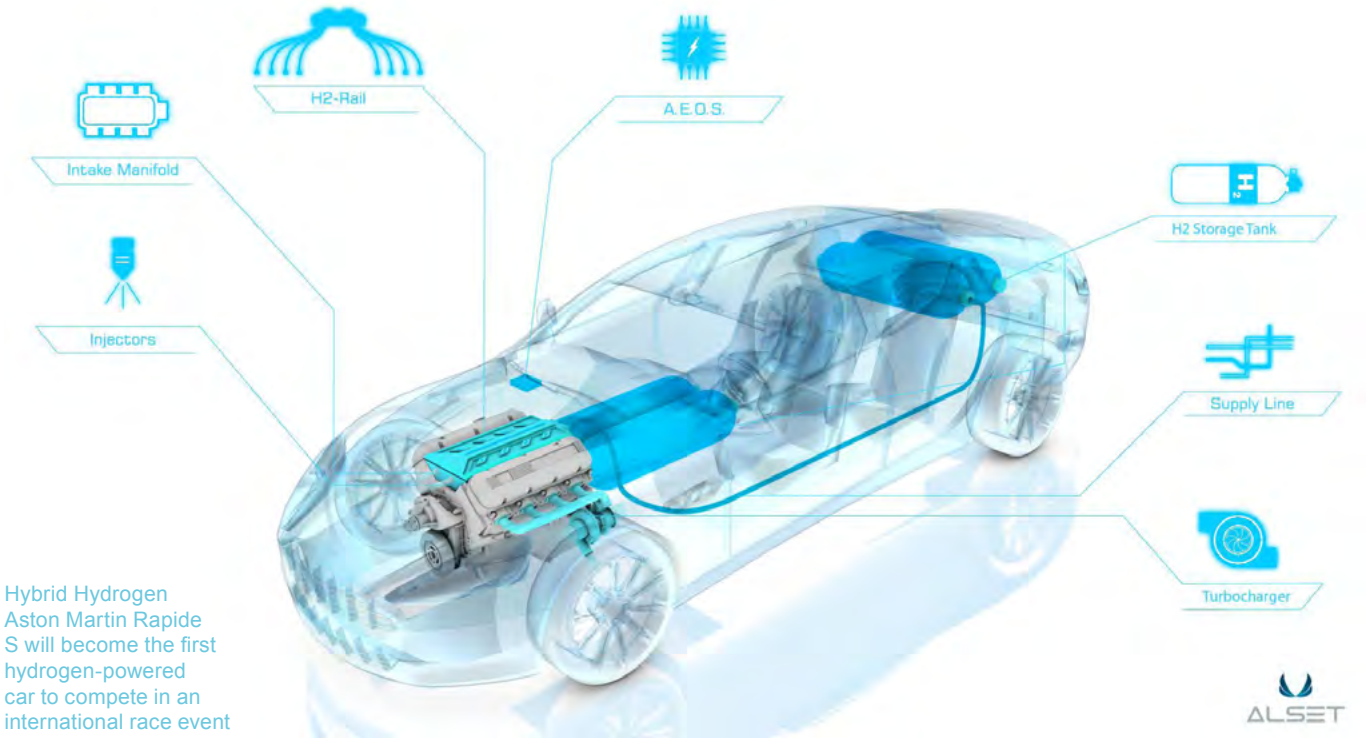
Alset Global's Hybrid Hydrogen system comprises a hydrogen fuel supply system, hydrogen tank and proprietary engine management system. The strength of the Hybrid Hydrogen technology is related to the flexibility of controlling the combustion process according to each particular driving situation: either pure hydrogen, gasoline or an arbitrary blend of both can be selected to ensure optimum power, acceleration and CO_2 reduction.

Aston Martin's Rapide S will debut the technology at the Nürburgring 24 Hours (May 19th-20th 2013) and become the first hydrogen-powered car to compete in an international motorsport event.

Fuel cells

A fuel cell is an electrochemical conversion device which is designed to produce electricity from a fuel source such as hydrogen, hydrocarbon fuels or alcohols. The first rudimentary fuel cell was developed in 1839, however, their commercial usage didn't take off until the NASA space programmes from the late 1950s onwards.

In a similar way to batteries, fuel 'cells' need to be electrically strung together to increase the voltage of the whole device. Although different cell chemistries deliver slightly different voltages, let's say a lithium ion cell has a typical voltage of 3.2 V so a number of them need to be electrically connected to make a battery 'pack'. Similarly, an individual fuel cell delivers around 1.4 V so a number of them need to be connected together and this then is referred to as a fuel cell



Hybrid Hydrogen Aston Martin Rapide S will become the first hydrogen-powered car to compete in an international race event

'stack' although commonly the whole device is known as a fuel cell.

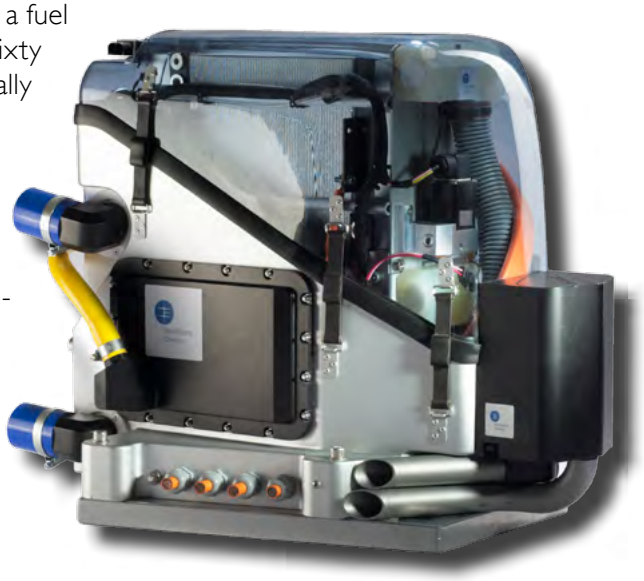
There are many types of fuel cells using a number of different fuels but the proton exchange membrane (PEM) fuel cell using gaseous hydrogen is regarded as the best long term solution for fuel cell technology. The chemical reaction of hydrogen and oxygen in the fuel cell generates electrical power and water. The gaseous hydrogen can be supplied from hydrogen storage tanks or from an on-board reformer that produces the hydrogen from other fuels such as methanol.

The electricity from the fuel cell is used to drive an electric powertrain in the vehicle, however, the fuel cell power must be supplemented by some other form of electrical energy as a fuel cell takes some time to 'warm up'. In addition to this, a fuel cell is good at operating continuously but not so good operating in a transient manner. The transient requirement for electrical energy can be supplied by a battery pack with the fuel cell used very effectively as a range extender.

The benefit of using a fuel cell, is that at best, the thermal efficiency of a combustion engine is around forty percent whereas a fuel cell is better at up to sixty percent and is continually improving.

The Hyundai ix35 fuel cell electric vehicle has been selected by the European Commission-backed Fuel Cells and Hydrogen Joint Undertaking to be used as a demonstration vehicle to test and promote hydrogen fuel cell technology in a real-world environment

Intelligent Energy's 30 kw Motive Fuel Cell System ©Intelligent Energy 2013



ABOVE: Hydrogen storage tank used in the fuel cell London Taxi

Hydrogen storage

There are a number of technologies applicable to on-vehicle storage.

The reason for the development of these technologies is that hydrogen exhibits poor energy density per unit volume compared with fuels such as gasoline or diesel (liquid hydrogen has 4 times less energy density than gasoline).

This means that a large onboard tank would be needed to store enough hydrogen for a decent driving range. It does however show very good energy density by weight, nearly three times the energy density of gasoline – making it attractive to be used as a clean fuel.

The main technologies for automotive hydrogen storage are compressed or cryogenic, or a mixture of the two, however, there is considerable research being conducted into chemical storage.

