



magazine ISSUE 44 SPRING 2012

INTERVIEW WITH JAMES ALLISON TECHNICAL DIRECTOR LOTUS F1 TEAM

CHASING THE WORLD CAR

CARBON NEUTRAL FUELS

LOTUS NEWS - INDUSTRY NEWS - INDUSTRY INTERVIEW WITH LORD DRAYSON - 10 YEARS OF LOTUS ENGINEERING IN AMERICA



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NOT FOR THE FAINT **HEARTED** THE NEW EXIGE S



Raw performance, mind blowing agility and unparalleled ride and handling, these attributes are what people have come to expect from Lotus. And we don't like to disappoint. Presenting the extraordinary new Exige S with its supercharged 345 hp V6 engine. The ultimate lightweight high performance sports car.

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Official fuel consumption, Lotus Exige S in mpg (l/100km): Urban 19.5 (14.5), Extra Urban 37.2 (7.6), Combined 28.0 (10.1). CO_2 emissions: 236 g/km.

The Geneva Motorshow is regarded as the hottest - in both senses of the word - of all the European motorshows and this year proved somewhat of a hot event for Lotus Engineering

Motorshows, apart from being glamourous showcases for OEM's to show off their latest products and technologies, are also important forums for Engineering Services Providers (ESP's) to meet clients.

At the centre of the Group Lotus stand was Lotus Engineering's Evora 414E Hybrid, developed via the REEVolution Consortium, a collaborative R&D project funded by the Technology Strategy Board. The consortium, is made up of three suppliers: Axeon Technologies Ltd, EVO Electric Ltd and Xtrac Ltd; and three OEMs: Jaguar Land Rover, Nissan Motors for the Infiniti brand and Lotus. The project's aim is to create three new demonstrator vehicles to showcase innovative new technologies in the fields of high performance Range Extended Electric Vehicles (REEV) and Plug-in Hybrids Electric Vehicles (PHEV) - two of which were shown in Geneva.

The other was Nissan's Infiniti Emerg-e - unveiled at this years Geneva motorshow. Under the skin of this stunning concept is essentially a Lotus Evora 414E, including the innovative Lotus/Fagor Ederlan three cylinder Range Extender engine/ generator.

We understand Nissan Infinity are delighted with the feedback and media reports of both the design and what is under the skin of the Emerg-e. One main aim of the development work on the 414E, is the creation of VEPS (Variable Electric Powertrain System), an agnostic flexible hybrid control system that can accommodate any electric motor, battery and engine of any type or size from any supplier. Making it suitable across the full range of light duty vehicles from small City cars to large Premium or Sports cars and Light commercial vehicles. The advantage of the VEPS architecture is that it offers a shorter development time for new vehicles or new derivatives for OEMs and economies of scale from common hardware, software, algorithms and control strategies when used across several vehicles.

Our Efficient Performance teams continue to work on a number of advanced projects including an advanced engine downsizing project, codenamed Ultra Boost which is a UK Technology Strategy Board-funded project intended to demonstrate drive cycle fuel economy improvements of 35% in a small pressure-charged 4-cylinder engine with equivalent performance to a naturally-aspirated larger 5.0Lt V8 engine.

We are now entering the show season and following on from Geneva, we will be on show at EVS26 in Los Angeles where taking centre stage will be the 414E and the latest Range Extender engines. Next is the Dynamics Expo / Engine Expo event in Stuttgart, on show will be the 414E cutaway, Range Extender engines, Sabre engine, a new electronic damper system and the Lotus Exige 270E Tri-fuel. We then go straight to the Goodwood Festival of Speed where Lotus are the key sponsor. aAll this activity is intended to build upon the 120 client projects that we currently

have on the go globally and the 200 projects in the "pipeline" at the proposal stage. The value of this pipeline work has risen from \pounds 80 million to \pounds 400 million - a 5 fold increase - in recent months. Whilst this is good news for Lotus Engineering, it's also an indicator that the automotive sector is still showing strong evidence of growth. The outlook for the rest of this year looks positive for automotive engineering.

3



Mark James

Mark James Director of Lotus Engineering







CARBON NEUTRAL FUELS Transition towards a sustainable energy supply



32-41

INDUSTRY INTERVIEW

just-auto editor Dave Leggett interviews Lord Drayson of Drayson Racing Technologies



LOTUS ENGINEERING INC. Celebrating 10 years in America

Contents Issue 43

ULTRA BOOST FOR ECONOMY
High-technology spark-ignition engine

42-44

45

EVORA 414E AND INFINITI EMERG-E Combined stars at Geneva 2012



INSIDE LOTUS JAMES ALLISON

just-auto editor Dave Leggett interviews Lotus FI Team Technical Director James Allison

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The Lotus International Rally team is set to make its race debut in the FIA European Rally Championship. In partnership with Italian team United Business, who won the title last year, the hotly anticipated Exige R-GT will be painted in Lotus' iconic black and gold colour scheme.

Ten cars will be built this year, with seven cars allocated to the official team and European racing drivers.

Lotus Motorsport re-brands to become Lotus Racing

As part of the re-branding of our racing platforms, Lotus Motorsport has been re-named Lotus Racing As Lotus is involved in an extensive and diverse range of racing activities, with racing ingrained within its DNA, the racing mantra has been adopted to re-emphasise our racing connections and to support our Brand communication as an innovative, creative, competitive brand with racing at its

heart.

Lotus' racing foundations are built on decades of competition, a pioneering attitude and will to win. In the 1970's the iconic Black and Gold liveries adorned Lotus FI cars of the era and took two FI drivers' and three constructors' titles.

Today that iconic livery has been reinvigorated and reintroduced as the livery for Lotus Racing and in most cases, the livery for Official

Lotus Racing Partner Teams.

In 2012 this infamous and largely successful colour scheme will adorn Lotus race cars in FI, GP2, GP3, Indycar, WEC, ELMS, ALMS, Rallying and Karting Championships.

By harmonising our activities under one identity, we will be best placed to provide a strong, coherent communication platform to increase the brands equity, drive further awareness and stimulate sales.



Claudio Berro, Director of Lotus Racing, started his career rallying and is thrilled to be back.

"Lotus, of course, has been successful in rallying before, winning the 1981 World Rally Championship with the Talbot Sunbeam Lotus. So in many ways we're all going back to our roots. Partnering with the United Business Rally Team

Lotus Racing

Set for tarmac and grassroots

in the FIA European Rally Championship makes perfect sense because they, like us, know how to win. I think this is going to be a very strong collaboration. The championship largely takes place on tarmac, which suits us too. It's so exciting to go rallying with this new project. It's another big challenge for Lotus."

Pier Liberali, Owner and President of United Business, commented:

"This partnership agreement with Lotus Racing fills me with pride. Lotus is one of the most famous manufacturers worldwide in the motorsports field. It is an honour for us to be able to work with them, and we will do our utmost to exceed their expectations."

Karting

The Lotus Racing Karts team is flat-out in preparation for the 2012 CIK-FIA Under-18 Karting World Championship.

The championship, which starts on July 8 in Braga, Portugal, aims to promote drivers aged 15-18 and rigorously limit the costs involved, such as with the free allocation of tyres and engines to all participants. The series promises to refocus the pure sport of karting not as a spending competition, which has seen costs rise drastically across most other international championships, but as the de-facto school for tomorrow's grand prix superstars.

Just like the greats, from Jim Clark through to Kimi Raikkonen, aspiring youngsters now have the opportunity to become Lotus factory-supported drivers.

Built in Italy, the Lotus Racing Kart is arguably the most fun, raw and inspirational Lotus ever to hit the race track. The focus is on quality, speed, reliability and versatility through its automated robot welding technology of the C30 and C32 chassis, and on developing the next generation of Lotus racers early.

The top three drivers to race Lotus Racing Karts will be richly rewarded: A fully-sponsored Formula Monza test with the Lotus Formula Juniors team and a go in Lotus' F1-inspired Type 125 customer car, plus a two-day test with the Lotus Racing Karts team and a tour of the Group Lotus factory and facilities in Hethel, England.



GT Racing

Lotus is to enter an official team in this year's European Le Mans Series. The black and gold-coloured Evora GTE will compete in the GTE Pro class with factory driver Johnny Mowlem at the wheel. The two other drivers that will

comprise this one-car team will be announced shortly. Lotus Giudici Racing is run by former professional touring car driver turned GT racer Gianni Giudici, who ran an Evora GT4 in the European Blancpain Series last year and finished runner-up.

Testing kicks off at Lotus' Hethel track, followed by six hour endurance races at Le Castellet (France), Zolder (Belgium), Donington (UK), Brno (Czech Republic) and Portimao (Portugal).

Director of Lotus Racing, Claudio Berro, is pleased to have GTE programmes on both sides of the Atlantic:

"Having already announced our American Le Mans Series team, Lotus-AJR, it's great to now announce our entry in the European Le Mans Series. Last year marked the Evora GTE's first year of competition. It was a foundation year, which proved promising, and by now splitting programmes between these two prestigious series I hope we'll be able to further hone the GTE into a title contender. Gianni Giudici has long been one of Lotus Racing's most important customers, and creating this official partnership makes perfect sense. He has been very successful in endurance racing, and has the capability to run the car at a very high level. With Lotus' technical support this will be a good combination for the European platform."

David Hewitt, Operations Director for Group Lotus, joins a list of captains of industry to promote manufacturing in the UK

The Make It In Great Britain campaign calls upon individuals, businesses and media to get behind British manufacturing and challenge the misconception that "Britain doesn't build anything anymore" – an outdated view that restricts investment, finance and recruitment to one of the country's most vital sectors.

Business Minister Mark Prisk said, "The outdated perception of the

manufacturing industry does not match the reality of today. Make It In Great Britain is all about encouraging support for the sector, dispelling myths and encouraging greater interest in industry by young people and investors.

David Hewitt has a wealth of experience and knowledge of the modern manufacturing environment, making him best placed to spread the good news we have to tell. That is why I want industry champions like David to generate excitement and interest amongst our young people and future workforce".

David Hewitt joins 29 other experienced executives, from some of Britain's most successful and reputable companies, in promoting the government-backed campaign. Group Lotus is one of just five automotive enterprises represented, the others being the Williams FI Team, Jaguar Land Rover, Ford and Nissan.

Group Lotus is at the forefront of Britain's high-tech and automotive engineering industries. Since the first Lotus car was built in 1948, the Lotus brand has been synonymous with innovation, style, and success on and off the race track. With five exciting new models in the pipeline and £509 million pounds planned investment at its factory in Hethel, Norfolk, over the next five years, Lotus is a proud British company





9

with a strong future. "Britain is a nation of innovators," explains David Hewitt. "Just look at all the brilliant products and inventions that have originated right here in the UK." Lotus is a great British company with a rightful place among the very best our country offers in both manufacturing and engineering," Hewitt continues. "I want to show that British

manufacturing can be an exciting, challenging and rewarding place to be."



Lotus to Star at 2012 Goodwood Festival of Speed

As well as firing up some of the most exciting classic and current Lotus models, Group Lotus is preparing a dramatic sculpture that will become a centrepiece of Goodwood House's stately grounds during the June 28 to July 1 festival.

Goodwood and Lotus have a lot in common: Passionate about the past and the future, for petrolheads they represent the very best of British. The shared philosophies of speed, emotion, style, competitive spirit and enjoying the good times are all here.

42 historic Lotuses will blast up the hallowed hill climb, while the Lotus FI Team looks to break the course record with this year's grand prix challenger, the black-and-gold E20.

The cars and enthusiasts will be joined by famous faces and Lotus legends from every era.

Lotus remains committed to the motorsport world, with activities at

every level in Formula One, IndyCar, GTs, endurance racing and rallying. Racing is core to Lotus' DNA, and with seven F1 constructors' titles, six drivers' crowns and a World Rally Championship to its name, few marques can boast such a successful and multi-skilled heritage.

Group Lotus CEO Dany Bahar is proud that the marque will be centre-stage this summer.

"The Goodwood Festival of Speed is such an iconic event, for me it completely captures the spirit and passion of British motorsport. We're always made to feel very welcome by all the fans and the organizers, it's a home from home for us and I'm delighted that we have such a strong presence at the event this year."

Organizer Lord March is thrilled that Lotus will have such a significant presence at Goodwood.

"Lotus is without a doubt one of the greatest, most evocative motoring and motor racing brands Britain has produced and we are very happy the company will be our featured marque this year. Lotus' beautiful, innovative, joyful cars and some of the heroes that made them famous will be out in force, not sitting silently but driven hard for the purpose they were born. It's going to be a wonderful automotive celebration."

Coachmakers Award 2012





MORE LOTUS THAN EVER

Raw performance, mind blowing agility and unparalleled ride and handling, these attributes are what people have come to expect from Lotus. And we don't like to disappoint. Just check out the new 345 HP supercharged V6 Exige S.

For an exhilarating and lively drive experience, adrenalin hungry sports car aficionados need look no further.

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



Official fuel consumption for the Lotus range in mpg (l/100km): Urban 19.5-34.0 (14.5-8.3), Extra Urban 37.2-56.0 (7.6-5.0), Combined 28.0-45.0 (10.1-6.3). CO_2 emissions: 236-149 g/km.

LOTUS NEWS

11

Of all the awards that Lotus has won over the years, the one presented by Worshipful Company of Coachmakers and Coach Harness Makers recently is not only one of the more prestigious accolades but also of the more unusual. Every year, this Livery company holds an awards dinner, where the annual award is made for 'outstanding contributions to technological advancement in transport, also involving elegance and commercial significance'.

This year, the award, a silver trophy, was presented to Mark James, Director of Lotus Engineering on behalf of Group Lotus plc for the Lotus Range Extender Engines.

The Worshipful Company of Coachmakers and Coach Harness Makers of London is one of the older City of London Livery companies, dating back to 1677 and is now associated with the aerospace and automotive transport industries.



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Lotus Exige S Roadster

Unveiled at Geneva 2012, the Lotus Exige S Roadster combines its coupé twin's mesmerizing grunt and handling with an open air experience that makes the driver feel all the more at one with the road.

It's the first time an Exige model has been offered with a factoryfitted soft top roof, one which is typically lightweight and easy to put up and take down.

In true Lotus fashion the finely tuned suspension delivers a responsive ride and sublimely agile handling, whilst the supercharged 3.5 V6 engine with race-derived technologies delivers stunning performance. Reaching 100 kph from standing in a neck-snapping 4 seconds (0-60 mph in 3.8 seconds) and 0-160 kph (0-100 mph) in 8.5 seconds this little roadster packs a punch both on and off the track. The top speed for the Exige S Roadster is 233 kph (145 mph) and it produces just 236 g of CO_2 per km.

