LOTUS ENGINEERING

proActive

The official e-magazine of Lotus Engineering

Safety Fast – Crash management for the Lotus Evora

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Welcome

Vehicle safety is all too easily taken for granted, often only thrown into focus by events such as the recent horrific motorsport accidents.

Although it may not be the first thing that comes to mind when you think of a Lotus, it is an area where we take considerable effort to engineer highly effective vehicle safety for our vehicles. For example, we pioneered use of composites in crash structures in the Elise. In this issue of proActive we take a closer look at the structural safety engineering of the latest Lotus, the Evora, which achieves global safety requirements and has the best crash performance of any Lotus so far.

On an altogether separate subject, the armed forces are taking a comprehensive approach when looking at what sort of vehicles to use in the future. As with many other industries, environmental issues and cost considerations now form a major part of the decision-making process and this has led to the defence industry increasingly turning to the automotive industry to find advanced solutions for their transportation requirements. Lotus Engineering is no stranger to military operations. having worked in the field for the past 15 years, and many of our latest technologies and engineering approaches are incredibly relevant in the defense sector, which is explored further inside.

Finally, you’ll have noticed that we have updated the way proActive is viewed. I hope you like this and, as always, I welcome any feedback.

Peter Morgan
Marketing Manager – Lotus Engineering

LOTUS ENGINEERING

GERMANY/SOUTH KOREA: Bosch-Samsung to supply BMW batteries

BMW has chosen Bosch's joint venture with Samsung SDI to supply lithium-ion battery cells for the carmaker's Megacity electric vehicle project due in 2011-2015.

BMW chief executive Norbert Reithofer said the decision was a major milestone towards serial production of the Megacity.

"With SB LiMotive we have selected a supplier who offers the best available technology, combining leading German automotive expertise with future-oriented Korean battery know-how."

The Megacity is part of BMW's 'Project i', which is developing new mobility concepts for cities with more than 10m inhabitants.

SB LiMotive, a 50-50 joint venture between the German and South Korean suppliers which recently acquired General Motors' hybrid battery supplier Cobasys, specialises in batteries for consumer electronics.

Samsung SDI CEO Soon Taek Kim said: "We want to establish SB LiMotive lithium-ion battery cells as a sustainable product which, after being used in the car, can be reused in other areas or recycled."

Developing reliable batteries has been a major hurdle in making electric cars but they now provide sufficient range to make such vehicles economically viable. BMW is currently testing about 600 models of its electrically-powered Mini in Britain, Germany and the United States, and mass production is forecast for sometime around 2015.

And Nissan has just rolled out its new Leaf EV which goes on sale in Japan and the US in 2010.

Source: just–auto.com editorial team

CHINA: Nissan/Honda partner Dongfeng launches own-brand range

Dongfeng Motor has launch its first in-house-developed sedan, the medium-size Fengshen S30, though it does have a 1.6-litre Peugeot petrol engine.

Prices in China range from CNY75,800 to CNY99,800 (US$11,100-14,600).

The five-model S30 range is offered with an Aisin Seiki automatic transmission.

Dongfeng also has vehicle manufacturing JVs with Honda and Nissan Motor and this is its first own-brand line.

It has installed capacity for 120,000 units and hopes to make about 80,000 S30s a year initially. It is building a plant to make 240,000 two-litre engines a year from 2010.

The automaker is also developing a Dongfeng Fengshen dealer network and has 180 sales outlets.

Exports are also planned.

Source: just–auto.com editorial team

US: GM plans plug in crossover

General Motors' Buick brand will launch a crossover with plug-in hybrid system in 2011, a year after the mainstream models arrive with new, fuel-efficient direct-injected petrol engines.

Announcing the new line at the auto industry seminars in Traverse City, Michigan, Tom Stephens, GM's product development head, said he expected the as yet unnamed-vehicle would be the first commercially available plug-in hybrid SUV produced by a major automaker.

Buick said the plug in hybrid version could achieve up to double the fuel economy of comparably-sized SUVs on short trips. It will combine a modified version of GM's current two-mode hybrid system with lithium-ion battery cells and Voltec charging technology developed for the Chevrolet Volt extended range EV due on sale late in 2010.

"LG Chem - the supplier of our battery cells for the Volt - has also been selected to supply the lithium-ion cells for the new Buick plug-in hybrid, and its Troy, Michigan-based subsidiary Compact Power will supply the pack," Stephens said.

The Buick plug-in will use the same manganese-based chemistry and polymer battery cells as the Volt. The 8kWh (28MJ) battery - containing half the energy of the Volt battery pack - will be packaged in a rectangular-shaped box under the cargo floor.

The lithium-ion battery can be fully recharged in four to five hours by connecting the vehicle to a standard 110V US household electrical outlet.

Initial testing has shown the plug-in hybrid is capable of electric-only propulsion for over 10 miles (16km) at low speeds, Stephens said.

"Buick has always been at the forefront of new technology, so it is only fitting that the brand should debut our new plug-in hybrid technology in a beautiful new crossover," he said. "This will firmly put Buick, and GM, front and centre in the advanced technology game."

Stephenson said the new five-passenger crossover would be smaller than the current Enclave.

"Some customers who have been drawn to the Enclave were looking for something a little smaller, but they didn't want to give up craftsmanship or a quiet ride to get there," said Susan Docherty, general manager of Buick-Pontiac-GMC. "We believe this new Buick will excite those customers, and will continue to broaden the appeal of the brand."

The new crossover will offer a standard 'Ecotec' 2.4-litre direct-injected I4 engine and an optional three-litre, direct-injected V6, expected to deliver about 30 miles per [3.9 litre US] gallon in highway driving.

GM already offers hybrid SUVs such as the giant Chevrolet Tahoe and the mid-size GM Daewoo design-based Saturn Vue. Rival offerings include Ford's Escape Hybrid and its Mercury branded clone.

Source: just–auto.com editorial team

Industry News

US: New Suzuki targets 'sports sedan' buyers

American Suzuki Motor has launched its first in house-developed mid-size sedan – the 2010 Kizashi, also the company's first entry into the all-wheel-drive sport sedan segment.

The car, heralded by a series of concepts displayed at motor shows in the last couple of years (and once reportedly cancelled), is built at a new plant in Sagara, Japan, and has a 2.4-litre DOHC inline four-cylinder engine with aluminium block and cylinder head plus a balancer shaft.

A six-speed manual transmission is standard and continuously variable transmission (CVT) automatic with paddle shifters on the steering wheel is optional.

Four-wheel-drive is also optional.

Suzuki has already ruled the model out for most of Europe - Japanese makers historically have not done well with non-premium four-door D-segment sedans in a market that prefers hatchbacks, wagons and crossovers.

Suzuki has previously offered mid-size buyers in North America a rebadged version of a GM-Daewoo-built model line.

Source: just–auto.com editorial team

US/CHINA: BorgWarner to build turbochargers and EGR valves for FAW

BorgWarner says it has been selected to supply turbochargers and exhaust gas recirculation (EGR) valves for various cars and light commercial vehicles manufactured by First Automotive Works (FAW) in China, beginning in 2010.

BorgWarner says its turbocharging and EGR technologies will help FAW meet China 4 emissions standards, which are equivalent to Euro 4 emissions standards.

"In China, increasingly strict emissions legislation is driving the trend toward turbocharged gasoline engines with smaller displacement. Vehicles are more fuel efficient, more eco-friendly and more powerful," said Roger Wood, President and General Manager, BorgWarner turbo & emissions systems.

"When it came to developing its new engines, FAW chose to rely on BorgWarner's turbocharging and EGR expertise. Our new cooperation with FAW marks a continuation of BorgWarner's expansion in Asia."

BorgWarner's turbocharging technology will be employed for FAW's newly developed 1.3-litre and 2.0-litre gasoline engines for the compact and midsize car segment.

BorgWarner is also supplying the EGR valve for the 3.0-litre diesel power unit for FAW's light commercial vehicles, up to three tons.

All three engines will comply with Euro 4 and China 4 emissions standards.