Chemical storage

There is significant research being conducted in using various hydrides to store and release hydrogen. Hydrides are compounds of metals and hydrogen that can be 'charged' by pressurised gaseous hydrogen and can release the stored hydrogen by heating the hydride. Some methods are not appropriate for on-board storage but are being developed for industrial storage. Hydrides can be liquids, slurries or solids.

Aside from the gravimetric and volumetric characteristics laid out in the chart there are other characteristics of hydrides that need to be considered such as cycle life, refuelling time, kinetics and thermodynamics.

Cycle life and refuelling time are self-explanatory but kinetics refers to the rate of hydrogen transfer and thermodynamics refers to operating temperature and the temperature requirements for hydrogen transfer.

Cryogenic storage

Currently, cryogenic storage systems only exist as demonstration units in a relatively small number of vehicles although industrially, this method of hydrogen storage has been around some time and is well understood.

As the boiling point of hydrogen is so very low, to maintain hydrogen as a liquid, a temperature no greater than -253 °C needs to be provided. Thus, a vehicle using such a system would be refuelled by liquid hydrogen. The tanks that exist at the moment use vacuum as the main insulating medium.

Calculations can show that the energy per unit volume of liquid hydrogen is much greater than compressed (even at 700 bar).

However, the downside is that if the vehicle is not used, the tank and contents will start to warm inducing the hydrogen to boil off.

As a purely cryogenic tank is not generally pressurised to a high level, the system would need to vent off the hydrogen to the atmosphere.

This may create problems if the vehicle is in a confined space and what it means to the user is that over a period of a few weeks, the hydrogen would be lost.

Compression storage

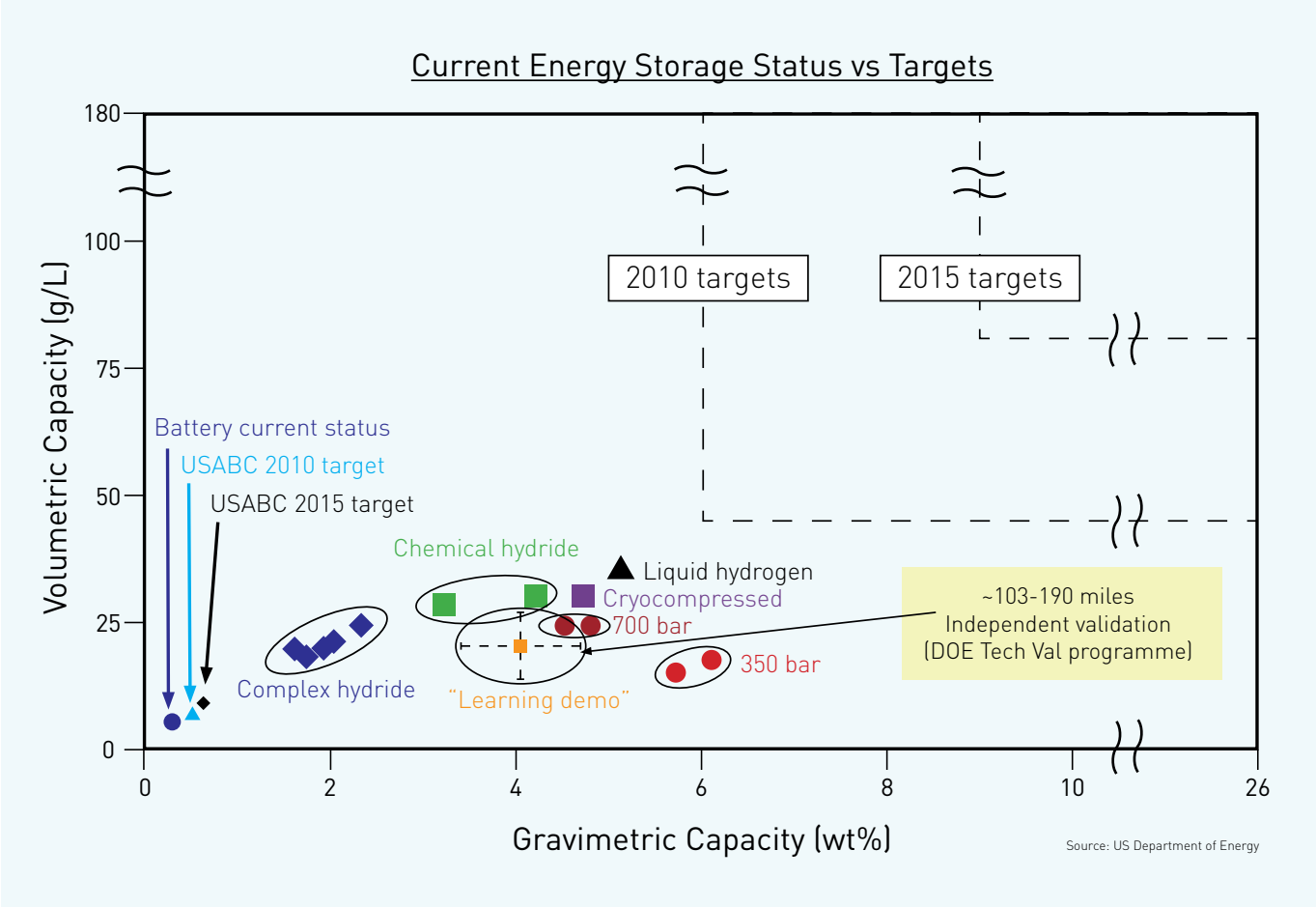
Two compression levels have emerged in the automotive industry as standard: 350 bar and 700 bar and tanks are available as 'off the shelf' production items.

The hydrogen remains in a gaseous state but the tank sizes are manageable to package into the vehicle and there will be enough hydrogen for an acceptable driving range.

An example of a 350 bar storage system can be seen on the fuel cell London Taxi. An exercise was conducted to identify a suitable tank and a number of options were considered, including 700 bar solutions and multiple tank arrangements.

Factors such as cost, size and availability were all evaluated and the solution chosen was to package a 350 bar tank in the engine bay of the vehicle.

The construction of the tank is a seamless aluminium inner tank 10 mm thick which is overwrapped with carbon fibre filament wound around the tank to a thickness of 25 mm.



This serves a number of purposes: firstly, to minimise seepage or permeation of the gaseous hydrogen, the molecules are small enough to allow this, however, it can be minimised with specialised tank construction; secondly, the structure allows the tank to pass certification, including abuse tests such as hydrostatic burst and drop tests.

Cryo-compression

Research studies have produced prototype tanks that combine cryogenics and compression giving the benefit of storing more hydrogen on board than either of the single systems.

These combined systems are far from production but they do help to achieve long term targets for on-board hydrogen storage.

A study conducted as part of the US Department of Energy Hydrogen Programme concludes that a cryo-compressed system has approximately twice the volumetric efficiency of 350 bar systems and has a 40 percent higher volumetric efficiency than 700 bar systems.

However these advantages come at the cost of increased off-board energy consumption due to liquefaction energy requirements.

Conclusion

All technology roadmaps are looking towards a hydrogen economy and the technology development to make this happen.

Fuel cell technology is becoming commercialised to the point that OEMs are already manufacturing fuel cell electric vehicles in large fleet demonstration numbers and from around 2015 onwards, there will be products available for consumers to buy.

As with all new technologies, the cost will still be a premium for some time to come and to a certain extent the acceptability of fuel cell electric vehicles will depend on the development of a hydrogen infrastructure.

The use of hydrogen in combustion engines could turn out to be an interesting and acceptable stepping stone to a full hydrogen economy in the future.