With a targeted weight of just under 1100 kg, this is one of the lightest six-cylinder roadsters on the market by some margin.

Outside, it's a fine balance of beauty and the beast. The drop-top adds extrovert style to the Exige's already muscular contours, at the same time it is an elegant machine that keeps its clenched fist under wraps.

The Roadster comes with a six-speed manual gearbox, but will also be available with Lotus' Serial Precision Shift (SPS), a paddleoperated automated manual transmission, which makes life more relaxed in the city and more F1-like when it's let off the leash. The SPS gearbox means the driver never has to take their hands off the wheel, it prevents errors during shifting, and it is lighter and more compact than a normal torque-converter transmission. The car comes with two different suspension settings. There's the standard setting for an active driving experience suited to public roads; and an optional setting as part of the Race Pack for maximum performance, developed for track use. The launch control system can be activated when the car is in Race mode.

Inside, the car is a lesson in stylish minimalism and functionality.

The customer can specify a comfort enhanced plush interior or go for a more stripped down, sporty option.

The car has been developed for the main markets such as Europe and Asia. The Exige S Roadster will not be available to the US market.

Lotus F1 Team Evora GTE

Lotus Formula One racing driver Kimi Raikkonen introduced a very special version of the Evora GTE

The Lotus FI Team Evora GTE is about as exclusive as a sports car can get. Kimi returned to Formula One with Lotus in 2012 and what better way to celebrate the return of the former world champion than by creating a special FI edition? Unique FI and Kimi-inspired touches include: An unpainted high-gloss carbon-fibre body, carbon interior with copper inlays, goldpiped black leather bucket seats, and Lotus FI Team Limited Edition badging. The GTE, expected is the most powerful Lotus road car ever: 444 horsepower from a 3.5 V6, and with over a 100 kg sheered from the standard Evora it boasts a better power-to-weight ratio.

"If the Lotus F1 Team Evora GTE is as quick as it looks then it is going to be absolutely incredible. I would love to have this as my company car! I like its aggressive shape and the carbon-fibre finish makes it stand out even more, I can't wait to drive it." Kimi Raikkonen

12

GENEVA 2012 NEWS FROM THE MOTORSHOW

13

Industry News



GENEVA: Look, honey, we shrunk the hybrid powertrain

A more compact version of Toyota's Hybrid Synergy Drive system used in larger models, like the Prius and Auris, will make its debut in Toyota Europe's Yaris hybrid due out later this year.

"Extensive R&D work has produced an efficient, full hybrid system for Yaris using a petrol engine and electric motor, that gives a total power output of 99 bhp (74 kW)," Toyota said. The powertrain uses a new 1.5-litre Atkinson cycle petrol engine that weighs 16.5kg less and is 10% more compact than the 1.8-litre unit used in the local Prius and Auris models. Other major components such as the electric motor, power control unit and transaxle were also made lighter and smaller: the size

of the motor has been reduced by 20% and the PCU 12%, compared to those in the Auris, while the transaxle has shed 11kg and is 6% shorter.

The packaging challenge for the B-segment supermini also demanded thought be given to the size and location of the nickelmetal hydride battery pack and the fuel tank, in order to minimise the impact on cabin space for rear seat passengers and the size of the boot. Both are positioned under the rear bench seat, which means the car's loadspace capacity, and rear passenger space, are unaffected, Toyota claimed.

"Yaris hybrid is set to deliver classleading CO₂, NOx and particulates

emissions, together with excellent fuel consumption and low total ownership costs," the automaker added.

Author: Graeme Roberts





GENEVA: Audi A3 first off new platform

The new Audi A3 launched in Geneva is the first car on the Volkswagen Group's new MQB platform. It is going to underpin a vast range of cars, from the next Polo to a replacement Passat - plus various Audi, Skoda and Seat models - over the next few years.

The A3 also introduces a democratisation of Audi's connectivity technology and, in fact, has elements that are a generation ahead of what is possible in the company's flagship A8 saloon at this stage.

The MQB platform is also under VW's second Cross Coupe concept, this time with a diesel-electric powertrain in contrast to the petrolelectric version revealed at the Tokyo show three months ago.

MQB, translated from German, stands for Modular Transverse Matrix, and it standardises many vehicle component parameters while making new technologies

possible. It makes features from luxury cars affordable in those at less than half the price as well as making it easier to mount alternative drivetrains in exactly the same way as internal combustion engines and transmissions.

Without MQB, Volkswagen "That promise is based on the MQB "It even makes it possible to The A3 is the first car to reap the

chairman Martin Winterkorn's pledge to oversee a 30% reduction in the CO₂ emissions of VW Group vehicles in the next few years, which will see the average VW's emissions cut to under 120g/km by 2015, would be impossible to achieve. platform," said VW head of vehicle concepts Christian Strube. produce different models for different markets in one factory." benefits. It will go on sale in the UK in September with three reworked engines producing CO_2 emissions

from 99 g/km, partly thanks to a

reduction in weight of up to 80 kg compared with the previous model.

But it is perhaps the car's connectivity features that Audi is most proud of. It will be available with an A3-specific Bang & Olufsen audio system with navigation, mobile phone preparation with online services and real-time traffic information.

Author: Chris Wright



GENEVA: The mysterious case of the missing Ford B-pillars

There are two inescapable topics of conversation with the B-Max, Ford's new lofty compact car. The first is the doors, or rather the absence of a supporting central pillar between those at the front and the sliding affairs at the rear.

The second is that it marks the introduction of Sync, the company's connectivity system already fitted to 4m American cars, to Europe.

The B-Max dispenses with traditional B-pillars to add body stiffness and act as anchors for the side doors.

"Cars in this segment are limited by the size (length) of the platform and the need to provide good ingress and egress,"

said B-Max chief programme engineer Klaus-Peter Tamm.

"In this segment, the B-pillar is an obstacle, so we had to look at ways to make the [car] on the Fiesta platform without B-pillars". "Coach doors (rear-hinged rear doors) were not what we were looking for because we needed the ability to be able to open them where there are posts, pedestrians or other cars. Sliding doors were always going to be the answer."

Tamm said removing the B-pillars and replacing them with body stiffening in the sills, roof and the doors themselves was the only solution considered but this posed some significant engineering challenges.

"Fortunately we have global teams who have an outstanding relationship, especially those in Europe and the USA. We have been able to give the car the same rigidity as our other small vehicles."

In the process Ford has also developed a new rear axle and powertrains and improvements to the platform that will appear on the next generation Fiesta. "The B-Max will be sold as a premium small car (for which read 'expensive'), which is why it can support Sync," said Tamm. The system gives full integration of mobile phones and portable electronic devices and can also alert emergency services in the event of a breakdown or accident and, with instant traffic messaging, can re-route the car in the event of a traffic jam ahead using the navigation system.

The only thing missing from the suite of features available in America is the voice-activated My Ford Touch because there are still language barriers to be resolved. Although it functions in 22 tongues, its interpretation of English is the American version and it might have trouble with a strong Scottish or Ulster [Northern Ireland] brogue.

Author: Chris Wright

US: Cadillac XTS to have vibrating seat warning

General Motors luxury car unit Cadillac is claiming a US industry first for its XTS luxury sedan, which goes into production this spring, and uses directional tactile sensation – vibrations of the driver's seat bottom – to warn of crash threats while driving and parking.

PSA's Citroen has previously offered a similar warning method in conjunction with a lane departure warning system.

The patented 'Cadillac safety alert seat' generates vibrating pulse patterns on the left and/or right side of the lower bolster to alert the driver of potential dangers, such as drifting from a traffic lane or toward nearby objects while parking. Threats from the front and rear trigger pulses on both sides of the seat.

"It's good to see automakers experimenting with new technology to help communicate to drivers when their driving is about to get them into trouble,"

said Adrian Lund, president of the Insurance Institute for Highway Safety.

"We commend GM for their innovative use of haptic feedback and hope that drivers find it helpful."

The system works in tandem with other visual alerts, and research shows that it can quickly and accurately focus driver attention to the direction of potential dangers.

"It's akin to someone tapping on your shoulder in a crowd to get your attention,"

said, General Motors active safety technical fellow Raymond Kiefer.

"Using the tactile sense to communicate crash threat direction provides an effective and intuitive way to cut through the clutter of visual and auditory sensory information that drivers routinely experience."

The seats are part of driver awareness and driver assist packages, a combination of active safety systems designed to help drivers avoid crashes.

According to Kiefer, GM research shows that the seat may direct driver attention to the location of a crash threat more quickly and accurately than beeping alerts.

"Vibrating alerts also may help drivers who do not hear beeping alerts due to hearing loss or competing noises and may be preferred by drivers and passengers who might be annoyed by beeps and shut crash avoidance features off," he said. "The last thing we want is for drivers to turn off features with safety benefits."

The seat works with a variety of sensors and cameras installed in the car that help intelligently decide when to activate warnings. For example, if a turn signal is on, lane departure warnings are not presented. Safety alert seat vibrations can be selected by the driver, via an in-vehicle menu, to replace the audible beeping alerts used across much of the industry.

The seats also will be connected to the park assist system and rear cross traffic alert system to help make parking in tight spaces easier.

Using exterior cameras, drivers can see the outside of the car along with dynamic parking guides on the eightinch LCD screen, located on the centre instrument panel. As the car backs up, the seat provides a few quick pulses to both sides of the seat when an object is first detected directly behind the car, and then provides repeated pulses when an object is closer.

Meanwhile, the cross traffic alert system looks for approaching cross traffic behind the vehicle that is signaled with either left or right pulses to the driver.

Author: Graeme Roberts





SWITZERLAND: Nissan announces arrival of first DC quick chargers

Nissan said the first of 400 units of its direct current quick charger, which will be installed at key locations across Europe, had arrived on the continent.

The 400 volt DC units allow charging of ChadeMo compliant electric vehicles (EV), including the automaker's Leaf, to 80% capacity in just 30 minutes. The Nissandeveloped unit is CE and TUV certified for all countries in Europe.

The quick chargers allow EV owners to significantly extend their journeys and will be positioned at key transport points such as motorway services, airports and retail parks. Nissan is giving the units away to kick-start the creation of national charging networks, which will give greater mobility to electric vehicle customers.

This project will open a number of zero emission corridors such as the route from Paris to Amsterdam which, when finished, will allow an EV driver to travel between the French capital and the largest city in the Netherlands with ease. These initial routes will be linked by chargers from partner companies who have agreed to sell or manufacture the innovative new system under licence. These commercial partners will be installing thousands of chargers over the next two years, adding to the already radically expanding EV charging network.

The new units are 50% smaller and 50% less expensive (now starting below EUR10,000/ US\$13,091) than previous designs, making them easier and more cost effective to install for commercial operators. The project to create the chargers is part of the automaker's proactive approach to the electric vehicle market, which seeks to make zero emissions motoring accessible

to more European consumers. Nissan sales and marketing chief Paul Willcox said:

"This is a huge first step in the creation of a European quick charge network which will open up electric vehicle ownership to many more people. We are creating an infrastructure which can be used by any ChadeMo-compliant vehicle, not just Nissan Leaf owners. These chargers are also compatible with our alliance partner Renault's AC 43 kW fast charging system for future network expansion.

Our approach is to overcome perceived barriers to the ownership of electric vehicles rather than waiting for others to do it for us. We believe this holistic approach is essential for the continuing success of our electric vehicles programme in Europe."

Author: Graeme Roberts

US: Ford uses kenaf plant inside **Escape doors**

Ford is using kenaf, a tropical plant related to cotton and okra plants, to replace oil-based materials in the doors of the new Ford Escape.

The company claims that use of this eco-friendly material is anticipated to offset 300,000 pounds of oil-based resin annually in North America and that kenaf reduces the weight of the door bolsters by 25 percent.

Kenaf is a tropical plant that Ford describes as looking similar to bamboo and is related to cotton.

"Kenaf and the other renewable materials in the Escape have made the vehicle more environmentally friendly and fuel efficient,"

said Laura Sinclair, materials engineer for the Escape.

Kenaf oil is used in cosmetics and kenaf fibre is used as an alternative to wood in the production of paper. The upper leaves and shoots of the plant are edible.

UK/JAPAN: Suzuki forms fuel cell JV with UK company

Suzuki and UK-based Intelligent Energy have formed a joint venture to manufacture fuel cell systems for the Japanese company's next generation of fuel cell vehicles.

The partners will build a GBP100m (US\$158m) plant in Japan to make the UK company's systems.

Intelligent Energy began as a government-funded research programme at Loughborough University in 1988. It has offices in London and California.

The 50-50 joint venture with Suzuki will be called SMILE FC System Corporation and it will develop and manufacture air-cooled fuel cell systems for a number of industries. The joint venture also includes a non-exclusive licence agreement that gives Suzuki

access to Intelligent Energy's fuel cell technology.

JAPAN: New Mazda bumper lighter and guicker to mould

Mazda Motor Corporation, with Japan Polypropylene Corporation, has jointly developed resin material for vehicle parts claimed to maintain the same rigidity as parts made with conventional materials while achieving claimed "significant weight reduction". "Using this material, the parts manufactured are thinner than those using conventional resin, resulting in a significant reduction in the resin required to manufacture parts," Mazda said. "When the material is used for both front and rear bumpers, it contributes to weight reduction of approximately 20%. In the bumper production process, this reduced thickness allows for a shorter cooling period for moulding and, by using computer-aided engineering (CAE) technology, the fluidity of the resin material has also been optimised. As a result, bumper moulding time, previously 60 seconds, has been halved to 30 seconds, leading to major reductions in the amount of energy consumed in the

production process."

JAPAN: Toyota to halve costs on component production

Toyota plans to cut capital spending on parts production by half within four years by standardising component designs.

Executive vice president Shinichi Sasaki said that Toyota is beginning to design parts using a new method under the company's New Global Architecture programme.

local market characteristics, but the design of components not visible will be standardised. Toyota aims to commonise around half of a vehicle's 4,000 to 5,000 components.

Body designs and interiors will reflect

GERMANY: TRW announces first contract for active buckle lifter belt

TRW Automotive Holdings has announced the first production contract for its active buckle lifter (ABL) seat belt technology with 'a major European vehicle manufacturer' for a production start in 2013. The system will be launched on rear seats but is also available for front seats.