Source: just–auto.com editorial team

JAPAN: Nissan turns over new Leaf

After a series of media briefings and the unveiling of a prototype on the new platform, Nissan Motor has finally revealed its Leaf electric vehicle (EV), billing it "the world's first electric car designed for affordability and real world requirements".

As promised, the car is a medium-size hatchback, claimed to seat five adults comfortably, with a range of over 160km (100 miles) "to satisfy real world consumer requirements", according to Nissan.

It will cost about the same as a well-equipped C-segment hatchback (GBP16,000-18,000 based on mid-range pricing of the UK's top-selling Ford Focus line) and can be recharged in 30 minutes at a 'quick charge' facility and in eight hours at home on a charger connected to domestic electricity supply.

Nissan expects owners to benefit from various government 'green' tax breaks and the reduced maintenance of an EV versus an internal combustion drivetrain should reduce running costs.

The car will come with an IT system that allows the owner to remotely programme charging times, set the air conditioner to pre-cool the cabin and access other convenience functions by remote control, internet and mobile phone.

When driving, the system monitors battery charge and power usage and provides a constantly updated list of recharge points in the area plus guidance to them via the navigation unit.

The Leaf will be launched late next year in Japan, the United States and Europe.

Nissan president and CEO Carlos Ghosn said: "We have been working tirelessly to make this day a reality - the unveiling of a real-world car that has zero - not simply reduced - emissions. It's the first step in what is sure to be an exciting journey - for people all over the world, for Nissan and for the industry."

The battery pack is a cluster of laminated compact lithium-ion batteries, and the electric motor is good for 80kW of power and 280Nm of torque.

As we found when sampling a two year old Nissan EV prototype recently (which we suspect may have had the Leaf's motor installed as under-bonnet inspection was firmly discouraged), the high torque available from start-off gives EV's brisk acceleration, ideal for the cut and thrust city driving most are likely to be used for.

Nissan promised "a highly responsive, fun to drive experience that is in keeping with what consumers have come to expect from traditional, gasoline-powered automobiles".

Though the initial 160km plus (100 miles) range on a full charge might be a bit short for some, Nissan claimed its own research found the range "satisfies the daily driving requirements of more than 70% of the world's consumers who drive cars".

Industry News

Nissan president and CEO Carlos Ghosn and the Leaf

"Our car had to be the world's first, medium-size, practical EV that motorists could afford and would want to use every day. And that's what we've created. The styling will identify not only Leaf but also the owner as a participant in the new era of zero-emission mobility," said chief designer Masato Inoue,

The Nissan EV certainly will be as distinctive on the road as Toyota and Honda's hybrid Prius and Insight hatchbacks. Styling details include light-emitting diode (LED) headlights with a blue internal reflective design that both split and redirect airflow away from the door mirrors, reducing wind noise and drag, and consume only 10% of the electricity of conventional lamps, helping conserve battery power for driving range.

Nissan's recent EV technical presentation suggested the automaker was being realistic with its goals and the launch announcement in Japan confirmed that.

"Leaf is a critical first step in establishing the era of zero-emission mobility," the company said. "However, we recognise that internal combustion engine technologies will play a vital role in global transportation for decades to come. Because of this, we are implementing its zero-emission vision through a holistic approach, which provides consumers with a comprehensive range of eco-friendly technologies from which to choose.

"For some consumers, Leaf will be the perfect match, and the only car they will ever need. For others, the Leaf will be a logical addition to the family fleet - the optimal choice for the daily commute, for example.

"While zero-emission is the ultimate goal, the company is committed to ongoing innovation in eco-friendly technologies that increase efficiency and reduce emissions."

Renault Nissan alliance zero-emission mobility programmes include partnerships with countries such as the UK and Portugal, local governments in Japan and the US, and other sectors, for a total of nearly 30 partnerships worldwide.

This should ensure the development of a charging infrastructure through public and private investment, incentives and subsidies from local, regional and national governments and public education on the benefits of zero emissions mobility, Nissan said.

The first Nisssan EVs will be made at Oppama, Japan, with additional output planned for Smyrna, Tennessee. Initial lithium-ion batteries are being made in Zama, Japan, with additional capacity planned for the US, the UK and Portugal, and other sites under study.

Source: just–auto.com editorial team

GERMANY: BMW pulls the plug on Formula One

BMW has confirmed it will pull out of Formula One racing at the end of this season for "image reasons" to focus on sustainability and the environment.

Chief executive Norbert Reithofer said: "We [think] the premium segment has to remain a positive role model within our society. We will remain loyal to motor sports, but we will do this in series that enable us to transfer technology more directly and to realise additional synergies."

Research, development and motor sport head Klaus Draeger said the sole reason behind the decision was a realignment of strategy to reflect the automaker's focus on reducing carbon emissions.

"The main reason for this decision was not our current performance or the general economic situation," Draeger insisted.

"It has been clear for some time that motorsport cannot ignore the world economic crisis," the International Automobile Federation (FIA) said in a statement.

"Car manufacturers cannot be expected to continue to pour large sums of money into Formula One when their survival depends on redundancies, plant closures and the support of the taxpayer," it added.

The FIA also said BMW's departure might have been avoided had some teams not put up resistance to regulations aimed at dramatic cost cuts.

BMW achieved eight F1 victories from 1982 to 1985 with the Brabham team winning the driver's championship with Nelson Piquet in 1983. The last win with its legendary turbo engine followed with Benetton in 1986. Ten victories were scored during a partnership with Williams (2000-2005). BMW had a total of 19 grand prix wins and 33 pole positions before the BMW Sauber F1 team era.

In its debut season in 2006, the newly established Sauber team was fifth in the constructor's championship. In 2007, the German-Swiss team came in second after McLaren-Mercedes' exclusion from the points standings.

The 2008 season saw the team in the hunt for the world championship until the end of the season, ending up third. Polish-born Robert Kubica achieved the first and hitherto only GP victory in Canada on 8 June, 2008.

So far, the Sauber team has taken one pole position (Kubica in Bahrain in 2008) and 16 podium finishes.

The team is eighth in the manufacturer's standings in the current season.

The cost of competing in F1 in the current economic downturn, against a background of production cuts and job losses, has seen automakers reconsidering their involvement. Honda pulled out of the series at the end of last season.

Source: just–auto.com editorial team (Image courtesy of Mark McArdle)

Autocar crown Evora 'Britain's Best Driver's Car 2009'

The Lotus Evora shows its pedigree by fending off tough competition from the world's best driver's cars to become the *Autocar* favourite.

The competition included rigorous road and track assessment, using the stunning roads around the South Downs and the fantastic high speed corners at the Goodwood race circuit. The feature included driver's cars from Aston Martin, Nissan, Porsche, Audi, Lamborghini and Jaguar.

Chas Hallet, *Autocar* editor, said about the Evora: "The best here. Brilliant on the track. Nimble, delicate and forgiving. Even better on the road."

Autocar magazine, in summing up the competition, added: "Decisions don't come much more clear cut than this, with nine out of ten judges placing the Evora first. This contest is about finding a car that is not only technically capable, but also thrilling and engaging wherever you drive it, and the Lotus nails those criteria".

The unique mid-engined 2+2 Lotus Evora combines a super stiff extruded and bonded aluminium chassis with decades of vehicle dynamics knowledge employed to tune its race-car derived double wishbone suspension. The result is a great driver's car that offers exceptionally high levels of ultimate grip, with performance and braking to match.

Roger Becker, Vehicle Engineering Director, said: "The dynamic ability and driving experience of the Evora were the foundation of the engineering process and we are delighted that *Autocar* has recognised this by giving the Evora this accolade. The Evora offers the great Lotus driving experience in a very comfortable, practical, refined and efficient package, and with only 205g/km of CO_2 it shows that the Evora is a supercar for the 21st century."

Luke Bennett, Director of Lotus Cars, commented: "We are really pleased to win this title as it not only demonstrates the engineering expertise and brilliant manufacturing at Lotus, but also asserts our position in this very exclusive and competitive sector. There is huge global demand for the Evora and to cope with this high demand we are taking on over 150 manufacturing staff, which is roughly a 30% increase."