Writer: Phil Barker

△ Chief Engineer H&EV - Lotus Engineering

ISO 26262

Safety related electrical systems

ISO26262 is an Automotive Industry specific standard for safety related electrical systems in passenger vehicles up to 3.5 tons. It addresses possible hazards caused by malfunctioning behaviour within and between electrical and electronic (EE) safety related systems and should:

- Provide an automotive functional safety lifecycle (management, development, production, operation, service, decommissioning) and support the tailoring of the necessary activities during these lifecycle phases.
- Cover functional safety aspects of the entire development process (including activities such as requirements specification, design, implementation, integration, verification, validation, and configuration).
- Provide an automotive-specific risk-based approach for determining risk classes, automotive safety integrity levels (ASILs).
- Use ASILs for specifying the item's necessary safety requirements for achieving an acceptable residual risk.
- Provide requirements for validation and confirmation measures to ensure a sufficient and acceptable level of safety is achieved, supported by documented evidence.

Legislation

ISO 26262 has been written to represent the state of the art best practice for EE Systems and therefore qualifies as a non optional requirement.

These directives do not provide guidance on implementation, nor do they provide interpretations of the law.

Legal critiques of products will be conducted in court using hindsight and evidence to determine whether or not the manufacturer was negligent, and whether or not the designer produced a reasonably safe design. Lawyers will argue how the evidence available shows how the manufacturer of the product applied (or didn't apply) good safety engineering practices.

A concern is that if a potential failure of a system occurs and litigation results as a consequence, there are no examples as to how the legal process will consider evidence supported by the use of the standard.

The standard, although not a legal requirement, will be used to ascertain whether all appropriate mitigation was identified, analysed, adopted and functioned in accordance to documented evidence based upon ISO 26262 methodologies, which concludes that the system is compliant with the current accepted 'state of the art' methods and principles.

Legally 'state of the art' could be regarded as moot and therefore difficult to establish whether the statement refers to what was currently in use within the manufacturer's establishment or what was currently available globally.

Another consideration should be as to whether the statements interpretation of 'current' is when the vehicle was designed, when it was launched or when the problem was discovered.

A current 'state of the art' condition is a constantly moving target especially within EE, so much so that what was state of the art at the concept stage of a project may be regarded as obsolete by launch.

There will be many anomalies that will come to light during the following months but we must be aware that ISO 26262 is still in its infancy and as such is Evolving.

As practical users, we must identify areas of the standard that provoke concerns and possible implications to OEMs, suppliers and end-users.

When we at Lotus were first confronted with the ISO 26262 functional safety standard, it was met with a little trepidation before realising that it mainly put a more formal process around what we considered as 'normal engineering business'.

ISO 26262 is a fundamental requirement of the automotive industry doctrine and ensures that current and future EE Systems within EV, hybrid and conventional vehicles are fully transparent regarding functional safety.

Similar logical processes, required to achieve acceptable functional safety standards within our range of controllers and EE Systems have been in use for a number of years throughout Lotus. These processes are part of the Lotus customer-driven engineering design tools referred to under FMA (failure mode avoidance).

At the working level the greatest challenges we face when adhering to ISO 26262 requirements is training engineering teams to embrace the benefits of the methodology contained in applying it.

Lotus methodology

The introduction of ISO 26262 has required Lotus to reassess its approach to EE development and in doing so has highlighted aspects of in-house knowledge that enabled the development of Lotus' own robust methodology in the determination of ASIL ratings. This is extremely time efficient when establishing the classification of HEV systems.

Lotus has used the ISO 26262 methodology across all aspects of electronic and electrical systems currently in vehicles and powertrain variations, conventional mechanical drive systems with manual and auto shifting, series and parallel hybrids as well as pure EVs. The process is fully adaptable and logical which concentrates the minds of engineering teams to the achievement and verification of the safety goals.

Testing

One of the biggest impacts is on product development, especially testing. By using the methodology defined, it has highlighted areas of concern which might have previously been overlooked. To this end, far more robust validation and verification methods have been introduced based upon proving that an acceptable functionally safe state will be achieved across all identified hazard scenarios.

An example is the detailed design and control strategy developed to provide robust, rapid identification and mitigation of theoretical electric motor faults.

This included MiL simulation and HiL virtual testing using IPG Carmaker and component failure mode testing on LabCar and Lotus EV testing chambers prior to inducing control level simulations of the potential electric motor failures on the development vehicle being driven at speed under specific manoeuvres on the test track.

Software

Software compliance is an essential requirement within vehicle control systems although many OEMs design and implement software which is unique to them. This practice is becoming less common as more and more companies adopt Autosar compliant operating systems.

The main fear of OEMs and the supply base is that as ISO 26262 is new, it will require a completely different approach and understanding on their part, entailing increased workload. Yes, there will be a certain amount of training and extra detailed work at the start of projects but this should lead to a far more compact, robust, realistic, time and cost saving validation plan.

Training

Training courses in the usage of ISO 26262 and FMA is a requirement of all Lotus teams, and first and second tier suppliers.

Lotus also offer courses to OEMs and suppliers who wish to understand the ISO 26262 and how best to implement it, supported with practical examples of its usage and results.

Lotus has the benefit of considerable expertise spanning the full range of design, development, manufacturing and production disciplines.

This provides a unique viewpoint from which to recognise, first hand, the many facets required to fully implement safety and functional safety at a component, system and vehicle level from concept and design, through product development to product implementation and on to full production.

Summary

ISO 26262 is here to stay and therefore all OEMs and their supply bases need to quickly develop structured usage methods based upon actual projects. It would be advantageous if all the learning generated by the adoption and application could be pooled. Unfortunately as this standard pertains to safety it is expected that most manufacturers will not openly divulge their experiences for mutual benefit and the greater good, so in general each company will develop their own interpretations and approaches to meeting the standard in relative isolation.

Lotus are well placed and available to train, advise and support the implementation and understanding of the Standard.

Writer: Richard Mayer

△ Executive Manager, EE Functional Safety, Lotus Engineering

Geneva Motorshow

Trends and observations

The Geneva Motorshow provides the spring insights into what the global companies having been thinking for the past year or more. The internet has made the communication of what's forthcoming more interesting and insightful, with teaser images released and microsites to engage with customers whether for the near term or to capture the imagination of future vehicle owners.

BELOW: McLaren P1

High End Luxury

Any time a new Ferrari, McLaren, Lamborghini, Bentley or Rolls-Royce is launched, it causes a buzz. To have all five companies introduce new products at the same time, made Geneva 2013 a very special show.

Automotive manufacturers in this segment know full well there is a limit to the number of very high priced cars that can be sold at any point in any one year, and that the market is cyclical. This sector has been driven by an explosion of wealth in China, and strong demand from the USA too. The effect has been seen by Porsche, BMW, Audi and Mercedes-Benz as this strong demand reaches other vehicle segments.

The high end sector sees three main product types the 'classic saloon', the 'grand tourer' and the 'sportscar'. New product types will emerge into this sector. We saw evidence with the Bentley and Lamborghini concepts which were based on the more traditional SUV type architectures, last year. The next few years will be interesting in seeing how manufacturer's offerings beyond the traditional bodystyle, package and powertrain combinations develop.

BELOW: Bentley Flying Spur (TOP) and Rolls Royce Wraith (BELOW)

RIGHT: Qoros 3 Sedan interior

Geneva, the statistics

20 Global unveilings of new production cars

3 European unveilings of new production cars premiered at other shows

31 Model additions, ranging from trim packs (the addition of 'Trekking' pack for the new Fiat 500L for example) through to both hybrid as well as Compressed Natural Gas powered versions of the Volkswagen MQB platform (seen on the Audi A3)

14 Facelifts, ranging from the very mild (new bumpers for the Volvo cars range except V40 for example) through to totally re-engineered (SsangYong Rodius, for example with the new body structure and the inclusion of the new Mahindra & Mahindra group turbo diesel engine

10 Concept cars ranging from the Bertone Jet2 through a variety of 'ideas' to the near production ready Toyota GT86 Open

7 Technology demonstrators, including the PSA/ Bosch co-developed hydraulic and pneumatic kinetic energy recovery system

The ultimate car?