ABL simplifies locating and fastening the belt by lifting the buckle into a convenient position once the passenger is seated; helps to reduce seat belt slack in dynamic driving situations; and, by helping to reduce slack in critical driving situations, can contribute to reducing the possibility of out-of-position occupants.

Uwe Class, TRW's senior engineering manager, active restraint systems, said:

"The ABL can help drivers and passengers to fasten their seat belts easier by raising the buckle by up to 70 mm - bringing it to a more convenient location if the buckle is difficult to access, for example due to a larger or higher centre console on the front seats or deep buckle positions on the rear seats. It can also help those with mobility difficulties minimising the twisting or leaning action required to locate the buckle. Once fastened, the buckle then returns to its normal position.

As well as improving driver comfort, the ABL offers support in dynamic driving situations such as hard braking or quickly driven curves. Using data from the onboard active safety sensors, it can retract the buckle which can reduce belt slack around the pelvis and chest. This may help to keep the occupant in the intended, and more controlled seating position."

Carbon neutral fuels

Transition towards a sustainable energy supply

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The rate of transition toward sustainable energy supply for all sectors is constrained not by the resource potential of renewable energy, which is many times current demand, but by the quantity which can be stored. Currently the penetration of renewable energy is limited by its intermittency so that it is necessary to continue to provide baseload power generation and back-up capacity using fossil fuels. By storing off-peak wind or solar energy in the form of carbon-neutral gaseous and liquid energy carriers, the viable proportion of renewable energy in the grid can be increased to 100%. An integrated sustainable energy system is possible, supplying the power, heat, and transport sectors, facilitated by the 'Renewable Power Methane' concept proposed by Sterner et al. Transport plays a central role in such a system and we show here how a contiguous transition process to carbon-neutral vehicles is possible which will provide affordable sustainable mobility.

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Image credit. iMechE.

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CARBON NEUTRAL FUELS TOWARDS A SUSTAINABLE ENERGY SUPPLY

21

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The drivers towards change

Over 90% of road transport uses petroleum oil-based fuels whilst air transport is 100% dependent on such products. The International Energy Agency (IEA) predict that by 2020 the majority of new cars will be sold outside the OECD and that all of the rise in oil demand to 2035 will originate from the transport sector in countries with developing economies. By this time China will become the largest importer of oil (and coal) and the global vehicle fleet will double to 1.7 billion vehicles China and India both have consumption-to-reserves ratios which are similar to the EU and the US. Concerns regarding security of energy supply in the transport sector are thus acute.

The financial implications are huge: at an average oil price of

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\$100/barrel the EU and the US each transfer \$350 billion (every year) outside their borders in order to satiate their thirst for oil. This situation is exacerbated by the on-going reduction in resource diversity. Up to the early 1970s Western investor-owned oil companies controlled - directly or indirectly - almost all of the world's oil production and reserves. In 2006 companies owned or claimed by their national governments controlled 80% of global oil reserves, with a further 14% controlled by Russian companies and joint ventures between Western and national oil companies. Western investor-owned companies controlled only the remaining 6% outright.

Current global production of

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87 million barrels per day (mb/d) in existing fields is declining to the extent that by 2035 a gross capacity increase of 47 mb/d, equal to twice the current total production of the middle-eastern OPEC counties, is required simply to stand still. These considerations of securing future supply should alone suffice to incentivise the development of an integrated sustainable energy system in which transport plays a key role. When combined with the imperative of reducing greenhouse gas emissions, the motivations to seek solutions based on 100% renewable energy are compelling.

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(A) Biomass refining (B) (B) Fuel synthesis (B)

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CARBON NEUTRAL FUELS TOWARDS A SUSTAINABLE ENERGY SUPPLY 23

Fig. 1: Generic schemes for the incorporation of CO2 in fuels

Recycling CO,

Fig. I (b) represents a generic open-cycle process in which CO₂ is captured from the flue gases of industrial plant, e.g. power stations, aluminium plants, or cement factories, and is combined with renewable hydrogen to synthesize fuel. By combining the hydrogen with CO₂ it is chemically liquefied into a high energy density hydrocarbon fuel. Clearly, if the captured CO₂ stems from the combustion of fossil energy resources this approach is not renewable and will still result in an increase in atmospheric CO₂ concentration. Rather than a recycling process it amounts to CO₂ re-use and offers the potential of a notional reduction in emissions of approximately 50%.

Fig. I (c) illustrates a closed-cycle fuel production process in which, ideally, there is no net release of non-renewable CO₂. The hydrogen generation process in both Figs I (b) and I (c) is likely to be via the electrolysis of water and this represents by far the greatest energy input to the process, as shown later. For this reason the fuels produced in this way may be referred to as 'electrofuels' as they are essentially vectors for the storage and distribution of electricity generated from renewable energy. When the feed stocks are water and CO₂ from the atmosphere the fuel production and use cycle is materially closed and therefore sustainable.

Such a cycle offers security of feed stock supply on a par with that of the 'hydrogen economy' since the time scale for mixing of CO₂ in the atmosphere is sufficiently short to ensure a homogeneous distribution. With access to sufficient water and renewable energy, the process has the potential to provide

fuel from indigenous resources. As the oil price escalates the provision of carbon neutral liquid fuels can ultimately be financed by the elimination of the wealth transfer involved in the purchase of oil. The recycling of the CO₂, rather than sequestrating it, after it has been removed from the atmosphere cannot result in any net greenhouse gas (GHG) reduction. Its inclusion in a closed carbon cycle to make transport fuels, however, can potentially have the effect of rendering carbon neutral the fastest growing GHG emissions sector.

Whereas the adoption of battery electric or hydrogen fuel cell vehicles requires paradigm shifts in the costs of the vehicles themselves or their fuel distribution infrastructure, or both, the development of carbonneutral liquid fuels enables a contiguous transition to sustainable transport. Drop-in fuels such as gasoline, diesel, and kerosene can be produced from CO₂ (via CO) and H, via Fischer-Tropsch (FT) synthesis but the simplest and most efficient liquid fuel to make is methanol. Indeed the option to make gasoline is retained even if methanol is produced initially since the former can be made via the Exxon-Mobil methanol-to-gasoline process. In addition to being the simplest fuel to synthesize from CO₂ and water feed stocks, methanol provides much greater biomass feed stock diversity since it can be made from anything which is (or ever was) a plant.

Although ethanol is currently the most familiar alcohol fuel used in the transport sector there is also much experience of methanol and it has been successfully used in largescale fleet trials over a period of 15 years in the 1980s and 1990s. With widespread availability of methanol

to extend the biomass limit of sustainable ethanol, dedicated vehicles with high-compression-ratio engines, optimised to exploit the high octane index and high heat of vaporization of the alcohol fuels would evolve. This would reduce the magnitude of the upstream renewable energy required to make carbon-neutral fuels. Importantly, such engines can still operate on gasoline at lower power output, circumventing range anxiety issues during the evolution of the supply infrastructure.

To aid the transition to electrofuels based on methanol it is possible to make a relatively conventional vehicle operate on any combination of methanol, ethanol, and gasoline with the aid of an alcohol fuel sensor and modified engine management software. A more immediate application for methanol is in blends of up to 3% by volume in European gasoline. Additionally, as described previously in ProActive, it is possible to formulate ternary blends of methanol, ethanol, and gasoline which have the same stoichiometric air-fuel ratio and volumetric energy concentration as any binary ethanolgasoline blend. In the form of E85 substitutes it has been shown that these ternary blends can act as drop-in fuels for flex fuel vehicles (FFVs), (of which there are over 8 million in the U.S. alone) and, in addition to serving as a market pull for methanol synthesized from CO₂, can act to extend the use of the limited amount of ethanol produced as a sustainable biofuel. The ability of synthesized methanol to extend the biomass limit of ethanol prevents biofuels being regarded as a deadend as a future transport energy vector.



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Methanol Synthesis

CO.+3H.=CH.OH+H.O

CO2 + 2H2O Methanol Combustion CH_OH+/3/210,=CO_+2H_O

CO., capture and regeneration

CH₃OH + H₂O



CARBON NEUTRAL FUELS TOWARDS A SUSTAINABLE ENERGY SUPPLY

25



Fig. 2: Schematic representation of a potential energy profile for methanol synthesis, methanol combustion and capture of CO. to from carbonates

Fig. 3. Process energy requirements for synthesis of methanol from atmospheric CO₂ and renewable hydrogen.

The need for large-scale energy storage

The movement towards high levels of renewable energy is encumbered by its intermittent supply. In areas of high wind penetration in the US, prime onshore wind energy is claimed to be cost competitive with coal, with a levelized cost of energy (LCOE) as low as \$45/MWh.The global annual growth rate of over 20% which wind energy has sustained over the part 15 years is likely to stall in the future due to the difficulties of dealing with off-peak generation. Large-scale energy storage solutions are the key to unlocking this problem.

The options are limited by the requirements of scale, as evidenced by the fact that underground pumped storage is being advocated.

One possibility for large-scale energy storage is to use off-peak renewable energy to synthesize chemical energy carriers. Chemical energy storage systems, based on the conversion of renewable energy into a gaseous or liquid energy carrier, enable the stored energy to be either re-used for power generation or transferred to other energy sectors such as transport, where the de-carbonization issue is more problematic, and there is an ever-present demand to supply a high-value energy carrier. In the case of liquid fuels the demand to fuel the vehicles is already in place and is ever present.

Here we propose to extend the scheme of Sterner to include the use of liquid fuels made from renewable energy and re-cycled CO₂. The general approach is to store renewable energy first in hydrogen via the electrolysis of water but then, for an additional small energy penalty, this hydrogen is reacted with CO₂ to form an infrastructure-compatible

hydrocarbon energy carrier. In this way hydrogen is used in the fuel rather than as the fuel. Importantly, if all processes are powered with carbon-free energy and the CO, used to make the fuel is captured directly from the atmosphere, then the combustion of this fuel would result in zero net increase in the atmospheric CO₂ concentration. Methane can be made in this way using surplus renewable energy and fed into the gas grid for storage producing a large buffer with essentially no time limits for storage using existing infrastructure in developed countries. This concept, which integrates the gas and electricity grids, is called Renewable Power Methane by Sterner. The combined existing storage and pipeline capacity of the German natural gas network is about 200 TWhth, enough to satisfy consumption for several months, compared with the existing pumped

TWhth in the power grid. Energy-dense liquid fuels can also be synthesized by this approach, resulting in an energy carrier which is easy to store, distribute, and utilize in other sectors. In the form of liquid hydrocarbon fuels they can be used in the transport sector and can supplement or extend the use of biofuels. They also have the potential to completely replace fossil-fuels since they are not feedstock-limited. Methanol, with its H/C ratio of 4, is particularly well suited to this task, being the simplest organic hydrogen carrier which is liquid at normal ambient conditions. Gasoline, diesel, and kerosene can also be synthesized as drop-in fuels at a higher energy penalty and using more complex plant than that required for methanol production.

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hydro storage capacity of 0.04

The concept of synthesizing fuel from feed stocks of CO, and water was first proposed in the 1970s by Steinberg and there have been many other proposals in the meantime. Three broad generic schemes for incorporating CO₂ into fuels can be envisaged as shown in Fig. I(a)-(c).

The most familiar manifestation of renewable liquid fuels is in the form of biofuels, depicted in Fig. I (a). Biofuels recycle CO₂ by extracting it from the atmosphere as part of the photosynthesis process which forms plants, algae, or cyanobacteria. The feed stocks are CO₂ and H₂O which are combined using chlorophyll to absorb the energy in sunlight and transform it into chemical energy in the form of carbohydrates in the resulting biomass material.





CARBON NEUTRAL FUELS TOWARDS A SUSTAINABLE ENERGY SUPPLY

27

Fuel synthesis

Fig. 2 shows a schematic representation of the various chemical reactions and processes involving CO_2 , hydrogen, oxygen, methanol, and carbonates. CO_2 is, with water, the end product of any combustion process involving materials containing carbon and hydrogen. Further reactions to form carbonates are exothermic processes. The capture of CO_2 in inorganic carbonates and other media is a burgeoning area of research.

Once hydrogen and CO_2 are available the simplest and most direct route to producing a high quality liquid fuel is the catalytic hydrogenation of CO₂ to methanol via the reaction in figure 3 which shows that, in producing methanol via the direct hydrogenation of CO_2 , by far the largest component of the process energy requirement is the hydrogen production. This is true of any electrofuel using hydrogen as an intermediate or final energy carrier. An 80% electrolyser efficiency has been assumed together with a nominal CO₂ extraction energy of 250 kJ/mol.CO₂ (representing about a 10% rational thermodynamic efficiency relative to the minimum thermodynamic work requirement). This gives a higher heating value (HHV) 'electricity-to-liquid' efficiency of 46%, including multi-pass synthesis of the methanol and re-compression of the unconverted reactants. It has also been assumed that the heat of

reaction generated in forming the methanol can be used elsewhere in the process, e.g. to offset the distillation energy.

Fig. 4 shows the estimated sensitivity of the process efficiency to the energy requirement for CO. extraction. Almost 15 years ago Specht et al. measured total-process CO₂ capture energy levels of 430 kl/ mol. in a demonstration plant using an electrodialysis process to recover the absorbed CO₂. This represents a rational efficiency of less than 5%. Despite this low CO₂ capture and concentration energy the measured overall fuel production efficiency was 38%. This matches well with the corresponding value given by the simplified analysis shown in Fig. 4.

Without policy intervention the intermittent use of alkaline electrolyzers, due to their limited current densities, is likely to be too expensive to produce fuel under present market economics. Improvements on this technology are at an advanced state of development and other promising technologies are emerging. Graves describes the use of high temperature co-electrolysis of CO, and H₂O giving close to 100% electricity-to-syngas efficiency for use in conventional FT reactors. This ultra-efficient high temperature electrolysis process using solid oxide cells combined with a claimed CO₂ capture energy (from atmospheric air) as low as 50 kl/

mol. leads to a prediction of an electricity-to-liquid efficiency of 70% (HHV basis). With a constant power supply this high overall efficiency enables the production of synthetic gasoline at \$2/gallon (\$0.53/litre) using electricity available at around \$0.03/kWh. Doty states that off-peak wind energy in areas of high wind penetration in the US averaged \$0.0164/kWh in 2009 and the lowest 6 hours of the day averaged \$0.0071/kWh. With more pessimistic values for the cost of CO₂ capture such as the \$1000/ tonne quoted by House et al. the gasoline cost component due to the supply of the carbon feedstock alone might be as high as \$7.5/ gallon (about €1.30/litre). With 20% electrolyser capacity this cost of fuel synthesis could be as high as \$4/gallon at \$0.03/kWh electricity (higher current density electrolysers could reduce this to \$2.2/gallon). For perspective, a cost of \$11.5/gallon is around €2.05/ litre). Currently gasoline retail costs in the EU range from €1.14/litre to €1.67/litre including duties and taxes (which can be as high as €0.6/litre). In a system which based fuel duty and taxation was based on nonrenewable life cycle carbon intensity, a fuel made from air-extracted CO₂ and water might be commercially attractive in the medium term.