Lotus Evora: 205g/km CO_2
32.5mpg (8.7 litres/100km) - Combined Cycle
22.8mpg (12.4 litres/100km) - Urban Cycle
43.5mpg (6.5 litres/100km) - Extra Urban Cycle

Source: Lotus Cars

LOTUS ENGINEERING

Hire your dream – Lotus cars now available for rental with Hertz Italy

Lotus Cars Limited, the sportscar subsidiary of Group Lotus plc, is delighted to announce a marketing co-operation agreement with the car hire company Hertz Italiana and to supply Lotus cars for its rental business in Italy.

Now driving enthusiasts, fans of the Lotus brand and those who want to drive cars from one of the finest sportscar marques in the world will be able to hire a Lotus Elise directly from Hertz Italiana S.p.A.

Lotus Elise SC sportscars will be available to hire from key Hertz centres throughout Italy from the middle of July.

Mike Kimberley, Chief Executive Officer of Group Lotus plc, commented, “I am delighted that Lotus Cars has entered into this agreement with Hertz, giving us the opportunity to make our stunning world class sportscars available to the rental market. The iconic and multi award winning Lotus Elise and the stunning Lotus Exige are the perfect fun rental cars for those who desire exclusive and high performance motoring.“

Mr. Andrea Manni, director of the official Lotus dealer, Lotus Rome said: “For many, to drive a Lotus is to fulfill a lifelong dream and now, thanks to Lotus and Hertz Italiana S.p.A. this dream can be realised for a longer period than just a quick test drive at a Lotus dealer. We expect some drivers who hire an Elise or Exige from Hertz Italiana S.p.A to visit a Lotus dealership afterwards, as once you have experienced the exciting and adrenaline fueled capabilities of a Lotus, there is no turning back!”

Ing. Giuseppe Caminiti, Fleet Director, for Hertz Italiana said: “We launched the Hertz Fun Collection last year to give our customers the possibility to drive the cars they have always dreamt of driving. The Lotus Elise SC is one of these dream cars and by including it in the Hertz’s Fun Collection our customers have an opportunity to drive a real sportscar. We are honoured to be able to work with Lotus and are delighted that Lotus has created personalised versions of the Elise SC especially for Hertz.“

To book a Lotus Elise car hire from Hertz Italy, drivers are invited to contact Hertz on www.hertz.it or by calling the Hertz call center on +39-199-11-22-11

Source: Lotus Cars

LOTUS ENGINEERING

Mike Kimberley retires

His doctors have now advised him to retire so as not to jeopardise his long term health. Under these circumstances, the board has regretfully accepted his resignation

The Chief Executive of Group Lotus, Mike Kimberley, has announced that he is stepping down from his role due to an ongoing back problem. An Executive Committee comprising current Group Lotus board members supported by the shareholder, Proton Holdings Bhd, will assume day-to-day control of the business until a successor is appointed.

Mike, who will be 71 in August, has been suffering from severe back pain for a number of months and underwent surgery in late 2008 which was only partially successful. His doctors have now advised him to retire so as not to jeopardise his long term health. Under these circumstances, the board has regretfully accepted his resignation.

Dato' Syed Zainal, Managing Director of Proton Holdings Bhd, said: "It is a great shame that Mike's health has forced his departure earlier than any of us would have liked. He has been a great asset to Lotus over four decades. Since his return in 2006, we have seen a huge turnaround in the fortunes of this great company. He leaves Lotus with our deep gratitude and our very best wishes for his retirement."

Under Mike's leadership, Lotus has produced the award-winning Lotus Evora, which was recently launched to the world's press with universal acclaim.

He has also overseen the expansion of Lotus Engineering, one of the world's most respected high-technology engineering consultancy businesses. Group Lotus now has a positive and stable platform despite the global economic downturn and is delivering against its defined growth targets in the company's strategic business plan.

Mike Kimberley said: "Sadly, it is on doctor's orders that I am stepping down but I will leave confident that Lotus is in great shape with a strong management team fully supported by our shareholder in Malaysia. It'll be very hard to leave knowing that there are such exciting times ahead but I'll take with me many very happy memories. I want to extend my thanks to the company's shareholder for their unfailing support, my management team and the wonderful staff both at Hethel and at our various operational locations throughout the world. Most of all I want to thank our Lotus customers and loyal fans worldwide for their support over the years."

Mike Kimberley – a very brief resume

Michael J. Kimberley (Mike) C.Eng., F.I. Mech. E., F.R.S.A., F.I.E.D, F.I.M.I has had a remarkable career in the motor industry over the last 56 years, working with some of the great engineers, innovators and leaders of the worlds motor companies.

Mike Kimberley retires

Mike started as an apprentice with Jaguar in 1953 before rapidly progressing to becoming Section Leader, Special Projects at Jaguar in 1965 where he lead the team developing the Jaguar XJ13 Le Mans car, under such famous names as Jaguar founder Sir William Lyons and Jaguar race director Frank (Lofty) England.

In 1969, he joined Lotus as Manager of Continuous Engineering, with the Lotus Europa Twin Cam being one of his most notable projects. Mike rose steadily but rapidly through the Lotus ranks, joining the Board of Lotus aged 37, and becoming Managing Director of Lotus Cars in 1976 and Managing Director of Lotus Engineering by 1980, being responsible for such Lotus icons as the Esprit, Eclat and Elite.

During the 1970s and 80s, Mike had the unique experience of having worked closely with the company's founder Colin Chapman, with whom Mike set up the world class Lotus Engineering consultancy to enable Lotus to work for many other cars companies around the world. Lotus Engineering is now a globally recognised high technology engineering consultancy and serves many of the world's car companies.

After Colin Chapman's tragic and untimely death in 1982, Mike became CEO of Group Lotus plc, as well as holding board positions with a number of Lotus associated companies such as Chairman of Millbrook Proving Ground and President of Moog Systems Inc. With Lotus under General Motors ownership, Mike became Chairman of Group Lotus plc before leaving Lotus in 1992 to become Executive Vice President (General Motors Overseas Corporation) based in South East Asia. Two years later, Mike became director of the Vector Aeromotive Corporation, and in 1994, he became President & Managing Director of Automobili Lamborghini S.p.A, being responsible for the rebuilding of Lamborghini after Chrysler's ownership and prior to its sale to Audi AG, as part of the VW Group. In the mid-1990s, Mike left Lamborghini and worked directly for Tommy Suharto as a board member of Timor Putra Nasional (owners of Lamborghini) until retiring with an undiagnosed tropical fever.

Returning to the automotive industry a few months later, Mike worked in a consultancy role for a number of organisations including Tata Motors Ltd.

In August 2005 Mike was appointed to the Lotus Group International Limited and Group Lotus plc Boards as

well as other Boards of Proton. He was appointed acting Chief Executive Officer of Group Lotus plc in May 2006, and confirmed as Chief Executive Officer of Group Lotus plc in September 2006.

During his second tenure at Lotus, Mike has been responsible for the creation and execution of a new five-year strategic business plan, and the new, already award-winning Lotus Evora is the first of the range of new Lotus cars to be designed, developed, manufactured and sold by Britain's most iconic and innovative sportscar company. Lotus Engineering has expanded to become a world-class consultancy employing over 500 highly qualified engineers in five technical centres around the globe. It is revered for innovation, outstanding driving dynamics, exciting niche vehicles and efficient performance engineering.

Mike (70) is married with three children and six grand children and lives in Norwich.

Source: Group Lotus

LOTUS ENGINEERING

Safety fast - Crash management for the Lotus Evora

From the outset the Evora was to be a global car. It would have to meet the many different crash requirements around the world and offer the best crash performance of any Lotus so far. From a clean sheet of paper to production within 27 months, it needed to be designed for safety…. and fast.

The key crash safety requirements are for Europe and the US. For Europe, there is a front crash test, where the vehicle is crashed into a deformable barrier aligned with one side of the vehicle at 35mph, and a side impact test where the vehicle is impacted by a deformable barrier of 1000kg at 30mph.

For the US, the main tests consist of a 35mph impact into a rigid barrier across the full width of the vehicle, a side impact, again with a deformable barrier at 30mph but with a mass of 1350kg, and at a crabbed angle, and a rear impact from a 1350kg barrier at 50mph. There are many other test requirements, encompassing unbelted occupants, roof crush and door strength etc, but this article is focussed on the structural requirements for the main front, rear and side impacts.