Not so long ago the ultimate car was embodied by hand beaten aluminium parts joined to form a sleek body, tailored in a bespoke interior suit of fine woods and leather. The modern version sees carbon fibre for outer cosmetic panels. It raises the question, could there be a trend in the future for an increase in more metallic cosmetic panels on body structures? If we look at other luxury products, formed metal still provides more emotional energy and attraction, especially when considering jewellery. So could the future see a combination of materials providing more tactile emotion?

McLaren and Ferrari introduced flagship products in Geneva, both using hybrid powertrains and carbon fibre body solutions. The main competitor to these products

would be the new Porsche 918 when launched.

Ferrari declared the planned production run had been sold out even before the public reveal. The information released by Ferrari via a dedicated website for the 'La Ferrari' will no doubt contribute to the exclusivity and desirability of the brand.

It ensures for the modern internet based community access and association with the brand that will result in Ferrari brand awareness and desirability remaining high, possibly even first choice.

The McLaren P1 was effectively unveiled in Paris last autumn, but many of the technical details were kept for the viewing of the first production car. The technology is astounding, the performance even more so. The hybrid drive is all new, and pushes technology not only for electric traction motors but also large batteries.

The game changer?

A move away from immense naturally aspirated internal combustion engines, to more compact units that can deliver high end power complimented by electric motor assisted traction launch system boosts, or backfills the acceleration from low speed, whilst giving the occupants a new level of thrill along with a big reduction to the big CO_2 tailpipe emission numbers.

The Bentley Flying Spur, powered by a bi-turbo V8 with cylinder deactivation, 8 speed automatic ZF transmission with active four wheel drive torque split, adaptive damping and more besides are 'as expected' and indeed, developed by the Bentley engineering team. The fit and finish is also 'as expected'. The redesign of the Bentley shows the tight gaps that result from good design and revising the manufacturing process of the vehicle assembly to provide the desired quality.

The *very* limited editions

Ultimate couture comes in the form of either a 'one-off' or very limited number product run, as demonstrated by the Lamborghini Veneno. Just three of these will be built and sold to customers. There is an important trend here, the rise of the one off /limited production run carbon fibre reinforced plastic (CFRP) car.

The process of making CFRP parts and adherence to a type approved central core allows manufacturers to reach a market greater than the price of the mainstream product and satisfy the requirement of the discerning client.

Veneno follows in the tracks of the one-off McLaren X-1, which was unveiled during the summer of 2012 for the Concors de Pebble Beach. A budget of GBP 3 to 5 million can provide the discerning automotive connoisseur with a unique product.

Interesting products in other segments

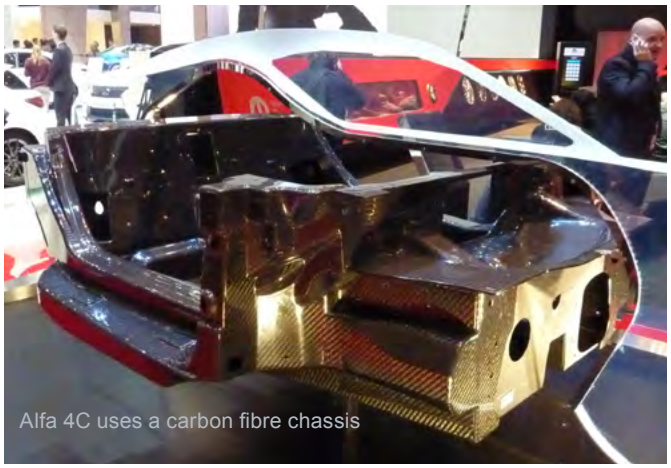
Away from the high end segment there were some interesting stars of which three stand out.

Qoros 3 tipped to be the first genuine Chinese built model to take on established manufacturers with a new brand providing the product range, desired quality and technology. The investors in Qoros created this company with staff picked from many European vehicle manufacturers and developed the product supplied by top component suppliers. The vehicle layout is

conventional for the segment (transverse engine, front wheel drive, McPherson strut front suspension and torsion beam rear suspension).

Tellingly the company produced two 'concepts' an estate and an SUV, with modelled undersides to suggest electric power for the rear wheels, for example. Qoros have spent their time studying competitors well, the car hits all the right notes in one go.

Volkswagen released the XL1, this ultra lightweight, twin cylinder turbo diesel powered super economy car. However, the low roof line (required to reduce aerodynamic drag to new world record levels for a road car) forces cut-outs in the roof skin in order to assist with ingress and egress. This is a car capable of using just 0.9 litres of diesel per 100 km (less than a litre every 62 miles).



Alfa 4C uses a carbon fibre chassis

VW's XL-1 also uses a carbon fibre chassis

Whilst the carbon fibre centre cell may not go into mass production, the hybrid drive powertrain is tipped to appear in other models in the future. This will result in higher fuel consumption due to the inherited greater vehicle mass as well as increased aerodynamic drag.

Tellingly the XL-1 follows the layout of a CFRP central cell with aluminium structures cantilevered from each end. Whilst the bulk of a two cylinder turbo diesel hybrid drive line is miniscule compared to other large displacement engines, the solutions used are rather more elegant.

The Volkswagen e-Co-Motion concept (built on the EV Caddys that have been on test for the past few years) has a markedly larger pay load and better range.

It has three traction battery options: 20 kWh (100 km range), 30 kWh (150 km range) and 40 kWh (200 km range). The idea being that these can be swapped at short notice as the operator wishes to extend range with very little notice.

The drive is via two rear mounted electric motors, whilst the powertrain ahead of front wheel centre line consists only of the cooling system for the high voltage electric system along with a heat pump for interior HVAC.

The big trends?

Lighting, from exterior with the rise of ever more efficient LEDs to interior mood lighting, where again LEDs are making huge inroads. In 2008 the 'star light' roof liner on the Rolls Royce Phantom Coupe was introduced, and is now on the Rolls Royce Wraith. Now the triumph of technology is reaching further down market at a fraction of the cost. The ambience that separated luxury product from mass market product is being altered, but introducing entirely new commodities to the automotive industry in the process.

The emergence of relatively high priced (circa EUR 50,000) super economical vehicles. The Renault Twizy as a pure EV was aimed at the French domestic quadracycle market, although with a unique take on semi-open occupant accommodation. However, this sector is defined by the Volkswagen XL-1 for the moment. In the wings will be similar vehicles from Audi, Daimler as well as Toyota.

Additional new products into the Compact segment have been suggested by various manufacturers over time. An SUV with a mostly open body, owing more to sports car design than traditional old fashioned off-roaders is what the ItalDesign concept demonstrates. The compact sector is the largest sector by market volume globally and the sector is set to have the highest growth and continues to fragment. The bulk of sales have been in either 5 door hatch or saloon / sedan version, depending on regional preference. However, we see additions of four wheel drive, two wheel drive with the four wheel drive 'look', coupes, estates, MPVs, cross over SUV/MPVs and more to come. The long term question relates to the viability of sustaining such product variety.

The high end sector has shown the technology it will

Audi uses OLED lighting on the outside of the car

deploy across its model ranges during the course of the next two years. There is unlikely to be any major development apart from the appearance of the new product types, initially SUV versions for the segment.

Carbon fibre

CFRP arrives in style. Regardless of manufacturing technique, the material cost is falling rapidly and new mass market applications are becoming more realistic. At the same show we saw EUR 1 million cars built with the same core structure technology as a EUR 50,000 Alfa Romeo coupe (the 4C) as well as the Volkswagen XL-1. The next steps? More sophisticated engineering solutions to optimise weight and cost

VW Group shows off its MQB platform

Audi unveiled the plug-in hybrid version of A3 (e-tron) along with an LNG powered version (g-tron). These two versions show the modularity of the rear part of the platform, capable of taking a traction battery package of two high pressure fibre reinforced plastic LNG tanks. The modular rear end of the MQB platform for the different brands will eventually include multiple rear overhangs, two suspension layouts, mechanical rear wheel drive, electric rear wheel drive, LNG, plug-in hybrid and full EV. The alternative propulsions systems shown in reality demonstrate the versatility of the MQB platform that Volkswagen is deploying across its brands.