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An integrated system

To achieve a fully integrated system based on the use of renewable energy requires largescale storage of an energy carrier which can be readily accessed for power generation. To provide long term energy storage capable of covering the contingency of extreme meteorological events a system based on the integration of the electricity and gas infrastructure would be a key component. Such a system could be based on the synthesis of renewable methane as an energy vector from CO_2 and H₂ (using the Sabatier process) and in many countries could use the capacity of the existing gas network for storage and subsequent re-use in the power generation and heat sectors. The synthesized and stored methane is thus readily retrievable to smooth out the supply of renewable energy. Sterner describes



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 $CO_2 + 3H_2 \rightarrow CH_3OH + H_2O$ $\Delta H_{298}^0 = -49.9 \text{ kJ/(mol. methanol)} (5)$

FIGURE 3: Hydrogenation of CO2

CARBON NEUTRAL FUELS TOWARDS A SUSTAINABLE ENERGY SUPPLY

such a concept in detail and has modelled its operation within a renewable energy system based on wind, solar, and biomass over a period of I week on a I hour resolution based on a winter load demand. The renewable-powerto-methane synthesis efficiency is predicted to be 48% using measured energy values for capture and concentration of CO₂ from air of 430 kJ/mol. giving an overall electricity-to-methane-to-electricity

The production of renewable electricity and renewable methane for power generation back up and use in the heat sector could be integrated with the synthesis of liquid fuels for use directly in transport. A schematic representation of such a system combining the power, heat, and transport sectors is shown in Fig. 5

efficiency of 28%.

(next page) where the renewable liquid fuels are represented by methanol, ethanol (C_2H_5OH) and drop-in hydrocarbon fuels. The production of liquid fuels also offers an energy storage option. The use of stored energy for transport via this route gives a similar efficiency to the 'round-trip' efficiency of producing renewable methane and reconverting it for use in charging electric vehicles but allows the use of significantly cheaper vehicles. Sustainable biomass can also be integrated into this system.

800 900 1000 :O2] Fig. 4. Sensitivity of methanol electrofuel synthesis to energy required for CO_2 extraction and concentration.

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Fig. 5. Integrated sustainable energy system based on carbon-neutral liquid and gaseous fuels. (WH = waste heat.)



Concluding remarks

The production of carbonneutral liquid fuels is proposed as a route to the continued provision of compatible, affordable, and sustainable transport. This approach retains the use of low-cost internal combustion engines and liquid fuel systems. These powertrain systems have high power densities, energy storage densities, and low embedded manufacturing and materials extraction energies. They also have considerable potential for further efficiency improvement, especially using highly boosted small ('downsized') engines exploiting the superior qualities of alcohol fuels.

The replacement of fossil fuels with carbon-neutral liquid fuels would not compromise current levels of mobility and would enable transport to remain globally compatible. Low-carbon number alcohols can be used for personal mobility and light-duty applications, and synthetic hydrocarbons for applications where maximum energy density is crucial. The technology to enable the transition from the current vehicle fleet to equivalentcost vehicles capable of using sustainable methanol has been described. This takes the form of either tri-flex-fuel vehicles capable of running on any combination of gasoline, ethanol, or methanol, or current flex-fuel vehicles which can run on specific pre-blended mixtures of these three fuels. All transport energy can be supplied using biofuels up to the biomass limit, and beyond it using carbonneutral liquid fuels made using renewable energy and CO₂ from the atmosphere. The role of biofuels in this transitional route and end-game prevents them being regarded as a dead-end by vehicle manufacturers. The potential to synthesize methanol from

anthropogenically re-cycled CO₂ and water in large quantities 'rules in' the use of some of the limited amount of truly sustainable biomass as a transport fuel, rather than ruling it out.

In addition to minimizing the environmental impact of the rapid growth of transport-related CO₂ emissions, the use of atmospheric CO₂ and water as feed stocks for renewable energy carriers offers potential freedom from dependency on imported oil and a concomitant reduction in associated financial transfers.

A broader integrated system is proposed here where renewable energy is stored in the form of synthetic methane in the gas grid for supply to the power generation and heat sectors while carbon-neutral methanol and drop-in hydrocarbon fuels are supplied to the high-value transport fuel sector which is difficult to de-carbonize. The liquid fuels also offer an energy storage option, increasing the flexibility of the system. In this scenario both the gaseous energy storage medium and the liquid fuel energy carriers are compatible with existing infrastructures, enabling a soft start to their adoption.

CO, re-cycled from the atmosphere may impose a shortterm cost and energy penalty over flue-gas captured CO₂ but directs the necessarily large investment toward leveraging sustainable resources, avoiding further lock-in to technologies based on 'depletables' with their ever escalating costs. In any case, the well-to-wheel GHG reduction level of approximately 50% for fuels made from fossil fuel flue gas CO₂ is not sufficient to meet long-term EU targets. Making a value-added product such as transport fuel from the extracted

 CO_2 has the potential to accelerate the commercialization of air capture technology and provides a more progressive concept for investors than the sequestration option. The re-cycling of CO₂ from the atmosphere to make fuels does not produce the reduction in CO₂ concentration which is possible from air capture and sequestration. Making a value-added product form the CO_2 may be the most viable way to commercialize direct air capture of CO₂ and, by neutralizing the most rapidly growing emissions sector, may be the most pragmatic route to minimizing the eventual stabilized CO₂ levels.

Authors: Richard Pearson, Jamie Turner and Peter Edwards

31

drayson racing

LOLA

Interview with Lord Drayson

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Drayson Racing Technologies

32

An entrepreneur with more than 25 years combined experience in the successful development of science-based enterprises, Paul Drayson is an engineer trained in the automotive industry. Founded in 2007 by Elspeth and Paul Drayson, for more than four years Drayson Racing Technologies has been devoted to pioneering the development of sustainable green technology in motorsport. just-auto editor Dave Leggett caught up with him to talk about his experiences and current projects.

How did you get interested in motorsport?

I grew up in Kent, very near the Brands Hatch race circuit and as a boy I was taken to the racing with my dad and that's where my interest in motorsport started. My interest in engineering was kindled by that, going to the racing, going into the paddock, the smells, the experience. That got me interested in the cars and in technology and that's stayed with me through my life.

I went to university and studied engineering and started work in the car industry. I have a PhD in robotics and that came about because of my involvement with industrial robots in the car industry. I built a business around some of the technology that I learned with that and then went into pharmaceuticals after selling my first company and subsequently learning about pharmaceuticals from scratch and starting a new business again.

But I am trained as an engineer,

specialising in production engineering and robotics.

And what about the low-carbon, environmentally responsible aspect to your projects? What ignited that interest?

Later in my career, when I worked as a government minister, the whole climate change issue was becoming much more evident as more data came out about things like the melting polar ice-caps. The data was becoming more inescapable in terms of conclusions about the adverse impact of human activity on the world's climate. I was still racing at that time in the British GT Championships with an Aston Martin and we began asking the guestions about how we can make our racing more green and less damaging to the environment. At that stage, in 2006, the way forward seemed to be through the use of bio-fuels and we went down the

route of pioneering the use of second generation bio-ethanol fuel. We raced with that fuel through the British GT Championship in 2007, got a number of pole race wins and narrowly missed winning the championship – we were runners up.

And it was that experience of racing with green technology in 2007 that convinced me – because of the reactions to what we were doing - that motorsport can make a significant contribution to meeting the challenge of climate change. It can do that in two ways. Firstly, by providing a means of accelerating technology development. Motor racing has always been a source of advanced technology development that has then gone on to be used in road cars. And secondly, and even more importantly, it changes public perceptions. The motorsport associations can make green technology cool and exciting. A few



scoffed when we went down the bio-fuel path, but when we started winning with it because it performed so well, it was taken seriously and we found that it was changing people's perceptions about going green and that's been maintained ever since. With electric cars I think perception is a big issue, so racing with electric cars both helps to changes perceptions and helps with the development of the technology.

And high performance electric cars also have a role to play in changing perceptions?

Certainly. When you think about the auto industry historically, premium high-end cars see innovations first and then that trickles down. EVs have been in an unusual position in that the technology has been applied initially in small city cars and that has meant the technology has a certain image. And those cars are in a very competitive and a price sensitive segment. It's pretty important that the industry invests in solving these technology barriers to include developing and producing highperformance EVs. Cars like the Tesla Roadster can make a big difference to perceptions and we need more cars like that to propel the technology and get it employed in more segments of the market.

Was the GT2 bio-ethanol car a difficult project to do?

Yes it was. We had a lot of reliability issues in 2008 when we went racing in the international series. The British championship in 2007 went well. We then worked with Aston Martin Racing on a new GT2 car for the international series and that had reliability issues with the engine, fuel system and so forth. And yes, it was difficult but in the end we got on top of those issues and then in 2009 we stepped up to the highest level of Le Mans style racing with the LMP1 car with Lola, and that was a flex fuel system that could run on second generation bio-ethanol and conventional gasoline fuel.

Are people still interested in second generation bio-fuels having a role in motorsport? Where does that technology stand now?

They are interested in certain countries; in South America and

North America, though not so much in Europe and particularly not in the UK. And that's largely due to government [UK] policies on the repatriation of fuel duty. It looked at one stage like bio-ethanol would become an important part of the energy mix here in Europe but that has tailed off and there is much more interest here now in electric cars and hybrids.

With the bio-ethanol car you developed there was an experimental fuel system that involved carbon capture. Are you still looking at that?

That was an interesting system using material in the exhaust that would react with the carbon in the exhaust gasses and then be retained so that you could reduce the carbon emissions from the car. It worked well on the test bed but when we were running at racing speed the temperatures inside the exhaust meant that we got too much degradation of material. We had to abandon that project in the end because we just couldn't make it work in the racing application, interesting project though it was.

Are there wider applications for that kind of carbon capture?

Well, yes, there is plenty of investment going into carbon capture and storage from coalfired power stations and that's based on the same principles. I don't know of anyone else who has experimented with doing this on a car application. Certainly there is a lot of investment going into the efficiency and cleanliness of the Internal Combustion Engine and real progress has been made on that and that will allow the Internal Combustion Engine to be used for many years yet. But fundamentally, we have got to move to zero emission cars if we are going to

meet our legally binding targets for overall CO, emissions.

Doesn't eking out greater efficiency for the Internal Combustion Engine make it more difficult for alternatives to emerge?

Yes. The Internal Combustion Engine has benefited from decades of investment to improve efficiency in manufacturing and therefore is way down the cost curve. It is very impressive how cost effectively the car industry can manufacture engines. In comparison, there is very little experience in developing the means of manufacturing cheaply electric drives or hybrid systems. They are therefore much more expensive at the moment and that's why governments are active in providing incentives to consumers. But still, they require significant investment. The costs will come down as economies of scale are achieved, as sales rise and as investment in the technology increases, but it's a classic case of a new disruptive technology that is not providing – to the consumer at the moment – as good a value as the established technology. Nonetheless, it is absolutely clear that the legally binding targets on climate change mean that countries need to have a significant proportion of cars on the road producing zero emissions. There is just no way around that and that's why the car industry has got to develop these new technologies and find ways to make the products better and able to be manufactured more efficiently.

"I think that is a very important and fundamental point. Electric car racing encourages the use and development of new technologies which have the ability to change the way things are done and the way things are made." Lord Drayson



35





How is Drayson Racing Technologies (DRT) set up?

It's a small company with half a dozen people designing and building a very high performance electric race car. They designed and built all of the electric powertrain for the B12 [B12/69EV electric-powered LMP racing car] collaboration with Lola. They are currently designing the electric powertrain for the Formula E car for next year's championship.

And what are you mainly busy with at the moment?

Right now we're all very busy with developing a car for the upcoming FIA Formula E – electric - Championship racing series in order to compete as a team. There's a lot of work connected with the regulations also and how it will all work. In Formula E a draft set of regulations has been published that sets out rules under which electric racing cars for Formula E can be built. They specify things like the aerodynamics that are allowed, materials, minimum weight of the car, batteries, power of the motors,

which then allow the engineers to design a car.

How would that be set up in terms of teams?

It would be very similar to a normal type of championship, like in Formula I, Le Mans, or IndyCar in the US, whereby teams would enter cars – which they would develop themselves or buy those cars from manufacturers and the cars would be specifically designed to the new regulations.

Are there many teams interested in competing in such a championship?

Yes there are. The FIA keeps that confidential. I would think there are not just racing teams interested but manufacturers of electric cars who are looking to sponsor teams and get involved in the development of the technology. It's very exciting because we are at the birth of a completely new type of racing, a new racing championship, and you've got a completely new sheet of paper.

Unlike the established

championships, there's a whole new set of decisions to be taken to shape how it looks and operates from the start. A lot of things are being decided for the first time and it is a really interesting opportunity for motorsport engineering companies. And one of the companies we are working with is Lotus Engineering as Lotus has developed interesting sound synthesiser technology for electric cars – and the FIA has asked participants to include sound synthesisers on the cars.

And you are working closely with Lola as well?

Yes. Lola has also been a partner before on the B12 [B12/69EV electric-powered LMP racing car] and we are working with others, too.

But the details of the FIA Formula E bid are confidential?

Yes, that's right. When the FIA are ready they will announce the structure for the new series, which teams are taking part and which technologies employed. As you can imagine, there is quite a range of views on the technologies

that should be used and what the specification of the cars should be. In all types of motor racing different teams have different solutions to the same basic problem: how to go fastest. Some people might, for example, focus on a different type of electric motor or battery technology. Everybody is keen to ensure the rules develop in a way that allows them to compete most effectively.

When can we expect to see Formula E races starting?

I think we are looking at the second half of 2013. The plan is for eight races around the world, city races on city circuits specially set up for this type of racing.

Are there technical aspects to using electric cars in motorsport that make it additionally technically challenging?