The key aspect of designing a vehicle structure that provides good crash performance is managing the energy of the impact and minimising the load on the occupants. For a front impact event the fundamental requirement is to design a structure that provides the required 'crash pulse' that enables the safety engineers to design and develop a suitable restraint system: the air bags, seat belts, pretensioners etc.

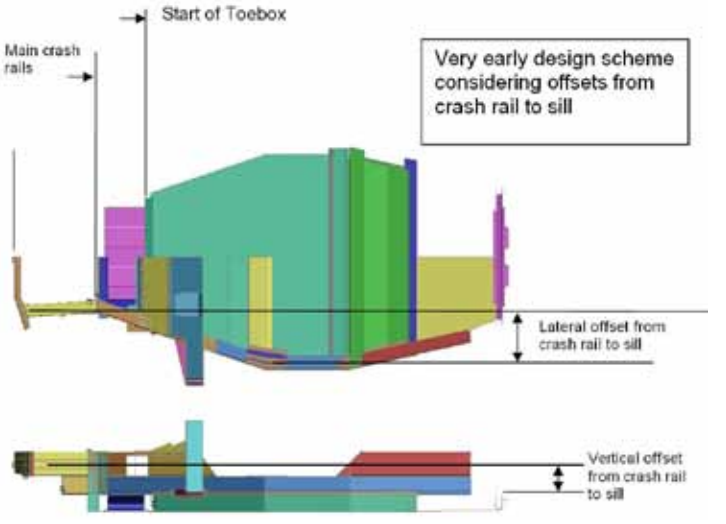
The crash pulse and the restraint system are designed to minimise the loads transferred to the occupants, slowing them down in a controlled way and over the longest distance possible. The structure must also provide a rigid passenger cell to limit intrusion in to the occupant space.

A 'crash pulse' is the term given to the relationship between acceleration and time. In its simplest form, this could be a square wave type pulse with an average acceleration over a given period of time. The deceleration of the vehicle is fundamentally a function of the distance over which the vehicle is brought to rest. For a given speed the longer the stopping distance, the greater the time to slow the vehicle down and therefore the lower the acceleration. The mass of the vehicle only affects the crush force the vehicle structure must provide.

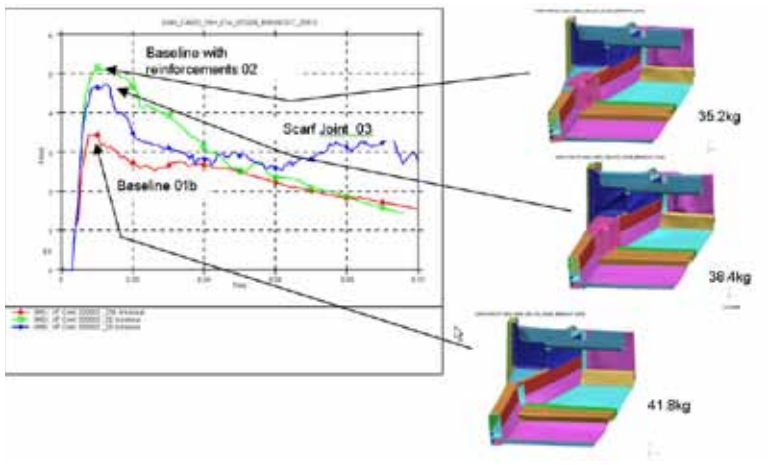
For example, if a 1,000kg vehicle comes to rest over 0.5m, the average acceleration will be the same as a 10,000kg vehicle coming to rest over the same 0.5m, but the force generated by the structure would need to be 10 times higher for the heavier vehicle.

For legislative front and side impact events at 30-35mph, the typical duration of the impact is only 70 to 150 thousandths of a second (70 to 150ms), less than the blink of an eye. This is the part of the impact where the loads and accelerations are high although the vehicle may not fully come to rest for many seconds.

At the start of the Evora programme, one of the key design parameters that had to be defined was the



Initial crash rail and sill geometry



Crush force capability of sill joint design concepts

LOTUS ENGINEERING

Military precision – How defence departments are turning to the automotive industry

Modern warfare against small groups of highly mobile enemy, often in urban or suburban environments, has caused a rethink of what sort of vehicles will be used in the future by the world's major armed forces.

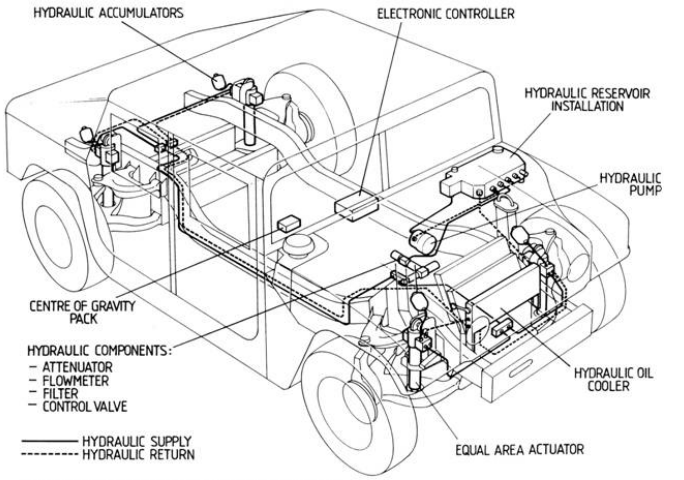
And this is not the only stimulus for change; as in all other areas of transportation, environmental issues and cost considerations are being brought to bear on the defence industry. It has been calculated, for instance, that by the time the US Army has installed an in-theatre infrastructure and shipped in its own fuel, it costs up to US$600 per gallon – in this context even a minor improvement in vehicle fuel economy will have a major impact on defence spending.

Defence departments in Britain and the US are increasingly turning to the automotive industry to find innovative solutions for their transport requirements and examining which existing and developing technologies from the automotive and motorsport arenas could be applied to the military environment; from Lotus Engineering's perspective, the response to that enquiry is a significant number.

Lotus Engineering is no stranger to military operations. In the early 1990s it developed an Active Track Tensioning Programme for the Scorpion tank to improve its stability as a gun platform on the move, and it also trialled active suspension on that great US military stalwart, the Hummer H1. Lotus is currently working with several Tier 1 suppliers on a variety of military transport projects, while last year over in Michigan, approximately 60% of Lotus Engineering's US division's business was military related. With the current shift in emphasis towards military vehicles that are lighter and more fuel efficient, not to mention purpose-designed to integrate increasingly complex electronics systems, what's now interesting for Lotus Engineering is how much of its skills and technologies are readily transferable.

Take powertrains, for instance. The US military's desire for lighter vehicles with more fuel efficient powerplants already sees Lotus working on next-generation diesel engines for a Tier 1 defence supplier and much of the testing in our Michigan-based engine test cells is military related.

Looking further forward with regard to engines, one of the latest advanced engine technologies in the Lotus research portfolio has great potential for the defence sector.



ACTIVE HMMWV - SYSTEM SCHEMATIC


Lotus trialled active suspension on that great US military stalwart, the Hummer H1

LOTUS ENGINEERING

Safety fast - Crash management for the Lotus Evora

"Real World" energy absorbing crush behaviour

Ideal energy absorbing crush behaviour

front overhang and the available crush length. There are conflicting requirements between the crash and safety engineers, who want the longest crush length they can have, and the stylist and package engineers' desire for the shortest length to minimise the weight and size of the vehicle and achieve the vehicle style. Trade-off studies are conducted and eventually a compromise is reached to best meet the requirements of the vehicle.

With a mid-engined vehicle, the crash analyst has a slightly easier time than for say a front-engine, front wheel drive platform. Without the engine package in the way, it is possible to engineer a less compromised structure. The crush elements at the front of the vehicle (the crash rails) perform more efficiently if they can be kept straight.

However, trying to incorporate the front wheel package and passenger space usually corrupts this ideal configuration. A straight line from the crash rail to the rear of the vehicle gives the lightest, most efficient solution. For the Elise, this problem was solved with a stretch bent sill member that was effectively straight from the rear of the crash structure to just behind the seats.