Product Portfolios

We see the market adding more bodystyles with increasing range of powertrain and drive options. Add into the mixture the additional trim lines or branded performance lines with more manufacturer aftermarket upgrade lines and options, and you have the question is this continued increase of product complexity sustainable? Of even more interest, what enables the execution, a revised product development process, good product planning or good market awareness and consumer insight.

For which manufacturers is it the right strategy and which manufacturers need to evolve or adopt more tailored approaches to their product portfolios.

Ultimately, for customers, we see the prospects for a continued technology rich, diverse vehicle population with more choice than ever.

Writer: Sanjay Walia

△ Vehicle Architect - Lotus Engineering

Nathan Leeming

Head of quality for Lotus Cars interviewed by Dave Leggett

Can you describe your role and how you mainly spend your time?

My role at Lotus is Head of Quality, which means I am the senior management representative responsible for the quality of the cars we design, engineer and manufacture as well as the parts we purchase to make them.

One of the great things about this is there is no typical day, each morning that I arrive at Hethel brings fresh challenges to face and it's this variety that makes the job rewarding.

Whilst I obviously have routine meetings on a daily and weekly basis where we review performance of quality and production and take appropriate management action, the variety could see me out in the factory reviewing product one day, in a design or engineering review the next or off-site visiting a supplier. I really love the fact that I am involved in all aspects of the product lifecycle and value chain, from parts through design and development into production.

Obviously, the priority is to ensure the cars we are making are the best that they can be and this means reacting to issues as they arise, and ensuring the resources are in place to address them. At times this does cause a level of fire-fighting but the teamwork within Lotus when a crisis happens is actually one of the pleasures of the role. Often my role is to pull together different departments to gather the facts and then make a decision on the right course of action and make recommendations to the COO. This makes the role quite high pressure at times but is all part of the challenge of managing quality within any manufacturing organisation.

When not fire-fighting my role sees me stepping back from the frontline to map out medium and long term strategies for Lotus Quality. We have already made significant changes to many of our products and the processes we use to develop, make and check them and with my management team we have developed a three year development plan to move the whole game further forward.

Lotus is obviously a relatively low volume carmaker. Can you describe the approach to quality control at Lotus and how it differs from the typical approach that would apply in larger scale automotive manufacturing?

The quality control processes that we use here at Lotus are based upon many practices that would be found in high volume manufacturing but tailored to the needs of our volumes and product. If I had to summarise the key differences it would be the low level of automation we use together with the amount of work-content a lotus team member needs to learn.

In terms of the former, our quality assurance processes are very much based around manual checking of the product as it is assembled, such is the nature of our manual build processes and the relatively low investment tooling we use to make the parts that go into our vehicles. We have to inspect quality into the product.

This is very much at odds with a high volume car plant where high investment tooling yields low variability parts and hence fully automated lines with minimum human intervention, and therefore only minimal inspections to confirm basic functionality and build is conducted.

If we consider build volumes at Lotus as a small niche manufacturer the cycle time is our other key challenge. Typically in say a Ford plant a quality team member may check just the right hand front corner of a car for fit and finish only and may have a cycle time of less than a minute to do so.

Their approach is a quick overcheck by lots of people to ensure the whole vehicle is checked during its manufacturing process. At Lotus we have dedicated 'quality inspection points' at critical phases of the vehicle assembly and in these stations we have highly skilled inspectors who check all aspects of the vehicle including fit, finish and function to find all potential customer issues.

We then work with manufacturing to repair these issues and always ensure that we, as the independent quality over-check, sign off all repairs and adjustments made, to ensure they meet our quality standards.

How has car manufacturing at Lotus and the approach to quality changed over the years?

Having only been at Lotus for some 18 months, that might be a difficult question for me to do justice to. My priority is very much the future and how we can further improve the processes and methods to engineer and manufacture our vehicles. I have many experienced old hands from within Lotus who can ensure we don't make past mistakes plus a few newer team members from other OEMs such as Aston Martin, BMW, Chrysler and Alfa Romeo, who bring new ideas and different techniques we can adapt and freshen things up with.

In terms of measurability, things like defects per vehicle, how do you actually measure that and how does it feed back into manufacturing processes?

For all of our internal quality measures we run regular cross-functional meetings within the manufacturing plant. Within these meetings issues are allocated owners and we follow these up to ensure we have customer containment in place and a long term countermeasure under development.

For instance, a simple process issue will be allocated to a production supervisor who will feed this back to his team, check the stock and come back to the quality manager responsible with a safe chassis number. We then monitor from this safe chassis number for a minimum number of cars to confirm that we have delivered the improvements we expected to see before we close the issue off.

All issues found from the field are immediately added to our 'pass to sales' check process to ensure a fully finished vehicle doesn't exhibit this fault where it can be detected. Our philosophy is always one of protecting the customer, even where we are yet to find the root cause of a problem it is vital we detect it and wherever possible stop it reaching our customers.

Where issues are more complex or cannot be solved simply, these are escalated into a weekly senior management quality review which we call the Quality Management Committee. This gives us a forum to escalate issues where additional resource may be required with owners having to present their progress to the COO. These reports provide a level of focus and direction that they often need.

If quality control and manufacturing activities are separate, how do they actually interface and how does that work in practice?

When I joined Lotus the quality department reported to operations as part of the wider manufacturing department. One of the first changes implemented by our new COO was to transfer quality out of operations as a directly reporting function into him. This separation might have caused tensions between the two groups but to be fair it hasn't - I think the fact that the teams have been so closely aligned previously means that excellent working relationships have helped in that respect.

That doesn't mean that it is always a bed of roses though, for sure we face a conflict or two on occasions. My priority is towards the quality of products whilst others may have differing priorities. But as a quality manager you also have to recognise the need to make pragmatic decisions that don't negatively impact either the customer or the bottom line.

Also, my management style is not one of conflict and in reality the best way to make high quality product is through close teamwork and cooperation. Digging my heels in or getting aggressive may work at times, and I have been known take that approach when necessary, but it's not a good management approach in the modern working environment.

Are there industry standards that you can employ to help with, say, quality auditing?

Indeed, we have recently changed our product quality audit process to align it more with industry best practice. We take a finished product that has been through our full manufacturing and quality assurance process and assess it for full cosmetic, functional and dynamic performance. We call this assessment the Lotus product quality audit (LPQA).

It is important for us as this is our quick feedback measure of how effective our quality control process is and a real driver for improving the perceived and actual quality of the products we make.

The assessment is conducted from a critical customer perspective and any error states

we find are rated based on their severity to customers. All high scoring issues are allocated owners from within the Lotus team who then investigate the issues and put in place corrective actions within the manufacturing process as appropriate.

Since introducing our new quality audit process we have made significant strides to improve our build quality. If you take our Evora model as an example this new process and the efforts of the Lotus team to address the issues we find has seen a 59% improvement in performance in the last 6 months.

This type of audit process is used by the majority of auto makers worldwide – although the scoring and weighting may differ, the principles are pretty common globally. So this is a good example of how we are taking the best processes of our peers and industry leaders and tailoring them to the needs of Lotus.

And how does the picture look in terms of things like defects per vehicle on Lotus cars?

Our internal measure of defects per vehicle (DPV) has seen significant improvement since we introduced our revised quality assurance process. Evora has improved 46% and the Exige has seen a 33% improvement.

The main driver for this level of performance has to be the willingness within the Lotus team to accept the issues found and fix them. The quality process itself only highlights the problems, it is the positive attitude of the wider teams within manufacturing and engineering and the drive from Lotus management that has turned these problems into opportunities and delivered the improvements we see in KPIs.