Yes, there are. The main challenge is that with an Internal Combustion Engine, you have a fuel that has an incredibly high energy density. Therefore, in a conventional racing car, you are not that worried about energy. You know, for example,

that if you put wings on the car for downforce, that will give you the ability to corner fast. And the fact that those wings increase the drag and therefore the amount of fuel that you have to burn to overcome that drag, you're not too bothered about it, because you have a 70-litre fuel tank and you just turn the power up and burn the fuel to do that. That has actually made us quite wasteful with energy in racing because we are so used to the fact that this liquid contains so much energy and you just fill it up and there it is.

When you go to electricity, storing electrical energy is much more difficult. There is much less of it in the car and you have a 300 kg battery. Every joule of electrical energy that you can store you have to make the most of and you can't waste energy overcoming drag. So you have to have a completely different concept of the way in which you are going to design the car and that goes through everything. For example in aerodynamics you need to use movable aerodynamics - the wings

change shape so that you can make them flat down the straight to reduce drag and put them up for downforce when cornering. And when developing the drivetrain you want to get maximum efficiency in the transmission of electrical energy from the battery through the system to the motors to translate that electrical energy to kinetic energy to propel the car. Getting that efficiency is key. And you are dealing with large amounts of energy due to the speeds you are travelling at - the B12 car has 850 horsepower with four electric motors driving the rear wheels. That means you are generating a lot of heat within the electric motors. The hotter they are the more efficient they will be, but if they run too hot they will fail. Managing heat and the cooling systems for the electric motors is very important. There are two cooling systems - an air one and a water one.

Designing all of that is a bit of a challenge; it is state of the art stuff. There are lots of new things we are having to learn and master for electric car racing. By contrast, for



IC-engine racing we've been doing it for many years.

But that's what makes electric racing exciting for me; it's a completely new field and I want to be a pioneer and a leader in this field.

And I guess the pioneering nature of electric car racing must mean high initial development and set up costs? There again F1 isn't exactly cheap...

Yes, that's true, there are considerable costs in dealing with new technology but it is still considerably cheaper, say, than Formula I. One of the things that the FIA is trying to achieve is that the Formula E series is sustainable – not just from an environmental viewpoint, but financially sustainable, too. They are looking at ways of designing the series so that costs are kept under control and the sport can provide a good return on investment for the investors and everyone involved.

I suppose Formula E would attract sponsors and investors who would not necessarily be interested in conventional motorsports?

That's absolutely right. People who are involved in green-tech

business, people who are involved in green energy – whether the generation of green energy, or things like smart-grid systems, the electrification of transport or other areas, it's a big field. These are all business areas that wouldn't normally consider motor racing as a good marketing platform to communicate what they do. But zero emission electric car racing is an ideal platform for some of them.

And electric car racing will also boost electric car technologies more generally?

Yes, I think that is a very important and fundamental point. Electric car racing encourages the use and development of new technologies which have the ability to change the way things are done and the way things are made. Manufacturing technology is a good example. There are new manufacturing technologies coming through the pipeline that electric car racing can use and I think they will have quite significant spin-off benefits. Because electric racing is new, the rules are more open and the ability to use new technologies is greater – you're not restricted by many years of established ways of doing things

which is the reality in many racing series – like NASCAR, where the rate of change in technology is very slow. Electric racing will be a great platform for new technologies, not just technology on the car, but new ways of making things, new approaches to business and with a focus on sustainability. There will be a revolution in the way things are done.

Obviously you and your company are heavily focused currently on electric car racing, but do you have thoughts on what might be the next big project? Could it be hydrogen fuel cell cars?

Possibly, yes. The revolution in the electric drivetrain is the area that we are really interested in. Hydrogen fuel cells are going to be part of the future. The challenge with hydrogen is not how you use it in the car - there has been plenty of work on fuel cells, stacks, the actual application of the gas. It's a very high energy density gas. The problem is the storage and distribution of the gas. There are some exciting developments taking place. Storing the hydrogen gas in nano particles so that you could store them at ambient temperature and pressure is a really interesting idea. If that

could be commercialised you could be easily pouring your hydrogen into a tank and not having to have highly pressurised solutions and that would hugely accelerate the use of hydrogen as a fuel source for cars.

In terms of the new technologies related to electric cars that you are working on, do the car companies seem interested in those?

Yes. One of the benefits that a company like DRT can provide to the big car companies is the opportunity to try things at an experimental level. We are building a car, testing it, using it and getting real life data. For example, we have valuable knowledge of electric motors, which are a vital part of the electric car's future. All car companies need to know how new generation electric motors perform in tough conditions. It's a way of trying new things.

To take other industries. pharmaceutical for example. About twenty years ago, you had the revolution in genetics and molecular biology. The emerging know-how and expertise was concentrated in small university departments and bio-tech companies. The big pharma companies worked with the small bio-tech companies to understand the new technology and transfer it to them. I see the same kind of thing happening in the car industry.

The car industry has huge investment in existing manufacturing processes which leads to fantastic efficiency and value for money for the consumer with a modern car. It's a huge system that delivers that and it's very capital intensive and slow to change. Finding a way of trying new things in smaller companies is a really important thing. I think you will see the growth of small companies like DRT providing the automotive industry with that kind of specialist knowledge and resource.

You've mentioned climate change, but did your spell in government provide any other particular insights?

Yes. One thing was being able to get an overall perspective on where different countries sit in the global competitive landscape. From that it became clear that the UK, and Europe as a whole, is facing a huge shift in global economic power towards the east in Asia. It is therefore very important for Europe and the UK to invest in those areas of industry and technology where we have a real competitive advantage and the possibility of





INDUSTRY INTERVIEW LORD DRAYSON

achieving growth, exports and new jobs. And we have to be continually creating and inventing to come up with the next big idea and building new companies and new businesses on the back of it. We can't compete on price. Places like China are growing rapidly and industries like automotive are going to focus much more closely on: what does the Chinese consumer want?

The UK has a very strong engineering base. To take motorsport for example, we are clearly the world's leaders in motorsport engineering. And we need to exploit that as an R&D



SPRING 2012 proActive magazine

39

resource for our industry more generally. Some of the advanced engineering things we have learned through motorsport can be applied to clean-tech, to aerospace, marine and other areas.

Given the economic crisis and the need to rebalance the economy, we need to put more emphasis on manufacturing-led growth. This is something that the UK needs to do and that's why I'm investing in it myself. This whole area of clean-tech and electric drivetrains is a classic area where the UK has a lot of expertise, it's a growth market, it's a market where there is real demand for the particular know-how the UK has and we need to make sure that is something we capitalise on.

The relationship between government and business is about there being a clear consensus about the measures that industry needs in a particular sector to ensure that it can compete, grow and attract investment from abroad. I think for example the success of JLR reflects the investment in products they have made at the added value end and with sophisticated engineering, hybrid technology. We are known throughout the world for our premium car brands.

The base we have now is based on the two B's: our brands and our brains. Where companies have developed strong brands that command good prices, combined with continuing to invest in their know-how, their skills, then world class products are the result. We now know, as an economy, that we have to build on our manufacturing base because going down the financial services route is not enough in itself.

Are you still active in politics?

As a backbencher and member of the House of Lords, yes, but not front-line politics. I'm really concentrating on the business side of things these days. What gives you the biggest buzz, being responsible for a green motorsport technology driven company like DRT or getting behind the wheel and racing yourself?

For me now, it's building the company. I was lucky enough to go to Antarctica over Christmas and see for myself the impact of climate change. It's one thing reading the graphs and seeing the data, but when you see it for yourself, it really brings it home to you. I've worked in science and technology all my life and the thing that excites me about DRT is the opportunity to do something that is really important, to accelerate innovation, change people's perceptions and make them believe that it is possible to solve this problem and have fun and a good life as well.

As a politician I learned that you don't get far telling people what they can't do or making them feel guilty. It's much more effective to come up with solutions and say 'look, do it like this and you can have the best of both worlds'. But to do that we have to invest in the technology. The car industry has a responsibility to be part of the solution to climate change, not part of the problem.

Being part of that and making it happen is a really worthwhile thing. What gives me a buzz is when I show my twelve-year-old son the design of the Formula E racing car and he says 'that looks really cool dad, I'd like to be able to drive that'. And that's the next generation; they're the ones that are going to have to live with these problems.

But, hey, I do still love to get behind the wheel. There is nothing more intense than racing and I love it. However, the ability to really make a difference, you can't do that by just racing a car.



Lord Drayson

President of the Motor Industry Association, Lord Drayson is the co-founder and owner of Drayson Racing Technologies (DRT).

An entrepreneur with more than 25 years combined experience in the successful development of sciencebased enterprises, Paul Drayson is an engineer trained in the automotive industry. A graduate of Aston University, Drayson had already built and sold one successful business backed by 3i plc when he met Professor Brian Bellhouse, as well as Drayson's future wife Elspeth at Oxford in 1993.

Over ten years they built PowderJect Pharmaceuticals Plc into one of the UK's most successful biotechnology businesses. The company grew from three to more than 1,000 employees, floated on the London Stock Exchange in 1997 and was the first UK biotech company to achieve profitability in 2002, before its acquisition for £550 million in 2003.

Having chaired the UK's Bio Industry Association for two years, in his political career Drayson focused on policies regarding science and innovation. In 2004 he was appointed a Life Peer and in 2005 Defence Procurement Minister by Prime Minister Tony Blair with responsibility for the UK's Defence Industrial and Technology Strategies.

In 2004 Paul started motor racing. In 2007 he



41

competed in the British GT sportscar championship, racing a unique bio-ethanol fuelled Aston Martin DBRS9, achieving a historic first win for a bio-fuelled race car, and coming second overall in the British championship. In November 2007 he took a leave of absence from the Government to compete in the American Le Mans Series in the United States, a key step towards his goal of racing in the Le Mans 24 Hours endurance race.

Paul returned to the British government in October 2008 as Science Minister with responsibility for the UK's science and innovation policies. During his period in office Paul established the UK Space Agency, the Centre for Defence Enterprise, the Innovation Investment Fund and the Office for LifeSciences.

Since 2009 Paul has competed in the American, European and Asian Le Mans Championships, and driven at Le Mans, Sebring and in the Petit Le Mans endurance races. In 2010 he won outright at Road America, and with his team Drayson Racing came third overall in the inaugural Intercontinental Le Mans Championship, campaigning a unique 225 mph Flex-Fuel Lola-Judd V10 LMP1 racing car.

Founded in 2007 by Elspeth and Paul Drayson, for more than four years Drayson Racing Technologies has been devoted to pioneering the development of sustainable green technology in motorsport.



Figure. 1: Ultraboost Phase 1 engine on the test bed at the University of Bath

The collaborative project 'Ultra Boost for Economy' (or 'Ultraboost') is a UK Technology Strategy Board-funded project intended to demonstrated drivecycle fuel economy improvements in the region of 35% through the aggressive 'downsizing' of a large capacity naturally-aspirated engine and without the use of hybridisation. The project partners are laguar Land Rover, Lotus, GE Precision, CDadapco, Shell, the University of Bath, Imperial College London and the University of Leeds, and it started in September 2010 with a duration of three years.

Land Rover is the lead partner in the project, with responsibility for engine build, general procurement, engine-mounted charging system

design and overall project management. Lotus is providing a dedicated engine management system (EMS), I-D modelling and know-how on pressure-charged engines, together with support for engine testing, which will all be conducted at the University of Bath, where dedicated boosting and cooled exhaust gas recirculation (EGR) rigs will be used for initial testing with the demonstrator engine. GE Precision provides engine design and machining capabilities. CD-adapco are supporting with steady-state and transient CFD analysis in order to support port and intake system design. Shell are providing the test fuels and autoignition know-how, providing support to the University

of Leeds who will develop their autoignition model to assist with the I-D modelling. Imperial College are specifying the charging system, with support from Land Rover and Lotus; they will also test the selected components in order to characterise them accurately so that the I-D model is as robust as possible.

The general target of achieving the same torque curve of the naturally-aspirated version of the 5.0 litre Land Rover AJ I 33 V8 engine was an inherent part of the project, along with the ability to provide driveability comparable with the Land Rover V6 diesel engine. An outline specification of a 2.0 litre pressure charged DISI engine was decided upon at the outset to the project. This represents 60%

downsizing and requires operation at up to 32 bar brake mean effective pressure (BMEP). Downsizing helps to achieve strong reductions in drive-cycle and real-world fuel consumption through a combination of operating the engine at a higher load (for any given road condition) and a reduction in friction through, in this case, a significant reduction in the number of engine cylinders. However, an extremely challenging target for the project in matching the torque curve of the original V8 is to achieve 25 bar BMEP at 1000 rpm, where preignition and other abnormal combustion phenomena would normally be expected to be a severe limitation. Taken together, these targets are extremely aggressive and it can be seen why the project was deemed worthy of funding by the TSB.

The project is split into several parts. In Phase I, which has already been completed, a 5.0 litre AJ133 V8 engine was commissioned on the test bed at the University of Bath, using the production Denso EMS. This was then replaced with the Lotus engine management system, which was shown to be easily capable of controlling the engine and giving exactly the same performance at full and part load. This phase therefore set fuel consumption benchmarks for the later downsized engine design and proved the capability of the Lotus EMS when controlling a direct injection engine with twin electrohydraulic cam phasers and two highpressure fuel pumps, while utilizing multiple-injection and multipleignition strategies.

In parallel with the Phase I engine test work, the Ultraboost Phase 2 engine was specified, designed and procured. In order to do this, the pooled knowledge of all the parties was used, resulting in a current industry best practice high-BMEP

engine. The Phase I engine was designed to use the cylinder block a main bearings of the donor Land Rover V8 engine, with one cylinder bank blanked off. A completely new cylinder head was designed which incorporated twin cam phasers, high flow and tumble inlet ports (themselves the subject of much work on the part of the partners), a second-generation close-spaced direct injection combustion system, and cam profile switching (CPS) on both the inlet and exhaust cams. The use of CPS tappets on the inlet was in order to allow investigation of a degree of Miller-cycle operation both at low- and high-load, and their use on the exhaust side was in order to minimise pulse interaction at low engine speeds, which is an issue for cylinder groups comprising more than three cylinders, as is the case here. The I-D model was developed in concert with this design process, and was used to help guide it.

The Phase 2 engine was fitted to the test bed and commissioned with no issues. Initial operation was at the naturally-aspirated condition, with the I-D model being used to define exhaust back pressures and help to understand the best cam timing settings to use. This phase produced fuel economy figures at equivalent torque to the V8 engine which confirmed the possibility of reaching the 35% reduction in fuel economy for the non-boosted road-load conditions. After this test work, the University of Bath then commissioned their charging rig and this was used to increase the load and the engine was operated in the supercharged region. A photograph of the engine operating at high load is shown in Figure 1.