For the Evora, greater interior space was required together with larger front tyres and a greater steering back lock, (for catching those opposite lock moments!) all of which meant that the crash rail and sill had to incorporate a considerable offset. The 'kink' that results from this offset was the subject of several design iterations to obtain the best solution.

Several joint combinations were considered: scarf-type joints, cut, bent and bonded and combinations of local reinforcements. The main sill joint has to be capable of reacting the full crash load which, for the Evora, can be up to 40-50 tonnes. Simulation models were generated for different joint sections and analysed to select the best combination of performance and weight.

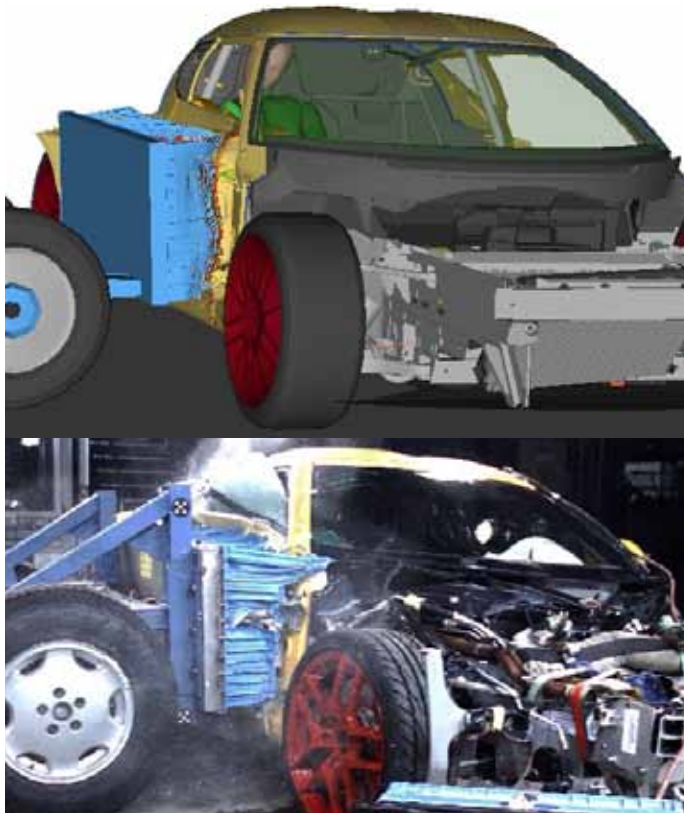
Added to these complications, the Evora had to be a car that could be used every day with much easier ingress and egress than an Elise, which resulted in the requirement for a lower thinner sill.

After basic initial sizing, the crash analysts use computer simulation models or Finite Element (FE) models to mathematically simulate the behaviour of various design options to enable the selection of the most efficient structure. As the design develops, a full vehicle Finite Element model is generated to simulate the crash events.

In the Evora front impact, crash energy is absorbed by crushing the aluminium longitudinal members. This is achieved by multiple folding of the material which is an efficient method of absorbing energy. The ideal behaviour is very symmetric and even. In practice, due to the multiple cells of the extrusion, design requirements for the suspension and other components packaged at the front of the vehicle, it is difficult to achieve the idealised crush behaviour but it is still possible to achieve efficient energy absorption.

The pictures to the right show a comparison between the full vehicle FE models and the physical tests. The use of simulation tools and being able to develop the performance of the vehicle on a computer meant there were no unpleasant surprises when the prototype vehicles were crash tested.

Safety fast - Crash management for the Lotus Evora



European legislative 30mph side impact simulation and test

With such a short programme the design had to work first time.

A further requirement for Evora was to significantly improve the repairability of the structure, and also to have complete front and rear modules to simplify the manufacturing process. The design solution that was selected consisted of a very stiff and strong extruded and riv-bonded aluminium central tub with a bolt-on extruded aluminium crash structure/front subframe and a bolt-on fabricated steel rear subframe. This gave the ability to repair the vehicle after low speed crash damage by unbolting and replacing the front subframe. This modular approach greatly assisted the test development programme as it meant that vehicles could be rebuilt and re-used after low speed (15-20mph) crash tests. Typically, low speed tests are used to develop airbag no-fire/must fire behaviour and, after these tests it was possible to rebuild the vehicle using the same central tub ready for a high speed test. In fact, even after a high speed impact at 30-35mph, the damage to the central tub, although not repairable to an 'as new' condition, was minimal. The integrity of the passenger cell was shown to be extremely good with footwell deformation typically less than 10mm and minimal deformation of the door apertures such that both doors could be easily opened after the test.

For side impact, there is much less space to absorb the energy of the impact so the structure must be very stiff and strong to minimise intrusion into the passenger space and enable the vehicle to be pushed out of the way rather than be deformed. To achieve this with the Evora structure there is a high strength tubular steel seat belt anchorage frame that is substantially connected to the sill section, which forms the B-pillar, and loops over the top of the occupants. This is connected to a secondary frame at the rear bulkhead with diagonal bracing running to the rear subframe. The door structure, which consists of a 7000 series high strength aluminium door beam, connects the tubular B-pillar to the door hinge on the extruded aluminium A-pillar. This structure

European legislative 35mph Offset Deformable Barrier (ODB) impact simulation and test

Federal legislative 35mph rigid barrier impact simulation and test

LOTUS ENGINEERING

Safety fast - Crash management for the Lotus Evora

together with the compliant design of the door trim and the wrap around form of the seat contribute to give the Evora excellent protection from a side impact.

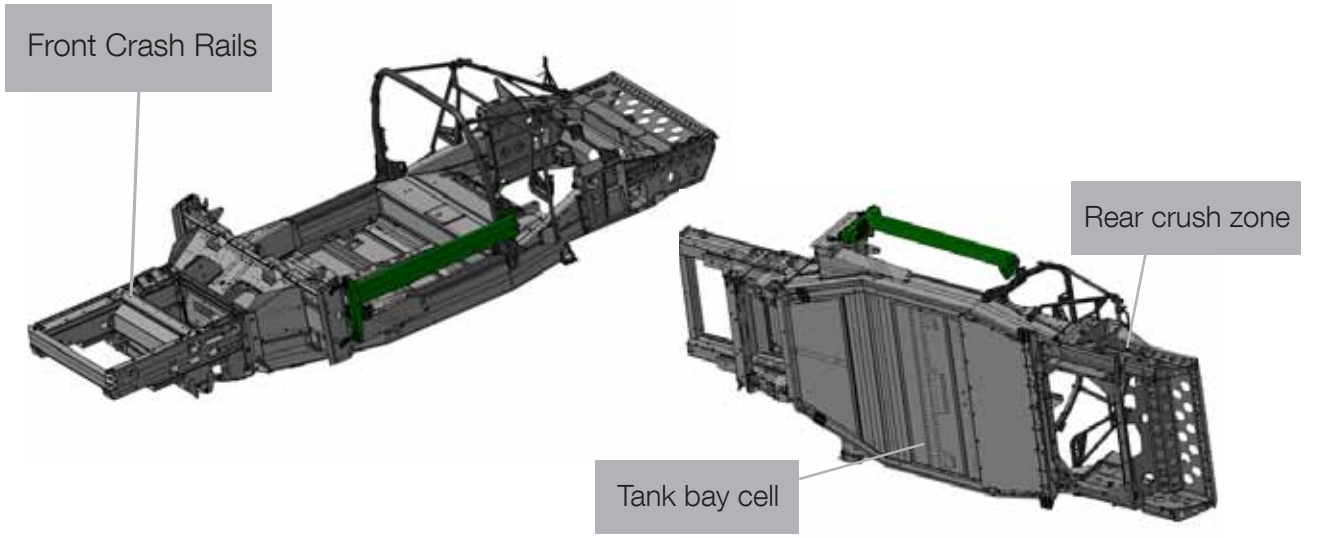
For the Federal market there is a requirement for a high speed rear impact that is primarily focused on fuel integrity i.e. after the test, the vehicle must not leak any fuel. The vehicle is impacted by a 1350kg deformable mobile barrier at 50mph offset slightly to one side of the vehicle. In the Evora the stainless steel fuel tank is protected in a central cell of the chassis with extruded aluminium crossmembers front and rear and aluminium skin panels. The engine is mounted to the rear subframe via 4 engine mounts and the rear of the subframe has crushable elements to absorb some of the impact energy.