The problems that we have fixed include process concerns where manufacturing have made changes, engineering concerns where we have made design changes to address and of course supplier part issues which we have fed back to our suppliers for resolution.

I guess there must be quality issues that also involve parts suppliers, for example a component that is prone to fail. How do you deal with that?

Supplier concerns are handled via our Supplier Quality Assurance (SQA) department, and this is an area we are now paying a lot of attention to having stabilised our internal quality control processes. For any OEM assembling a complex product the quality of parts we receive from our supply chain is critical and we recognise we have much to improve in terms of supply chain management.

Today, we have a small dedicated team of engineers who take component problems found at Hethel and then engage our part suppliers to resolve. This will often involve last minute travel across the UK and Europe to visit our suppliers' manufacturing facilities to understand how we can fix these problems.

At the moment this area of the quality function is very reactive. One of the things we have agreed going forward is to expand this team by 40% to have a split role – teams dedicated to reactive problem solving like today, and more importantly a team dedicated to pro-active work to break the fire-fighting cycle for the future. Our intention is to have engineers dedicated to supplier development and supplier preparation activities. These teams will work to ensure we get improved long-term supplier performance and that for new models and new parts we have clear agreed standards, capable processes and good quality parts in advance of start of production.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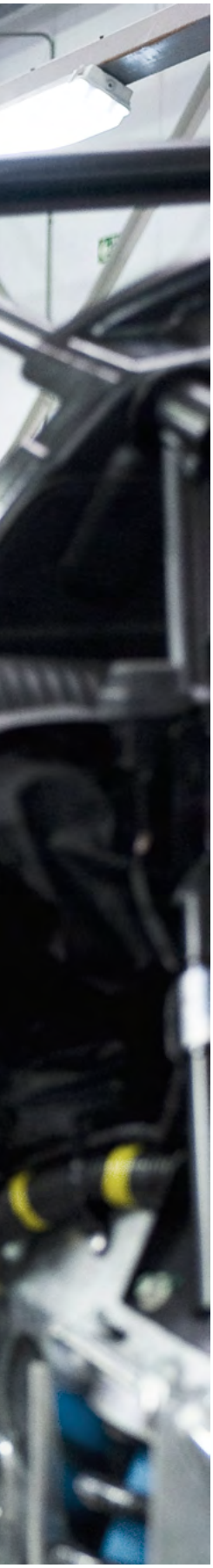


In terms of readying a vehicle for production from the prototype stage, can you describe how that process works to ensure that quality in series production is not compromised and that quality is built in?

In terms of new model development and launch we have made several changes to ensure the quality is right before we release the product to market, as was demonstrated with the Exige S model in 2012.

The most important step taken was to ensure clear concise communication of product status and manufacturing readiness between the project team and senior management. To realise this we implemented a formal 'handshake' review prior to each prototype stage to ensure all of the key elements were in place and all stakeholders agree to proceed with vehicle build.

It was these reviews that drove the right behaviour within the Lotus team to stop with Exige S and address some of the technical and process challenges we faced prior to pushing the car into the market. This was a very difficult decision for all of us given our belief in the product and the desire within the market. But escalating the issues to senior management, on a daily basis in the latter stages, ensured that the right decisions were made and that the product was the best it could be before we were happy to start shipping the first cars out to expectant customers.

From a product quality perspective we also set clear targets for key vehicle performance attributes applicable to the end customer. We then measure these at each prototype build and where we have a gap to target we develop action plans to close. At the series production phase we don't release the cars to market until all of these targets are achieved and quality have signed off the functional and aesthetic performance of the new model. To deliver this we have put in place a dedicated team of quality engineers to work on new model development to drive quality into the design and development process going forwards.

The next step for this team is to focus on failure mode avoidance (FMA), ensuring we prevent recurrence of previous issues on new models and removing potential new failures during the design phase. Through these actions, I am confident the new cars we build in the future will be of an even higher quality than those we are making today.

As we all know, human beings make mistakes. How far is manufacturing automation progressing at Lotus and what impact will that have on future quality levels?

In all honesty the Lotus manufacturing process we use today does not really feature much in the way of automation. The nature of our build process and our low volumes means the return on investment for automated lines or robotic assembly just doesn't add up.

Currently we have no plans to significantly change our manufacturing strategy and our medium-term investment is being targeted towards new model development rather than purely on facility investment for current models.

From the customer perspective (the customer experience) how are expectations in the area of quality 'managed'?

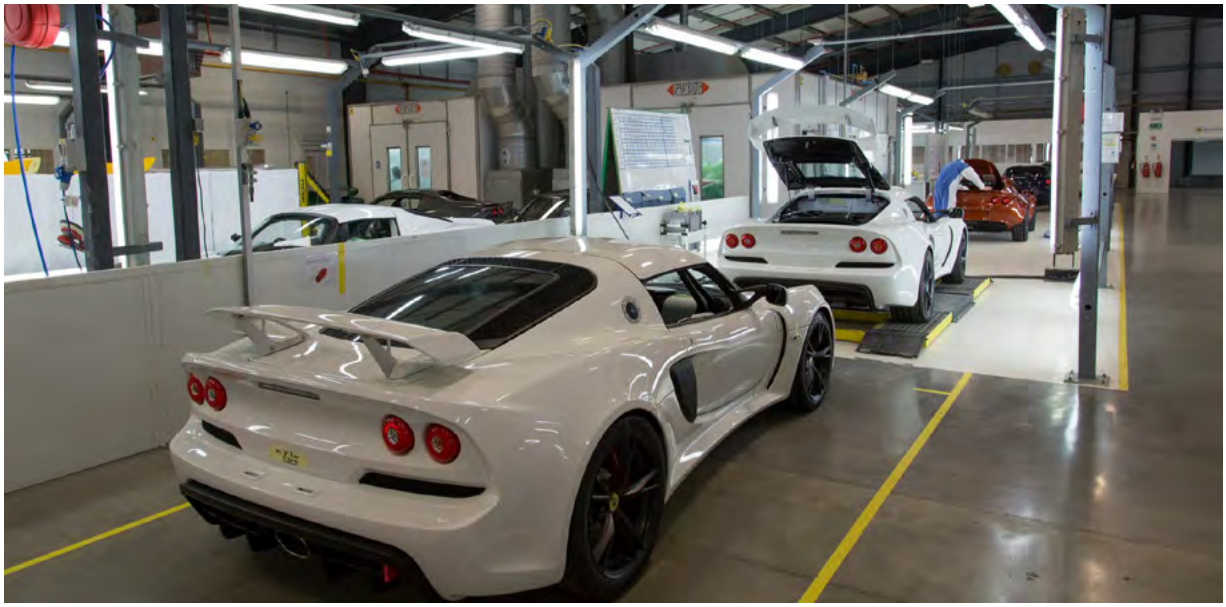
Our inputs from a customer perspective mainly come though the aftersales operations team based in Norwich. We have a small team within our aftersales and service support function who provide a contact and technical support function for both dealers and customers alike.

The issues they escalate from the 'field' are fed into a dedicated quality team at Lotus who do an up-front investigation, allocating them to team members within Lotus to resolve.

This team runs regular reviews to follow the problem resolution process which is reported weekly to Senior Management.

This regular forum is the driver to get the right resources in place to tackle issues affecting our customers and dealers. Since its inception in Summer 2012 this weekly quality management committee has already closed 46 real customer concerns across our three model lines.

We are also looking to gain more direct feedback ourselves from the field in terms of two separate activities for 2013. Firstly, we are going to pilot a postal customer survey. This will enable us to get real feedback on our products, not just in terms of hard faults, but also the usage and perception of our customers.



This information will then be analysed by the quality department and fed into both current and future models to drive improvements in customer satisfaction. Our second initiative is to work closer with our aftersales operations team and dealer network through regular Lotus-dealer reviews. This will get us closer to our partners and understand their issues, the feedback they get from customers and also allow us to share with them the actions we taking within the factory to make improvements.