Phase 3 of the project seeks to combine some minor modifications to the Phase 2 engine and to incorporate a self-contained charging system, allowing the engine to be used to gather full performance and economy data to prove the veracity of the approach. In order to do this, the I-D model was extensively used to help specify the charging system, with several different technologies and technology combinations investigated. This work will be described in detail in a paper submitted to the upcoming Institution of Mechanical Engineers Turbochargers and Turbocharging Conference but, in summary, a turbocharger was selected as a lowpressure stage and a supercharger as a high pressure stage. Such a system has some similarities to that employed on the Volkswagen Group's 'Twincharger' engines, but here the layout is different since the turbocharger is the first stage in the charge air path. This configuration was chosen for several reasons, including the ability to interpose an intercooler between the charging stages in addition to one conventionally-placed before the throttle. Conceptually, this is very similar to the charging system employed by the Lancia Delta S4 rally car, except that here the supercharger can be fully declutched, which in fact needs to be done above 3,000 rpm since it is being driven at very high speed to provide the necessary boost for driveability and response reasons below this engine speed.

In order to simplify the testing process, the I-D model was also extensively used to set the intake conditions for the boost rig and the related exhaust back pressure so that, in the area where both charging devices work in series, so-called 'superchargerbiased' and 'turbocharger-biased' operating conditions could be investigated. This is important to investigate since, with an operating

43



condition biased towards using the high-pressure supercharger to provide boost, one expects higher parasitic losses, but with a trade-off in potentially significantly better combustion efficiency (since there is a reduction in the mass of autoignition-promoting residual gases retained in the combustion chamber from one cycle to the next). This operating mode must be compared with achieving the same operating condition by closing the turbocharger wastegate and extracting more turbocharger compressor work (at the expense of increased residual rate due to the greater requirement for work from the turbocharger turbine increasing the back pressure at the exhaust ports). A photograph of the engine during high-load testing is shown in Figure 2.

Thus far during the Phase 2 testing, injection and cam timing have been investigated, together with PFI/DI fuelling split ratios (the engine also having port-fuel injectors in order to assess this), and cooled EGR has also been employed. Cooled EGR has shown significant benefits and the engine is easily achieving the initial high-load torque targets with extremely good specific fuel economy figures and virtually no preignition. However, in order to improve this further, a water-cooled exhaust manifold is also being procured and will be tested shortly.

An important extra dimension to the Phase 2 test programme will be to conduct some fuels testing. To date all testing has been conducted using a European-standard 95 RON gasoline; the test fuel matrix will permit investigation of RON and MON appetite for highly-downsized engines, which is a topic of significant interest for the industry at present; in attempting to understand this, Shell are at the forefront of the field, with mathematical treatment of the interaction of fuel RON and MON in relation to engine load having been undertaken for several years with an octane appetite weighting factor approach.

At the time of writing, the first of the Ultraboost Phase 2 engines had been removed from the test bed after more than 80 hours of very successful testing with no concerns (of which more than 15 were at high-load conditions above 20 bar BMEP, with most of these at or above 30 bar). It has been replaced with engine number 2 and will be stripped and inspected to gauge its mechanical integrity. The first Ultraboost Phase 3 engine fitted with the self-contained charging system described in the upcoming IMechE conference paper, is set to be tested from July 2012 onwards..

All of the partners express their sincere gratitude to the UK Technology Strategy Board for funding this exciting, challenging and successful engine technology project.

Author: Jamie Turner

Evora 414E and Infiniti Emerg-E

So what was our message at the show? Well, right at the centre of the Group Lotus stand was the Lotus Engineering exhibit, based around the brilliant Lotus Evora 414E cutaway technical demonstrator.

The Lotus Evora 414E has been exhibited at a few shows and symposiums around the world over the last 12 months, including the Geneva Motorshow in March 2011 and at all these shows, it always attracted a great deal of attention the subsequent media coverage has demonstrated this.

The Evora 414E has been developed as part of the

REEVolution Consortium, a collaborative R&D project funded by the Technology Strategy Board (UK's Innovation agency). The REEVolution consortium, made up of three suppliers: Axeon Technologies Ltd, EVO Electric Ltd and Xtrac Ltd; and three vehicle manufacturers: Jaguar Land Rover, Nissan Motor Company Ltd for the Infiniti brand and of course Lotus, is creating three new demonstrator vehicles to showcase innovative new technologies in the fields of high performance Range Extended Electric Vehicles (REEV) and Plug-in Hybrids Electric Vehicles (PHEV).

Infiniti Emerge-E concept car



Combined stars at Geneva 2012

Nissan's Infiniti Emerg-E was unveiled at this years Geneva motorshow. Under the skin of this stunning concept is essentially a Lotus Evora 414E (but extended in the wheelbase by about 50 mm), including the innovative Lotus three cylinder Range Extender engine. This gave us an opportunity to brief the press once again about our technologies within our own car and the Emerg-E.

Nissan is delighted with the collaboration and the feedback on its concept and the media reports have also been in praise of what is under the skin.

Chasing the World Car essons from the past

Julian Buckley looks at what is standing in the way of true global vehicle production and whether modern manufacturers will ever achieve the same commonality as was seen in production of Ford's famous Model T

The idea of making a 'global' car has been around for almost as long as the car itself. When Henry Ford started production of the Model T in 1908 at the Piquette plant in Detroit, Michigan, it would have been impossible to imagine that 20 years later the car would be in production on five continents: North and South America, Europe, Australia and Asia, Such was the overwhelming dominance of the Model T, it is estimated that over its production lifetime it accounted for a full 50% of the global car park.

Although some production locations used a limited number of locally-produced parts, most cars were assembled from CKD (completely knocked down) kits shipped from key production hubs. As Henry Ford believed that any changes to the Model T's construction would be interpreted by the buying public as a weakness in the original design, very little was (publicly) altered over the car's production run. This meant that through to the end of Model T production in the late 1920s, cars built at any given location were remarkably similar to those

TOP: Model T production at Ford's Highland Park plant in 1913; the site was a template for Ford production around the world

RIGHT Rolls-Royce uses assembly line principles for production of the Ghost (pictured), but it is custom work that adds cost

at Piquette and later, Highland Park.

which had rolled off the original production lines still true today. A Rolls-Royce costs more than a Citroen because beyond the chassis The rapid spread of Model T production and coachwork, the former offers a suite of across the globe was helped by the fact that customisation choices. Although the French firm there was virtually no competition. Over the claims never to have made two identical DS3 same period, most manufacturers were still models, this lack of uniformity can be largely delivering bespoke hand-built vehicles which traced back to the customer-defined decals on were so prohibitively expensive that they were the car's exterior. Rolls-Royce also claims to have out of reach to all but the wealthiest customers. never built two identical cars, which beyond As is widely known, Ford was able to achieve stickers, is directly linked to the idea that what a reduced production costs due to his adaptation customer wants, a customer gets - for a price. In of the assembly line build process for vehicle fact, it could be said that a Rolls-Royce customer manufacturing. In setting up localised production who chooses not to have any bespoke work of the Model T, Henry Ford was simply completed on their vehicle is still paying for the extending a promise first made to the American privilege of choice, as the master craftsmen who public; to deliver an affordable vehicle which any complete customer requests must still be paid, working man could aspire to own. working or not.

Essentially, it costs more to deliver a unique product. It was true in the 1920s and it is



CHASING THE WORLD CAR LESSONS FROM THE PAST

47



Achieving economies of scale

As a ubiquitous part of the modern vehicle manufacturing environment the assembly line is easily overlooked, but it remains one of the most important elements of modern vehicle production, to the point that even Rolls-Royce has dedicated assembly lines at its Goodwood, UK, production centre delivering the Phantom and Ghost models.

The assembly line supported global production - and related affordability - of the Model T and more than a century later, it is still supporting global vehicle production. The difference today is that with a wide range

of competitors using the same production methodology, carmakers must achieve savings in other areas in order to reduce vehicle priceto-market and this is largely achieved through economies of scale.

This can be seen in the push to deliver almost identical models at production sites which are for all intent the same wherever they are located around the globe. Of course, the numbers stack up in favour of such programmes; why invest in the development and production of region-specific models when for far less cash, the same models can be brought to market in

a series of countries? Further to this, the quality of new vehicles is such that there is little to be gained by such local specificity. If a given model is considered good enough for a European customer, it is unlikely that a customer in China or Brazil would want nothing less but the same car.

Such was the case when Mercedes-Benz first looked to start local production in China. Having launched a new E-Class model, the German carmaker shipped the previous generation's production equipment to China in order to start local production, but the car proved unsuccessful.

Chinese buyers were well aware that a new model had been introduced and this was the car they wanted. Now, there is little difference between the production launch date of a model at the carmaker's Sindelfingen plant in Stuttgart, Germany, and that of the same vehicle entering production elsewhere around the world. The next-generation C-Class is a case in point, as the identical model will enter production in 2014 in four countries located in widely separated regions around the world; Germany, China, South Africa, and the United States.



LEFT: The second generation Fusion and Mondeo will join the Focus and Fiesta as products

Elements standing in the way of globalisation

Not only do carmakers want to bring the same models to market across different regions, but customers want to buy the same models. Following in the footsteps of the Model T, Ford is taking the lead in development and delivery of 'global' models through the 'One Ford' programme. The carmaker claims that the current Focus and Fiesta models are the first in a series of vehicles which will be identical no matter where they are manufactured. Having been launched in the United States as the second-generation Fusion, the next Mondeo is also destined to pick up the global moniker.

The question remains, what does global mean in terms of vehicle production? The Model T was 'global' due to its wide range of production locations, the similar production arrangements, and the fact that every car was virtually identical to those built in the United States. Can the same be said of the Focus or Fiesta? The fact is that the neither of these models is as global as their venerable predecessor.

As mentioned, Henry Ford was convinced that the buying public would view 'on the fly' changes to the Model T in a negative light. He was wrong. If there is a problem with a vehicle, if there is an improvement to be made over the existing product, customers the world over want that change to be implemented as quickly

as possible. But although production systems are being designed with the flexibility needed to manage new and updated parts, it takes time for these changes to filter through the system. In an ideal world, a change made in the United States would be adopted at exactly the same time everywhere else in the world where that model was being built, but although the update process is considerably guicker than it used to be, regions lag behind others for a variety of reasons.

The primary cause of this is part supply. It takes time to retool for delivery of a given part and it takes time to deliver and test that tooling. Some places are better than others and this is usually related to how long the region has been producing cars. In the US and Europe changes are made far more quickly than in places such as China and Indonesia. These regions will catch up, particularly as the technology used by part suppliers is updated, but it does create a wave effect of incorporated improvements.

Part supply is not the only cause of differentiation between models produced in geographically distant regions. In Russia, production of some Renault models has been altered from those made in France due to the market not having sufficient supplies of ultra-high strength steels (UHSS). Where components in

within Ford's global production portfolio

France have been made using UHSS, Russian production has been forced to adopt the best available product, meaning that the associated weight reductions gained through using such advanced materials were lost through the use of standard steel grades.

Another issue standing in the way of a truly global car is local preference. While the chassis of a Focus is largely the same across all production regions, elements within the suspension mounts are tuned to control body roll in European countries, while cars delivered in India are set to allow a more supple set-up. Taking India as an example, the reasons for this are two-fold; road conditions in the country are sometimes less than ideal, which favours additional suspension travel. Another factor is that the person buying the car in India is quite possibly going to be driven rather than take control of the car. This.



RIGHT: The long wheelbase Audi A8L is popular in

CHASING THE WORLD CAR LESSONS FROM THE PAST

51

too, favours a softer suspension.

Other cultural differences affecting vehicle production can be found in China, where car owners are also often seated in the back of the vehicle. In this case, the preference of the Chinese consumer is to have greater leg room in the rear seat, which has lead to the introduction of various extended wheelbase models from companies such as BMW and Audi, While the chassis from a Focus is the same between regions, these extended wheelbase models require adaptations to be made to various elements within the production environment. Even if it is something as minor as having to update the choreography of robots in the paint shop to accommodate the longer vehicle, any deviation from standard translates to added complexity and added cost.

Sharing the cost

Yet while these changes do require adaptations which inevitably require further investment, there are myriad benefits to be gained from getting as close as possible to the global vehicle model. For example, General Motors refers to its automated windscreen application station as being 'global'. This essentially means that the equipment is designed to be installed at every GM plant and, not withstanding a very limited number of models, be used in production across most vehicles. In turn, this means that while development of a single such station would have been prohibitively expensive, copying and applying the technique around the world has drastically reduced the relative investment.

Staying with GM, the company is looking to achieve similar gains as it plans to slash

the current number of engine types by 50%. This means that there will be less equipment dedicated to building low-volume engines and more investment capital for production of the new engine types. Factored across the various GM engine plants around the world and the potential savings are staggering. Should the new engine lines be produced in plants with an increased depth of automation, then there are also benefits to be gained in terms of quality, which is another win when it comes to realisation of global vehicle production.

Beyond the 'One Ford' strategy, the latest trend emerging in the quest to get as close as possible to global production is to share production duties across brands. One of the latest examples of this is the deal which sees Daimler and the Renault-Nissan Group teaming BELOW GM production around the world features a range of largely identical manufacturing cells

RIGHT: Engine production at Nissan's Decherd plant - the facility is to deliver engines for the next-generation Mercedes-Benz C-Class

up to deliver engines from the Nissan engine plant in Decherd, Tennessee for production of the Mercedes-Benz C-Class and an as yet unnamed Infiniti model.

unnamed Infiniti model. The benefit for Mercedes-Benz is clearly that the company will not have to invest in the capacity required to deliver the new fourcylinder engine which will be used in production of the next C-Class in Tuscaloosa, Alabama. For its part, Nissan will gain access to Daimler's advanced engine technology, which is likely to increase the desirability of any model to which the new powerplant is fitted. After all, if it worked for Ssangyong, which has produced models fitted with Mercedes-Benz engines, it could certainly work for Nissan's premium brand.