As the barrier impacts the vehicle some of the energy is absorbed by the crushable elements of the rear subframe and then the barrier contacts the rear wheels and lower wishbone which start to move the vehicle forward. By managing the load paths into the structure and retaining the engine there is effectively no deformation of the fuel tank cell or fuel tank and no intrusion into the rear bulkhead. The photos (middle column, bottom row) show the rear bulkhead after the rear impact and a comparison of the FE simulation model and the physical test.

This brief article gives an insight in to the design and engineering effort that has been put in to make the Evora such a stunning and safe vehicle.

Next time you see, or are fortunate enough to be in, an Evora hustling down a demanding country road, spare a thought for the engineers and designers at Lotus who have made it the awesome car that it is.

Source: Dave Marler, Lotus Engineering



Evora structure (body panels removed) showing rear crush zone and protected tank bay cell

Rear bulkhead area after Federal legislative 50mph rear impact showing negligible deformation

Federal legislative 50mph rear impact simulation and test

LOTUS ENGINEERING

Q&A with Cenex CEO Robert Evans

Cenex has been created with the aim of bringing together the many UK organisations demonstrating excellence in specialist fields related to low carbon and fuel cell technologies. It is a UK government initiative, supported by the Department of Business, Innovation and Skills (BIS) and automotive industry technology is at the heart of its activities. just-auto's editor Dave Leggett recently spoke with Cenex CEO Robert Evans to find out more.

DL: What's occupying your time at the moment?

RE: Two things stand out: driving through the outputs of the projects we are running and also providing engagement, advice and support for some of the new initiatives we are involved with. On the programme side, we are launching – on behalf of the Department of Transport – grant funding for providing low carbon vehicle refuelling infrastructure. The Department of Transport has allocated GBP1m to be spent over two years for things like electric charging points, hydrogen stations and natural gas and bio-gas stations.

In the build-up to the launch of that I have been lending a hand to the team.

And then, with the low carbon vehicle public procurement programme, we have just announced the successful bidders for that programme and the team is engaging with public sector fleets to place the successful bidders' vehicles into small fleet demonstration in that programme.

Those are some of the programme outputs that we are doing.

On a personal level, I am also involved at the moment in work we are doing with Regional Development Agencies, which we are working with to identify opportunities to support local participant firms' engagement in low carbon vehicle Research, Development and Demonstration (RD&D) projects.

DL: In a nutshell, what does Cenex do – what is its mission?

RE: We were set up to try and accelerate the development and deployment of low carbon vehicles, particularly looking at the market transformation and the deployment of low carbon vehicles within a framework that strengthens UK industry in this area and a long-term competitive gain for the UK.

We are very much about supporting the development of the UK's low carbon automotive sector.

That's what we were set up to do, but increasingly we are working on behalf of national and regional government to help them deliver their strategic objectives – jobs, carbon reduction and so on – through this low carbon innovation system. We are working between government and industry and running projects on behalf of government and Regional Development Agencies.

We also work closely with industry to help industry access funding and know the best places to go within the funding landscape to support their projects and business development aims.

So we are kind of an interface really, between public sector funding structures and an industry that is seeking to commercialise and grow and develop low carbon automotive solutions.

The challenge in this is that the market in itself would just not deliver without facilitation and support.

DL: When was Cenex formed?

RE: Cenex was formed in 2005 and it was actually a recommendation of the first Automotive Innovation and Growth Team - which brought together senior players in the UK industry and public sector to look strategically at the future of the auto industry and how to facilitate growth in the UK. Intelligent Transport Systems (ITS) and low carbon technologies were identified.

At that stage, the Department of Trade and Industry's Automotive Unit – as was – formed Cenex as a single-purpose organisation with a brief to connect together what was viewed as a fragmented landscape of UK capabilities in this area.

Q&A with Cenex CEO Robert Evans

Subsequently, the whole idea of low carbon technologies – in terms of strategic importance for the UK motor industry – has gone further up the agenda and our role has expanded to become a programme deliverer for a whole range of public sector organisations beyond just the DTI's Automotive Unit. Our work is now very much about project implementation and working closely with industry – rather than simply giving advice.

Working with early innovators in the vehicle user community has become much more important. These are organisations that want to deploy low carbon vehicles. Fleets and niche vehicles are an area we are becoming very active in because that is one of the first early markets for low carbon vehicles.

If we don't have markets for these vehicles then there is no point in producing them.

DL: It's interesting to hear of the 'facilitator' role that Cenex has, acting to coordinate strategic objectives that come from government with industry, but - on a philosophical level – couldn't it all be left for market mechanisms to sort out?

RE: We are needed to help government understand how it can support this emerging sector. This is a technologically very complicated area - in terms of new technologies, technology propositions at varying degrees of development and the electrification of transport is a very new and developing theme. It's complex for the government to know how it can assist companies and if government doesn't assist, then UK competitiveness could fall away. And that is particularly the case in these challenging times for the motor industry.

When transitioning from R&D to demonstrations and deployment, industry needs initiatives to help secure investment because the uncertainties and risks are so high at this early stage of development.

The business cases are not clear enough at this stage to say 'industry or users will invest'. There is a need for facilitation and support.

DL: Who are the key participants in the programmes you run? Are you working with vehicle makers for example?

RE: We are, but we have got a wide active engagement across our programmes and projects. We estimate that we have engaged with more than 150 supply chain organisations in terms of helping them to steer their way through this landscape and do things like effectively identify funding opportunities, find partners for projects and so on. We are very much trying to help steer organisations and companies through this landscape.

We are not major sponsors of industry programmes in the sense that, say, the car companies do have their own R&D programmes and quite large budgets.

There's a wide range of companies we are working with all along the supply chain, especially technology providers and potential early adopters - people like Royal Mail, Transport for London and so on - on the user side.

Q&A with Cenex CEO Robert Evans

DL: Can you mention any vehicle makers you are working with?

RE: Toyota's next phase of UK plug-in hybrid trials will be conducted as part of a programme we are running. We have also worked in partnership with Mercedes UK on its first 100 vehicle electric Smart car trial. But it's not so much mainstream car companies in the projects that we are running at the current time. We are working with a variety of engineering companies and tech companies, firms that can help in the development of niche low carbon vehicle applications.

DL: In terms of Cenex's activities, can you identify particular strands of Cenex activity and strategy that are important to push right now?

RE: The electrification of road transport is a very important agenda. I think in the motor industry it is recognised as one the key pathways to de-carbonising road transport. But there is a great deal of uncertainty concerning how consumers will respond to electric vehicles and what type of infrastructure will accompany their introduction, as well as what sort of incentives may be required to assist the deployment of electric vehicles and ultimately how quickly they can become a cost-effective proposition.

We have done a lot of work in early niche markets for electric vehicles and we are feeding our input into a larger government project called 'Test Bed UK' which will result in much larger numbers of electric vehicles deployed over the next five or so years,

There's also the question of where hydrogen fuel cell technology fits in to that emerging picture Cenex is working with Royal Mail, which is very interested in deploying hydrogen fuel cell vehicles in its fleets.

Bio-gas is another interesting application area for us and we are working with a number of supermarkets and other organisations with a strong CSR (Corporate Social Responsibility) agenda to cut their carbon footprints. These organisations have set targets for carbon reduction that are more aggressive than those of the mainstream vehicle manufacturers. So they are especially interested in the combination of low carbon vehicles and low carbon fuels.

DL: What about bio-methanol?

RE: Yes, that's an interesting one, too. If we really want to drive carbon out of the system it is a combination of low carbon vehicle technology allied to low carbon fuels. I know Lotus has undertaken plenty of work on flex-fuel vehicles that can run on different types of alcohol fuels as well as petrol.

I expect there to be more interest and activity in the area of methanol, certainly. And direct methanol fuel cells are quite interesting, too. They were developed for portable small electronic device applications – like PDAs and e-book readers – but they are moving into small transport applications.