Can you give an indication of where Lotus is today, quality-wise, and where you would like Lotus to be in the future? Are there targets to aim at?

I am very pleased with the progress we have made within Lotus over the past 12-18 months. I believe that in terms of functional performance and reliability we have made significant improvements in a number of areas for our current models.

The support of our new owners in particular and their recognition of the importance of quality for a brand like Lotus have helped immensely in making these changes possible. Their continued commitment in terms of resources today and for the future is a welcome platform for us to build upon.

As we look to develop future models we have to acknowledge that our quality in terms of aesthetics, function and usability is competitive in all areas and that we match the current accepted industry norms.

I believe we can achieve this and maintain the driving purity that makes our brand unique, and success for me would be to see more customers stepping out of competitor products into ours without having to feel that they are making too many compromises to do so.

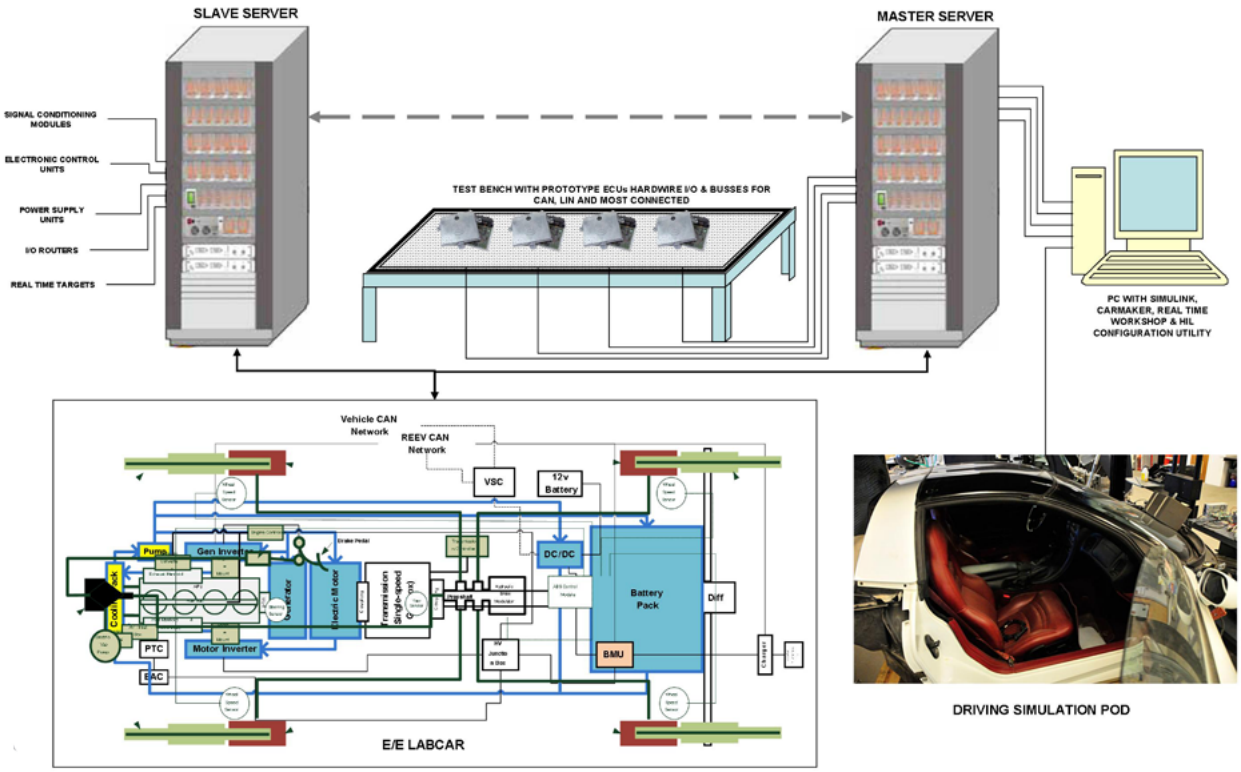
From an automotive business perspective our quality by any measure is competitive and the processes we are now using or implementing are all industry best practice. The combined experience within my team from both Lotus and other companies from which they have joined are a strong asset for us.

I am pleased with the progress we have made internally in improving our performance and our focus now is to work with our supply chain to deliver similar improvements in process and performance for the materials we buy to assemble our vehicles.

I would be the first to acknowledge there is still much to do at Lotus but the journey we have started on is an exciting one and we will all be proud to continue improving our current models at the same pace cars and to deliver exciting future new models with even higher levels of customer satisfaction.

Writer: David Leggett

△ Editor - just-auto.com



In the Loop

Developing and validating hardware and software

Over the years, electronic control units (ECUs) have proliferated in the automotive world and modern day vehicles may have up to 90 or more individual ECUs, controlling everything from engines to interior lights. Due to this, new ways of developing and validating hardware and software have been developed and are known as 'in-the-loop' testing.

Model in the loop (MiL)

MiL is where a mathematical model of a physical system or systems can be tested in the virtual world. Here, the control strategies can be written, developed and validated but the main aspect to MiL is that the algorithms can be quickly modified or updated to validate the outputs.

Software in the loop (SiL)

The next stage is to test how different system models interact with each other, using control algorithms. This stage is called software in the loop. SiL can be used to develop real-time software models of control algorithms by taking the 'rough' coding from the MiL and developing, validating and implementing the 'real' or production-intent coding that will be used in the vehicle controllers.

At this point, any changes to the control algorithms cannot be implemented as quickly as in MiL due to how the production intent coding works.

Hardware in the loop (HiL)

HiL is a technique used for the testing and development of real-time sophisticated electronic control systems. It is based on taking the SiL coding and using plant models of systems in a simulation environment.

HiL allows test and development of hardware such as an electronic controller connected to equipment that mimics the rest of the vehicle, fooling the ECU into thinking it is actually controlling the vehicle or systems that would be on the vehicle.

Conventional engine control development

A set of control algorithms is either developed from scratch or carry over algorithms are used. These are coded in C or Simulink and can then be loaded into a production or development controller.

Engine dynamometer testing can be done using the controller and base-level calibrations can be performed. The next stage is to install the engine into a vehicle and perform open loop testing on a rolling road.

Calibration refinements can be made to the control algorithms culminating in open and closed loop testing on a test track. In a similar way to suspension tuning, lots of iterations can be tried until it feels right.

Strengths of conventional development

It is a well established process with minimal, if any, investment in facilities required. The testing can start quickly particularly if the vehicle is already running. A 'quick and dirty' approach can be taken if this is appropriate. This won't create a refined solution but will get results fairly quickly.

Weaknesses of conventional development

Only open loop testing is normally conducted on rigs, this has limitations as real life (closed loop) testing can only be done with a vehicle that is representative and reliable.

Testing is limited by time, cost and track availability, therefore only a limited range of combinations or iterations can be tried. Tests for specific responses are not reliably repeatable as there are human factors, road and ambient conditions included.

Safety or failure related issues are difficult or even may be too risky to test. Additionally, it is difficult to test any interactions with other systems in the vehicle.

What is required to address the shortcomings?

The shortcomings of conventional design, development and testing can be addressed by the use of hardware and software that simulates real life driving, analysing how the vehicle systems interact with each other and how the systems are electronically controlled.

Development of objective criteria against which to evaluate the simulations is important so that the boundaries of pass and fail criteria are understood.

The simulation system can facilitate real life closed loop testing when it is linked to a test rig or dynamometer, proving that the process can be demonstrated and create real results.

Simulation of real life driving

Using proprietary software, a dynamic simulation model of the vehicle can be created. To get the most out of the simulation (virtual testing) there needs to be refined models of the systems that are part of the vehicle model but once this is done, the model can be connected to a virtual test driver for closed loop tests and virtual roads for a variety of topology and configurable test manoeuvres.