Whether Daimler and the Renault-Nissan



Alliance will extend this partnership remains to be seen but interestingly, there are Nissan engine plants in every build location of the next-generation C-Class. With that in mind, is this partnership model a strategy which could support development of a 'global' vehicle? Possibly, but what really stands in the way of achieving the reality of a global vehicle is not part or material supplies, as these can be addressed with time and investment. What really stands in the way of this goal is the diversity of human preference and that will be much harder to overcome

Author: just-auto's Julian Buckley



Lotus Engineering Inc. (LEI) Celebrating 10 years in America

Lotus. To most enthusiasts, it conjures up images of exciting minimalist sports cars, Formula 1 cars engineered with just enough structure to cross the finish line, colours of black and gold, green and yellow, a founder ruthless in his endeavour to 'add lightness'. To most readers of this magazine it brings back memories of hours spent perfecting designs for independent clients – many of which will go without public recognition. But while some of Lotus Engineering's work may go uncelebrated, one event within the company we would be remiss not to celebrate is Lotus Engineering's tenth anniversary of U.S. operations and its achievements so far. The future is exactly what our American engineering centre - Lotus Engineering Inc. (LEI) is concentrating on; where is the automotive industry going? Where is Lotus Engineering headed and how does it fit into the automotive industry? Will it be limited to the automotive industry?

"No,"

says Darren Somerset, CEO of LEI. to the last question.

"Lotus is a technology service provider, working with OEMs and tier l suppliers – as well as migrating its expertise into other industries [military, aerospace, rail, renewable energy] – to increase efficiency in all areas of transportation. Lotus specializes in providing innovative solutions to meet the clients' commercial and technical objectives. The market drivers right now are to find sustainable transport solutions in a cost effective manner. These drivers are aligned with Lotus' core competencies – lightweight architecture, efficient performance, electrical and electronic integration, and driving dynamics."

These core competencies all come from Lotus Engineering's origins in Britain.

Lotus started entertaining more American clients from 1986 when General Motors acquired Group Lotus. One of the first projects delivered was the Chevrolet Corvette ZRI engine, which current Group Resources Director Tim Holland was a part of. Tim was actually the first member of Lotus Engineering to move to the States with this project, recalling

"As part of the development team, I came over to America to head up the development and calibration activities Stateside in 1987. This [Corvette ZRI] project continued until 1995."

Tim then became the sole Lotus Engineering employee in America, feeding projects – including powertrain integration, transmission, engine, chassis, and ride and handling work back to Lotus Engineering's headquarters at Hethel in the UK. As this setup worked against Lotus' ideals of simplifying everything, a group was developed to create an American centre for the company with the purpose of simplifying and expanding operations in America.

The team, assisted by a consulting agency in Boston, immediately began identifying what types of programs were typically outsourced by the major OEMs as well as scouting the prime location for the first office. The Ventures Team determined there were opportunities in all of areas of automotive engineering and brought a total of ten staff over with expertise in powertrain, vehicle engineering, and CAE analysis. The original 10 took up residence in an office in Southfield, centrally located between the major Detroit-area OEMs. While searching for an office building, the team discovered a powertrain testing facility for sale in Ann Arbor, Michigan. Buying such a facility was not in the original plan, but given that any major powertrain project would inevitably require development and validation, a decision was made to purchase the Ann Arbor testing facility with 27 test cells and an emissions lab. An advantage being that the existing

customer base rolled over with the ownership change. The facility has proved an invaluable resource to LEI as it is capable of testing everything from small single-cylinder engines, to large marine engines, and electric motors. Additionally, the emissions lab is capable of certifying smaller vehicles such as motorcycles and providing a preliminary estimate on CO₂ emissions for other vehicles.

Ann Arbor, Michigan, USA

LOTUS ENGINEERING INC. (LEI) CELEBRATING 10 YEARS IN AMERICA

55



Mark Wilby, a senior engineer and Project Manager, was initially drawn in by the diversity of Lotus projects and it has kept him at the company for 21 years. Wilby recalls of what drew him to Lotus initially: "the active suspension Esprit and Vauxhall Lotus Carlton, both used as part of a demo [at university]." Over the years in his career at Lotus, Wilby has worked on everything from mass produced four-cylinders to racing specials, exotic vehicles and a few encounters with some innovative entrepreneurs. His experiences with Lotus bridge the divide between the powertrain and vehicle groups even extending into manufacturing.



More recent hires, such as Senior Calibration Engineer Greg Banish, share the enthusiasm about working for a smaller, more diverse company. "The projects that happen here are generally more interesting than a run of the mill OEM engineering group", having spent 3 years with an OEM prior to joining Lotus. "It [the diversity of projects] keeps you on your toes and always has you thinking about different solutions."

Expanding LEI's reach

LEI's vehicle engineering team relocated to a new environment last year. Gone are the familiar streets and aged corridors of the Southfield office, transposed for light and airy hallways of a larger, more modern office building in Sterling Heights. While the change of scenery and work environment is certainly welcome, it was also partially necessitated by LEI's growing workforce. Since the purchase of the Ann Arbor facility and the inception of LEI, the company has greatly expanded from the original twomember sales and engineering staff.

Although the Ann Arbor powertrain team has grown and is now at maximum capacity - in terms of both personnel and occupied test cells – the location has remained constant due to the nature of the facility and work. In order to accommodate this expanding workforce and work load, LEI is currently investigating remodelling the offices to add a significant amount of floor space and additional testing capacity. The existing test cells have been the residence of numerous forms of combustion – big V-engines to

small single cylinders and even the occasional unintended combustion and all manner of planes, trains, and automobiles have passed through the doors as well as marine vessels, armoured vehicles, and even a shopping cart. This diversity and ability to adapt to change is one of the factors that draws people to Lotus Engineering – both clients and employees.

Clients trust Lotus' expertise in vehicle design as well as powertrain design and testing, which leads to long-standing relationships across nearly every aspect of automotive engineering. LEI's vehicle division can work on the chassis and suspension, which may lead the client to cooperate with Lotus on powertrain design and testing as well – which has happened on numerous occasions. While this diversity merely sounds like a good business proposition, it's also highly motivational for employees too, creating a challenging and everchanging work environment - you may be working on a small, efficient gasoline engine and your next project may be a fully armoured vehicle development program.

Lotus' history is impressive, and this history is helping to direct the company in its future endeavours. This doesn't mean LEI is content to rest on its laurels but rather it's bringing back one of its founder's great mantras - 'simplify, and then add lightness.' A prime example of this is Lotus' work with the California Air Resource Board on developing a lightweight fuel efficient crossover. "No weightsaving stone was left unturned" in developing the CARB vehicle according to Senior Technology Specialist Gregory E. Peterson. To this end, the piece count was

reduced, more components were used as fully stressed members, and the suspension was redesigned and lightened because of the reduced mass to name a few.

Mass optimization and lightening the vehicle load lends itself to a manner of efficiency gains - the lighter the vehicle, the lighter the components can be to cope with the mass of the vehicle, the smaller the engine can be, and the list goes on. One particular area of interest is engine downsizing - another path Lotus engineers are pursuing in all manner of vehicles. "The continuing evolution in powertrains will result in one litre engines with over 150 horsepower and improved brake specific fuel consumption," says Peterson, about Lotus' work in powertrains. Lotus is also applying the idea of making small-block power with a smaller, pressure charged engine to modes of transportation outside the realm of automobiles as well.

"The important thing to realise is that engines don't know where they live, so the technology that works on a car can just as easily be applied to other uses such as generators, marine, off-highway equipment, etc,"

says Senior Calibration Engineer Greg Banish, to this end, Lotus is working with companies on small displacement, turbocharged engines for production vehicles as well as smaller, pressure charged engines to replace gas-guzzling V8s in marine applications.

Diversifying for the future

The idea of marinising a smaller displacement, pressure charged engine is just one of LEI's many ideas to grow and expand from the greater Lotus Engineering and Group Lotus. Lotus Engineering Inc. was born of Group Lotus in Britain, but just as America created its own path in history, LEI is determined to forge its own path in the American marketplace with the help of its innovative and forward thinking employees. These employees are determined to grow the company, looking into all corners of the marketplace for ways that LEI can show its expertise. Smaller marinised engines, high performance hybrids are in the works alongside lightweight family vehicles, sport aircraft, and alternative energy programs, showing the full range and potential of LEI and LEI's determination to prove high performance and fun are not synonymous with 'gas guzzlers.'

LEI is continuing expansion in powertrain validation and testing – including diesels and hybrids. Powertrain validation and testing is a large part of LEI's history and has continued to diversify and grow as the OEM's requirements change.

Author: Andrew G. Peterson





LOTUS ENGINEERING INC. (LEI) CELEBRATING 10 YEARS IN AMERICA

57



Group Resources Director Tim Holland was the first member of Lotus Engineering to move to the States recalling "As part of the development team, I came over to America to head up the development and calibration activities Stateside in 1987. This [Corvette ZRI] project continued until 1995." Tim then became the sole Lotus Engineering employee in America, feeding projects back to headquarters in the UK



Andrew Peterson a recent graduate of the University of Michigan and a [relatively] new hire at Lotus and long-time petrolhead. "There was no question in my mind of where I wanted to work. The diversity of products I would be able to work on along with Lotus' reputation for high-quality engineering, innovative design, and philosophy of 'simplify, then add lightness' drew me in. Thus far, I have worked in both vehicle and powertrain groups – designing a lightweight, fuel efficient vehicle; managing the engineering and design of a production-intent vehicle; designing a turbo-diesel V8 engine; and testing and calibrating everything from a small gasoline engine to large turbo-diesels."



Based at Enstone in Oxfordshire, the Lotus Formula 1 team is competing in the 2012 season for the first time under the Lotus name (Group Lotus is now its chief sponsor; it was previously racing under the Renault name). The team's Technical Director, James Allison, talked to Dave Leggett.

DL:As the FI season approaches, there is obviously much to do to ready the team and cars. As the technical director, can you describe how the pre-season preparation schedule works and what the priorities are?

IA: From a technical director's point of view there shouldn't be too much that changes as a result of the season approaching. The team has a very strong group of people and the different functions are covered by the different managers and resources in the different areas.

For example, on the production side, there is a small army of people putting about a 1,000 works orders a week through the system in order to try and get everything ready on time this work looks after itself without much of my involvement.

In a similar vein, our Race Engineers are busy preparing for the new season, making baseline set-ups and preparing analysis sheets....it's all happening because the team is divided up into functional groups that know their business and are doing it.

My usefulness in this period is not really anything special. I guess there's an opportunity for me to get involved when something unusual or unexpected happens. For example, there was the problem that we had in the second winter test when we had an issue with our chassis. That involved me greatly because that was definitely something steering us towards the rocks and I needed to make sure we were taking all the right steps to make sure we were okay.

But the kinds of things I'm interested in, as technical director, tend to be on longer time horizons.

DL: So how do you see the role of the technical director and how it fits with the team objectives?

|A: Every team will tend to be different but I'll give you my view of it.

A lot of people ask me this question and I find myself trying to describe what is an utterly thrilling job with words that maybe make it sound boring! When you take away all the thrill and fun of what I do, you're left with an engineering management job and when you start describing the constituent parts of that, it doesn't sound like much fun, but you'll have to believe me that it is.

The technical director has to create and

the way.

So the technical director attempts to create I have to decide how to allocate resource -

the environment where the combined efforts of hundreds of engineers can bring us success. It's fairly mundane at one level: I have to make sure that we have the right calibre of staff in the right posts so that the smaller groups of devolved engineers in particular areas of responsibility - transmission, composite design, mechanical design... - are capable of getting the job done. that's very important. For example, how much do we place in the current racing car compared with how much we are investing in next year's car and indeed, with the challenge of 2014 coming up [a very substantial change to the regulations], how much effort do we put in now to ensure that we are starting to be ready for what will be a very different Formula 1 in two years' time?

The technical director has to make other resource decisions such as: what should our balance of effort be in terms of designing the product, compared with how much effort should we make on improving the manner in which we go about designing the car? If we put all of our effort into the former, then we extract all of the creative skill of our designers into the car, but we run the risk of our design process getting stuck in a rut. A certain amount of effort needs to be devoted to improving the manner in which the work is approached. And how much do you put into real blue sky stuff that may not pay-off but if you don't have a portfolio of different projects, you are likely to fall back with respect to a more enlightened

team.

maintain a technical environment where the team is capable of building and running championship winning cars. And this has to be done in a way that doesn't hurt anyone along

So resource allocation is key.

And I have to control budgets. We are lucky to be generously resourced but you have to make sure you are spending that in a wise way and not exceeding budgets.

Another key part of the job is retaining a relationship with the governing body of the sport. All the technical directors of the respective teams contribute to the formulation of regulations through the technical working groups that meet with the governing body. That's a vital investment in the future of the sport.

And we have to make sure that we are getting the most out of the current set of regulations so that our team has understood precisely where the boundary line is between what is and what is not permitted. Generally speaking, what isn't permitted is higher performance than what is, so you need to run right up to the boundary and understand where the loopholes are, where grey areas are and stay the right side of that line.

Management of technical risk is something else that I have to look at. In every year there are aspects of the car that are more or less the same, from a design point of view, as the year before, but there are also aspects that – if not a step into the unknown – do constitute a new development or new method of designing a part or realising a part. Every time you do something you haven't done before, there is an element of technical risk. The technical director decides how much we can bite off and chew and has to be responsible for putting in place programmes that mitigate that risk in case it doesn't pay off for us.

DL:To pick up on the thrills, what do you find thrilling about the job?

JA: I find lots of aspects of it thrilling. I have been in Formula I for over twenty years now and in whatever position I have occupied, I have always found it exhilarating that the sport affords the most direct and immediate feedback about the quality of your work. What the team designs ends up being realised on the car in a very short timescale and then it gets measured in a completely inescapable fashion. There's no doubting who's done the best job because there is a very, very clear way of establishing that and that's taking a car and putting it on a track and seeing who is fastest. That is utterly thrilling.

The other part of it that has always been fun, and this fun has only increased as I have been given added responsibility, is that Formula I is all about teamwork. Anyone working in the sport has a very strong sense that they are part of a team that is all focused on one goal. In the best teams that feeling is very strong. It is a great feeling to be part of a group activity where everyone has put a lot of themselves into a project, where everyone cares a lot about it, where they know that not only their own wealth and the well-being of their families depends on it, but also that their sense of professional achievement is utterly dependent on how quick an exquisitely assembled bit of carbon-fibre, rubber and metal goes around the track.

Sharing that experience with the team is thrilling and to be fortunate enough to try to lead the technical team and motivate the technical team, in this environment, is extremely rewarding. When stuff goes well you feel like king of the world. It's a great feeling and it's very direct and very immediate when it's going well.