The main downside with methanol is that it is a fairly toxic fuel and it causes problems if it gets into waterways. Fuel spillages for petrol and diesel are not uncommon, so that is something to consider.

But it's knowing and understanding the business models that could develop that's important, alongside the opportunities for UK companies.

Robert Evans

Robert Evans is Chief Executive Officer of Cenex, the UK's national Centre of Excellence for Low Carbon and Fuel Cell Technologies.

Cenex was established in 2005 to assist the UK motor industry supply chain development in the area of low carbon vehicles. Cenex manages, for the public sector, programmes and projects designed to help deliver stakeholder strategic objectives (market transformation, environmental improvements, job creation, inward investment, etc) through accelerated development and deployment of low carbon vehicle technologies. Outputs of Cenex-run programmes include procurement exercises and small fleet demonstration of new low carbon vehicles, strategic studies and accelerated knowledge transfer within the low carbon vehicle community.

Robert has more than 15 years experience in developing markets for environmental and automotive technologies including those for low carbon vehicles, vehicle emissions control technologies and fuel cells.

Robert has been awarded a Masters in Management Science from Imperial College London and a Masters in Corporate Affairs and Communitication (Motor Industry) from Leeds Trinity and All Saints University.

Q&A with Cenex CEO Robert Evans

Image courtesy diusgovuk

We're involved right from research and development through to demonstration and deployment.

We are particularly interested in the 'Valley of Death' phase – lots of R&D has been done, but then huge commercial investments are needed on the part of the technology providers and end-users in order for those new technologies to be adopted. That is a really challenging phase.

You also have to overcome the inertia to change and a resistance to new technologies and fuels. It's partly about acting as a change agent, helping organisations who want to go faster than the ambient pace of technology shift in the industry.

We are seen as supporting fleet operators wanting to adopt the revolutionary as opposed to the evolutionary.

The trials we are supporting assist both the fleet operators to plan for the adoption of low carbon vehicles and fuels into their fleets, as well as assisting innovators in the UK motor industry supply chain to see their technologies proven out in real world operation as a vital step on the way to being adopted by mainstream motor manufacturers.

The whole push of low carbon, for us, is about accelerating these processes and achieving a competitive advantage for the UK.

DL: Isn't fuel cell technology – in a significant sense - quite a long way off?

RE: I've worked in and around fuel cells for quite a long time and it's always been described as having a long gestation period. We are though beginning to see commercial sales of fuel cells into some niche applications. In the area of transport it has always been very challenging because of the performance and cost considerations.

What we are seeing is fuel cells being deployed in easier areas, for competitive advantage.

The latest one, that is attracting a lot of interest, is fork-lift trucks where there is a battery replacement opportunity.

We are starting to see those first commercial markets for fuel cells. As far as fuel cells for transport are concerned, product development is being driven by Californian regulations – the zero emissions vehicle mandate is still a significant driver pushing interest in fuel cells.

But market introduction is beyond the 2015 timeframe for anything other than small niche vehicle applications.

We are working with technology companies across the UK and organisations that want to be early adopters.

When it comes to low carbon automotive technology, the industry itself has a roadmap – the Automotive Innovation Growth Team Roadmap – and organisations running large transport fleets are starting to have their roadmaps, also. The fleet operators want to know when hydrogen fuel cells are coming down the line, what will be the penetration of electric vehicles – in terms of their fleets, and so on.

They are looking at future investments in terms of reducing fuel costs – as well as diversifying fuel use to hedge against the volatility of oil pricing. These organisations are looking strategically at the long-term future for their businesses. They know that they will need to transition from dependence on fossil fuel in their operations.

There is genuine interest out there in hydrogen fuel cells because you get the zero emissions that battery electrics offer but with rapid refuel times – it's an attractive technology that a lot of motor industry players are working on.

DL: When do you think fuel cell vehicles will be mass market or at least constitute a major slice of the vehicle market?

RE: Based on the more aggressive scenarios, electric vehicles with batteries might constitute 5% of UK vehicle sales by 2020. With fuel cell vehicles you are

Q&A with Cenex CEO Robert Evans

Cenex worked in partnership with Mercedes UK on its first 100 vehicle electric Smart car trial, here being trialed by the Metropolitan Police Service

looking beyond the 2020-2030 timeframe for anything major. But mainstream vehicle makers talk of 2015 as when we will be seeing the beginning of the early launch of fuel cell vehicles. It is going to be interesting to see, because some fleets want to be early adopters and within the next decade we will start to see whether the technology is going to make a serious market breakthrough.

But one of the challenges in this work space is that the technology can always prove you wrong in the sense that the wider penetration of pure battery electric vehicles is going to depend on advances in battery technology and the wider development of hydrogen fuel cells will depend on breakthroughs in hydrogen storage on board vehicles and improvements in fuel cell durability and cost. There are uncertainties over the speed at which these developments may happen, giving rise for some technologies leapfrogging others.

The internal combustion engine is here to stay in the mainstream for the foreseeable future. The question is, can the other technologies gain strategic niche markets to begin with and then develop beyond that?

DL: Cenex has a clear UK brief, but how does it play into the international field?

RE: We do a number of international activities – for example, we work with UK Trade and Investment (UKTI – a government organisation), looking at supporting the inward investment of companies looking to bring jobs and capability to the UK automotive sector. In the low carbon area we are offering advice and support to UKTI and we get involved in the supporting dialogues that the UK government has with the Japanese auto industry, Indian auto industry and so on.

The other area where we get involved internationally is in making sure that the UK is not reinventing the wheel when it comes to lesson learning, for example from the early demonstrations of low carbon vehicles. We are very much involved in looking at international collaboration and we are making connections as part of the push for early demonstrators on low carbon vehicles globally over the next five-ten years.

We are part of the process of international knowledge transfer in the low carbon vehicle area, but the industry that we are looking to help is the motor industry in the UK as part of driving UK carbon reduction.

DL: And you are confident that the UK has the sort of capabilities, expertise and critical mass to be at the forefront of the sort of technologies you are talking about?

RE: Yes. When we were first established it was already clear that the UK has leadership capabilities in this field – but it's in pockets or areas and somewhat fragmented. That meant that it was difficult for the UK government to put in place policy initiatives specifically

Q&A with Cenex CEO Robert Evans

The newer model Iveco Daily operating on biomethane displayed an overall 6% reduction in fuel consumption

to support those emerging pockets. It was a problem of reach, in terms of those disparate companies.

What's happened is that a community has developed and grown, helped by organisations like Cenex and others – like the Technology Strategy Board through its Low Carbon Vehicle Innovation Platform.

The new Automotive Innovation Growth Team has just commissioned some work on UK capabilities to identify the key areas where the UK can compete internationally and also what areas where maybe it doesn't make sense for the UK to try and compete.

What we see is strength in a number of areas and also some areas where there is an opportunity for inward investment to fill some gaps. The government is interested in 'sticky' technologies in the sense that if you support their research and development, they will stay in the UK.

The integration of cells into battery management systems is an example where the UK has a strong capability, but the cells themselves typically come in from overseas. The research area in the UK is developing new and better materials for batteries – but without inward investment it may well be that those batteries are ultimately made elsewhere.

However, Nissan's recent announcement shows that battery manufacturing investments can happen in the UK.

The UK has an opportunity to be competitive in some key areas, but when you support innovation there are no guarantees that everything you support will be successful. It's a risk and reward kind of approach. Some will be successful and some less so – or put another way, they won't realise their potential.

The outlook is promising as we see good growth opportunities and some very strong players in individual technology and market sectors.

DL: How do you measure the achievements and the success of the work you do?

RE: That's always a challenge. What we try to do is agree key performance indicators or output measures with the sponsoring government departments and organisations we work with.

It's always a challenge to be clear cut about such things. We're involved with technologies that are at an early stage of development and I like to look at the number of organisations engaging in the programmes that we run – be it procurement, collaborative R&D or demonstration activities. Eventually we'll be able to link the organisational engagement and project outputs through to numbers of vehicles on the road that follow on from the projects that we have run.

DL: What gives you personal satisfaction in your role?