This means that we have virtual driving testing where any parameters are available as 'measurements'.

Real life driving with controllers

Virtual test driving can be undertaken with a virtual vehicle, with virtual electronic controllers on virtual roads. The vehicle can be developed to a good level on the test bench or laptop.

Algorithms can be validated against aims and targets in a perfect environment i.e. always repeatable with no human errors. At this point it is possible to quickly change algorithms, strategy and calibration.

One aspect of this that cannot be overlooked is the ability to support failure modes effects analysis (FMEA) and safety analysis. This is where the limits in safety can be explored without endangering a real test driver or an expensive prototype vehicle.

This is particularly important for the latest developments in electric drive systems where individual wheels can be driven with individual motors. Many 'what if' scenarios can be played out in virtual testing and faults can be artificially inserted.

Aside from the benefits in testing safely, virtual testing allowed over 3,000 scenarios to be computed and run through in 24 hours, showing that significant development time can be taken out of a programme if real vehicle testing can be supplemented or replaced with virtual testing.

Real life testing on the rig

Moving on from SiL, now we have a model simulating the vehicle in real time so instead of emulating the electronic controller and its software we can exercise the real hardware as if it was in a real vehicle.

Inputs to the controller come from signals generated within the plant model and drive signals from the controller interpreted as inputs to the model. This is virtual test driving the controller hardware and can be used to validate that the control algorithms, implementation and hardware meet the design criteria.

HiL is not just for the controller

The HiL boundary can be drawn anywhere and other pieces of hardware could replace its modelled (SiL) counterpart. For example, as well as a physical controller, a physical electric drive motor could replace the virtual one, a real engine, a real battery pack etc.

Another aspect would be that the controller may still exist in software but it is controlling a piece of hardware like a steering gear or brake system mounted to the rig. An engine could be on a dynamometer and run as if it is in a real vehicle.

Ultimately, a whole vehicle could be in the emissions lab and do virtual test drives under open or closed loop control as if it was driving different emissions routes. An electric vehicle, or just its motor and battery could drive different routes, with or without traffic, to test its range with different energy management strategies.

Additionally, HiL provides a platform to bench test multiple network communication systems alongside multiple ECUs and this is the industry standard of proving whole vehicle systems.

At a practical level, there is the potential to decrease the number of expensive prototypes that form part of a vehicle test and validation programme.

Summary of benefits of using HiL

Integration of electrical systems is at the core of HiL and it can provide a quicker means to development and validation compared with the traditional design-build-test methodology.

Fault and safety analysis can be conducted in a manner that doesn't put personnel or expensive prototypes at risk. Controllers that are not yet available can be emulated and when controllers are available, they can be tested and networks proven before they are assembled into the vehicle.

Complex system interactions can be developed and tested with automated execution, analysis and documentation. Tests are repeatable and can be done before a vehicle is built.

More rigorous and varied testing can be conducted on a 24/7 basis and this simulation and testing can be used to homologate type variants rather than building and testing actual vehicles.

Writer: Phil Barker

△ Chief Engineer H&EV - Lotus Engineering

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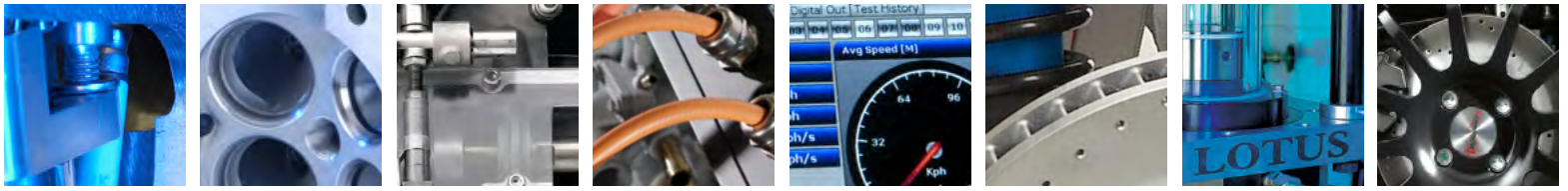

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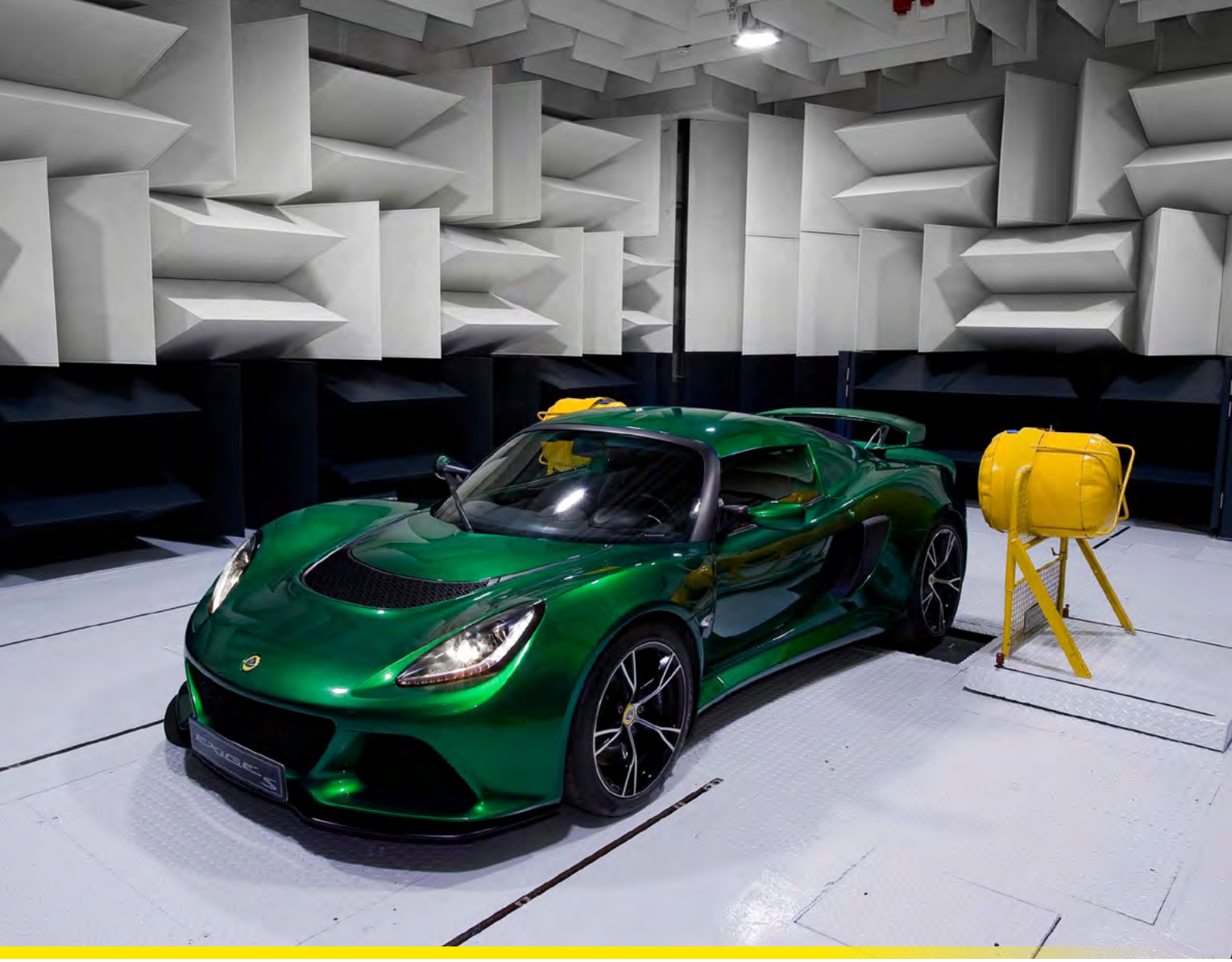

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