DL:And I guess, as well as the highs, there can be big lows as well...

JA:Yes, that's the downside. It's completely crushing...

But we work in a business that is also a sport. I think we probably share a small amount of what elite sportsmen feel. The joy of the success is so overwhelming that it actually makes the lows associated with failure manageable. Those who have been fortunate enough in FI to have sampled winning know how sweet it is and it is the lure of success that allows you to ride out the inevitable disappointments.

DL:And there must be very tight schedules to work to, hard deadlines to meet. Is that stressful?

JA: Yes, it is. Going into that first race or first test, it's not a question of whether you are going to get there in time or not. If you are two or three days late there's nothing left, there race has been and gone without you. You have to get things done on time or the company is finished. The pressure that comes with that is both thrilling and stressful in equal measure.

DL:As far as the new E20 car is concerned, it sounded like there was some intensive work required back at HQ to get the chassis ready in time after some unforeseen suspension problems arose when testing. How did the problems become apparent and how quickly did you determine the best way to approach it?

JA: The problems became apparent in the most unsatisfactory way, which was out on

61

the track with the finished product failing in its designed working environment. That's not something that we are remotely proud of. It should never happen and we should have seen that the design that we put together was not up to scratch before committing it to manufacture. The design we produced for the anchor point of one of the legs of the front suspension to the chassis was capable of withstanding the design loads under ideal conditions. Indeed on our first chassis it tested for 1,800 kilometres with no problems. However, in the detail of that joint were undesirable features that meant the strength of the joint could not be guaranteed when we ran our second chassis the joint failed almost immediately. Really you want a design that is comfortably strong enough, (ie the basic design has a good safety factor) and that every single item you make enjoys the same safety

Having understood the shortcoming of the original design it was a question then of ensuring that we could redesign the anchor as quickly as possible in order to get the car back and up and running for the final winter test. We knew that having suffered the failure on the first day of the middle test that we were not going to be able to put that right inside the four days of that test, but that we had a fighting chance of putting it right for the final test a week later and that's what we did.

factor.



DL: And that required going back to the drawing board...

JA: It required taking the unsatisfactory aspects of that joint design out and replacing them with a different detail that was inherently stronger, but most importantly, if you made ten of them they would all fail at the same load and that load would come with a comfortable safety factor.

DL: Landing 2007 World Champion Kimi Raikkonen as a driver for this season was guite a coup. What do you think attracted him to Lotus and how important do you think his experience and racing style will be to the team's prospects this year?

[A:Yes, I agree that is quite a coup to have a driver of his class join us. It is very important for a team to have a top notch driver line-up. Look at any of the teams that succeed over the years and it's very rare that you get a great driver and a crap car or a great car and a crap driver. You have got to try and get a great car and a great driver together. So it is very good news for us.

You'd probably have to ask him yourself what attracted him. I can give you my opinion of the kinds of things that are attractive about us.

While we don't - yet - have the technical resources and depth of some of the bigger teams ahead of us on the grid, we do have a very impressive facility here at Enstone. We have strength in depth on the engineering front

which is more than capable of developing into a team that can genuinely have a claim on winning a drivers' and constructors' championship. We have owners committed to the long-term and investing in the team to make sure that we are able to operate at the absolute highest level. And we have serious intent with a campaign in which we intend to push ourselves forward, year-on-year, to make sure that we are capable of winning a championship in 2-3 seasons from now.

And all of those intentions are absolutely resolute here at Enstone, in the ownership of the team and amongst the employees and I hope some of that resolution was attractive to Kimi when he decided to join us.

DL:And I guess you are looking for various things, qualities, from the driver?

A:Yes, you want a few things from a driver. The single most important thing you want is a guy who is fast and consistently fast. Even if he never opened his mouth, never said a word, that gives you a baseline from which to assess everything.

If the guy is a random number generator because he can sometimes go fast, sometimes not, you don't know whether it's the driver or the car and you don't know where to attack the problems. All the great drivers remove that whole area of doubt from the engineering side.

You know when he gets in the car he's going to wring whatever lap time is possible from that car and if it's not fast enough, it's because the car is not fast enough. If, for example, tyre wear is too high, it's because it's eating the tyres too quickly, it's not the driver...you want that consistent baseline.

If the driver is also articulate and capable of explaining to you what it is he feels is a limitation on the car, then that's a very valuable bonus. With Kimi we are fortunate to have both of those things. He is very clear and very articulate in focusing on the things that we need to do. You don't want a carpet bomb of random noise from the driver, but a clear set of 'do this, do this, do that...', that's very helpful.

And finally, when you have a very experienced, proven driver and you have a young, fast and raw driver, the benefit to the young, fast, raw guy in having the proven guy to work with and learn from is massive. The access to the data of the other car and the approach that the other car is taking through the weekend is completely and transparently visible to the newcomer. That helps the young driver ratchet themselves up the learning curve more rapidly.

But data doesn't have much to say about the handling of the car. You could generate a channel that tells you whether the car is understeering or oversteering and that's a mathematical channel, but it doesn't tell you what an acceptable level of understeer might be. That is very much a driver preference and different drivers can tolerate different levels of understeer, or at different points of the race or track. You need to rely on the driver on what's acceptable and once you have that threshold of acceptability established, then you can use the

DL: How important is driver feedback versus what the electronic sensors and telemetrics tell you? For example, are there times when you have to trust the driver's judgement when the data is apparently in conflict with the driver's assessment?

A:There's very rarely a conflict between the two because the data is excellent for certain things and lousy for others.

The driver, for example, can't tell you how hot the radiator is or whether he has overheating tyres. Some things lend themselves to objective measurement very easily. Data is terrific for that type of thing. Data can be good for seeing when the driver is over-revving or making small errors in the way he is using certain systems in the car. The drivers don't fight against that; they regard that as a helpful thing because it is data they can't gather any other way.

data to judge whether you are delivering what the driver wants. But you need that input from the driver.

Where handling is concerned, data is not helpful in giving you absolute values, but it can provide guidance once the driver has provided a baseline on how to interpret the data.

DL: From a technical point of view, what do you see as the major strengths for the Lotus team?

JA: We have good facilities here. Any engineer looking around our factory would conclude that we have enough kit here to get the job done. In almost every area of our engineering enterprise we have people of the necessary calibre and experience in order to compete for championship honours.

You might say, well why aren't you then? The reason is that Formula 1 is ever such a punishing sport and it is no good having nearly everything right, you have to have everything right. The job for our team over the next year or two is to ruthlessly track down the bits that we believe are below par and eliminate them. So we're not just content with the 95% of our factory that is championship performing level, but so we can look at this company and say that every bit of it is where it needs to be..

Everything I have just said is generic to any FI team.

But, specifically to Enstone, I believe that there are aspects of our team that are very special. Many people who have worked here over the years would all agree that it has always been a team with very few internal politics. It is also a very open team, too. I have worked in a few places and most of them keep certain sections of the team silo-ed from one another as a means of protecting themselves because such a structure ensures that no individual knows that much about the whole team. We have always taken a different approach and we feel that people will feel more a part of the team if the team is open. So we take a calculated risk in involving everybody in our plans and our objectives, so that people know what's going on. That has always led to a very convivial atmosphere with everyone feeling a part of the team.

I have worked here two or three times in my career at different levels of seniority. Even though it is an entirely different group of people now to when I first joined twenty years ago, the underlying culture of the team - an open, friendly approach – has stayed constant and it's quite special.

DL: And how many people are there?

JA: It changes constantly, but it is somewhere in the region of 520.

DL:What are the biggest challenges that the team faces, technically?

A:The general technical challenges are constant, but in particular 2014 is bearing down on us in a hideous fashion – there's so much to do and so little time.

But all of it would be easy if no-one else were competing with you. The slowest car on the grid is an awesome bit of kit and an incredibly fast car with some super engineering on it. The challenge is that you have to work in this dynamic environment competing directly with another 500 or 600 people in another factory twenty miles down the road who are just as dedicated and just as obsessed with it as you are and who are doing their level best to ensure that they screw you - not in a Machiavellian way, but by putting a car on the road that beats you.

That's the nature of the challenge. If you stop running at full pelt even for a few days, someone else will pull out a tenth of a second on you. There's a completely inexorable pressure knowing that all your competitors are relentless and you have to be relentless plus if you are going to beat them.

It's only the fact that you are competing with these other buggers that makes it hard.

DL: What is actually happening in 2014?

|A: At the moment we have a 2.4-litre V8 and unrestricted fuel – in terms of quantity. You can put as much in your fuel tank as you want to. The current rules only permit a very light hybrid motor – 60 kw – that can be used for around 7seconds per lap.

The future environment is a smaller engine V6 which is heavily turbocharged (the current engines are normally aspirated) and with heavy hybrid 120 kw electric motor. In addition, there is a further sizeable electric motor/generator coupled to the compressor and turbocharger. Any excess heat energy over and above that needed to compress the inlet charge can be vectored by the coupled motor/generator either to provide extra drive to the car or to be stored in an on-board battery for later use. Conversely if you have a dearth of energy available in the exhaust at a given moment and you need to get the turbo spinning faster, then you can vector energy out of the battery via the coupled motor/generator.

business.

James Allison

After graduating from Cambridge, James put his engineering skills to immediate use in Formula One by joining the aero department of Benetton in 1991. A couple of years later he moved to Larrousse as Head of Aerodynamics before returning to Enstone for a second time with Benetton, this time as Head of Aerodynamics in the mid-1990s.

A five-year spell with Ferrari began in 2000 as James oversaw trackside aerodynamic operations during the most successful time in the Scuderia's history.

In 2005 James returned to Enstone to join the Renault FI Team in the role of Deputy Technical Director as the team won back-to-back drivers' and constructors' world championships.

In 2009 James moved to his current role as Technical Director.

This all combines to produce an engine of very similar performance to today's but with about 30% less fuel consumption. Furthermore the 2014 rules require that we use a maximum quantity of fuel during the race, with that limit being progressively reduced each year so that we are forced to make the engines more efficient over time. The imperative for the teams will be not to allow the power to drop, even though the fuel used is dropping.

So the idea is that the rules force the sport to become more efficiency driven rather than appearing wasteful in its use of energy.

DL: Do you use 3-D printing in the manufacturing of parts?

A: Oh yes, we use that quite a bit and we have been for almost a decade now. Aerodynamics departments in Formula I couldn't exist without that technology and it has changed the economics of manufacturing in our



SPRING 2012 proActive magazine

65

DL:What about the use of new and better materials? Are there new developments there?

JA: If you wind the clock back eight years or so, there were very few limitations on materials usage, but it was getting a bit out of hand because you can always make an engineering device better by investing in materials. If you have a better material than the next guy you are going to have an advantage that he can't do anything about. But it was quite quickly recognised that materials development shouldn't really be part of the sport because it is punishingly expensive and you really are handing over the championship to the person with the biggest wallet if you do that (and even the person with the biggest wallet can't really afford it either!). So we issued a list of materials that are permitted to be used on the race cars. It's quite a generous list, allowing materials that you wouldn't find on a normal road car; for example carbon fibres and fairly exotic aluminium alloys. But nevertheless the list prevents teams from going out and brewing up their own materials from scratch.

At the periphery there are still some freedoms. For example, you can make heat shields out of whatever you want and that has allowed us to benefit from material developments in high-temperature composites. But you can't make the main chassis out of anything you want.

DL:We've had DRS and KERS introduced in recent years – do you think there are further technical refinements ahead that can enhance cars' performance and/or make the sport more exciting for spectators?

JA: I think from a regulatory point of view we are going to have relative stability this season and next. DRS and KERS are now part of the landscape for the next few seasons, for sure. As are tyres made by Pirelli which have been designed to not be too good. A race is not that great to watch if everyone's tyres comfortably last the race distance without being on the edge of falling to pieces. You want a tyre that is safe and reliable but which has quite a sharp wear rate. As the tyre gets older the car gets slower and some cars and drivers manage that degradation rate so they're just okay, and other cars that are a bit heavy or leaden footed step over the boundary so that they are not okay. This mixture of fortunes tends to mix up what's happening on the race track. That part of the sport I think will be fairly stable for the next two years.

The biggest next change will be in 2014 because the new engine that has been conceived from driving efficiency into the sport has also got built into it some nods to the sporting spectacle as well. This is because the peak power of the engine that is available in qualifying and in the race, should you choose to use it, is much higher than the average power of the engine imposed by the limited total fuel quantity. A team will have the option of blasting off at full power, but that will mean effectively borrowing fuel from later in the race and so that team will need to go correspondingly slower later in the race. The mix of strategies that drivers can then choose will unfold in the race in terms of variability and I hope bring a racing spectacle.

DL: Didn't Bernie Ecclestone float the idea of artificially adding wet track conditions?

JA: He did, but there's a fine line to tread between making the sport a thrills and spills pantomime and making it a genuine sport. The consensus is that moves last year to introduce DRS were a success and that has helped to make the races interesting without making them too contrived. But you have to be careful with going too far in that direction.

DL:What aspects to your job do you particularly enjoy?

JA: It is the immediacy and the camaraderie that comes with being part of a single minded team that succeeds or fails together. That really is the best part of it.

DL: Do you like the travelling?

JA: I've done a fair amount of travelling over the years and personally I loathe it. Not the actual being at the races, you understand. Once you are there and the race weekend is underway, that's always fun and a challenge. But being at airports, going around the world...I like being at home.

Author: just-auto's Dave Leggett.

INSIDE LOTUS INTERVIEW WITH JAMES ALLISON





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POWERING A NEW GENERATION OF **ELECTRIC VEHICLES**

The range extender will be offered in 3 cylinder and 2 cylinder versions with 50 kW, 35 kW and 20 kW outputs.

Designing the engine specifically for hybrid applications has resulted in a low engine weight of just 51 kg for the naturally aspirated 3 cylinder variant. The engine is optimised to generate power at engine speeds between 1,500 and 3,500 rpm allowing a lightweight simple 2 valve per cylinder engine architecture and eliminating the need for a complex four valve per cylinder design.

HEINEEN

The generator is driven directly off the crankshaft to reduce weight, package size and cost. The engine, generator and power electronics are controlled using a Lotus controller to improve communication and efficient running of the systems.

The engine architecture and engine management system are designed to offer flex-fuel capability to allow the engine to run on renewable alcohol fuels.

LIGHTWEIGHT ARCHITECTURES - EFFICIENT PERFORMANCE - ELECTRICAL AND ELECTRONIC INTEGRATION - DRIVING DYNAMICS



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