RE: It is hugely rewarding to work in an area that contributes to environmental objectives and the space we are in is a hugely challenging one. De-carbonising road transport is a critical element in addressing big issues like climate change and energy security.

But for me, on a personal level, assisting market transformation, is the real motivator. Seeing the introduction of low carbon vehicles into the marketplace and helping the early innovators to be successful gives me great satisfaction. That it is also contributing to things like reducing CO_2, promoting energy security and so on is obviously very welcome, but to me it's the market transformation aspect of our work that I find particularly rewarding.

And Cenex is a change agent, facilitating that vitally needed change in the marketplace and doing it in a way that helps to promote UK industrial competitiveness in what will be a growth area for the future.

Source: Dave Leggett, just–auto.com

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Improving the world through engineering

Military precision – How defence departments are turning to the automotive industry

Modern warfare against small groups of highly mobile enemy, often in urban or suburban environments, has caused a rethink of what sort of vehicles will be used in the future by the world's major armed forces.

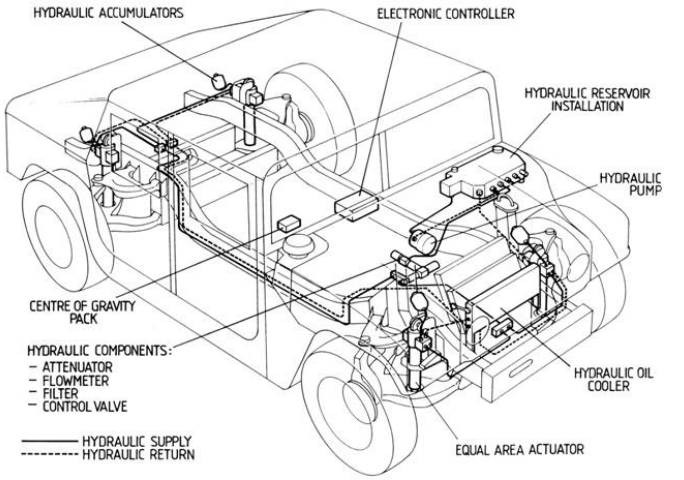
And this is not the only stimulus for change; as in all other areas of transportation, environmental issues and cost considerations are being brought to bear on the defence industry. It has been calculated, for instance, that by the time the US Army has installed an in-theatre infrastructure and shipped in its own fuel, it costs up to US$600 per gallon – in this context even a minor improvement in vehicle fuel economy will have a major impact on defence spending.

Defence departments in Britain and the US are increasingly turning to the automotive industry to find innovative solutions for their transport requirements and examining which existing and developing technologies from the automotive and motorsport arenas could be applied to the military environment; from Lotus Engineering's perspective, the response to that enquiry is a significant number.

Lotus Engineering is no stranger to military operations. In the early 1990s it developed an Active Track Tensioning Programme for the Scorpion tank to improve its stability as a gun platform on the move, and it also trialled active suspension on that great US military stalwart, the Hummer H1. Lotus is currently working with several Tier 1 suppliers on a variety of military transport projects, while last year over in Michigan, approximately 60% of Lotus Engineering's US division's business was military related. With the current shift in emphasis towards military vehicles that are lighter and more fuel efficient, not to mention purpose-designed to integrate increasingly complex electronics systems, what's now interesting for Lotus Engineering is how much of its skills and technologies are readily transferable.

Take powertrains, for instance. The US military's desire for lighter vehicles with more fuel efficient powerplants already sees Lotus working on next-generation diesel engines for a Tier 1 defence supplier and much of the testing in our Michigan-based engine test cells is military related.

Looking further forward with regard to engines, one of the latest advanced engine technologies in the Lotus research portfolio has great potential for the defence sector.

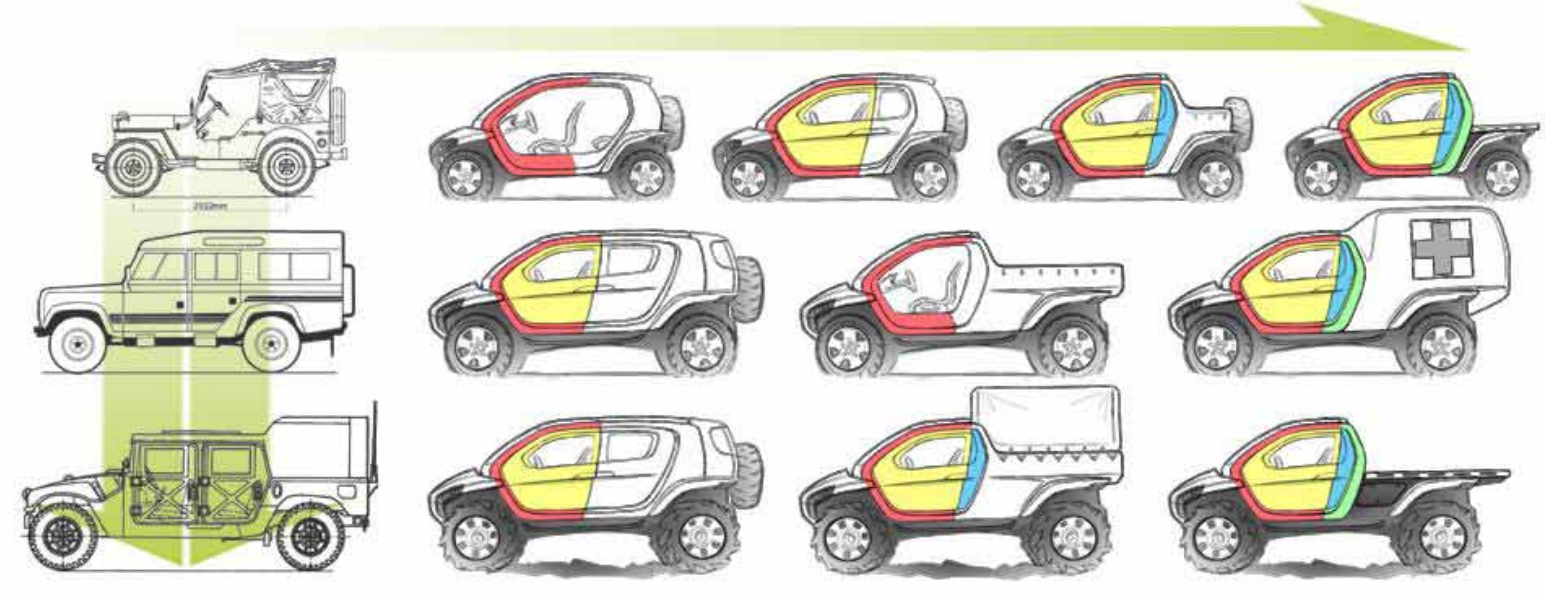


ACTIVE HMMWV - SYSTEM SCHEMATIC


Lotus trialled active suspension on that great US military stalwart, the Hummer H1

LOTUS ENGINEERING

Military precision – How defence departments are turning to the automotive industry



The advanced engine concept, OMNIVORE, can be run on a number of alternative and fossil fuels and thanks to its variable compression ratio and Homogeneous Charge Compression Ignition, it is able to operate with optimised efficiency whatever the mixture of fuel. In theatres of war where fuel quality is patchy and supply erratic, the OMNIVORE concept's ability to adapt to what is currently available would help keep troops mobile.

Another important requirement of the British and American militaries is to reduce fossil fuel dependence. Whilst the ability to run on non-fossil fuels is part of this, so are hybridisation and electrification. Hybrids and electric vehicles, of which Lotus Engineering has much experience for numerous automotive clients, also offer advantages in cutting fuel consumption. Hybrids, in particular, have tremendous battlefield potential; when not moving they can sit silently, with command and communications teams still able to operate electronic equipment using the power stored in the vehicle's batteries. Our ongoing research into lighter, more powerful batteries, supercapacitors, range extender engines and whole vehicle energy management for passenger car applications has particular relevance to the military market as it shifts towards greater reliance on powered weapons.

Lotus is also a strong advocate of hydraulic hybrid technology in the defence sector. It provides excellent fuel economy, it's a known commodity and, in crude terms, can be fixed with spanners during operational duties.

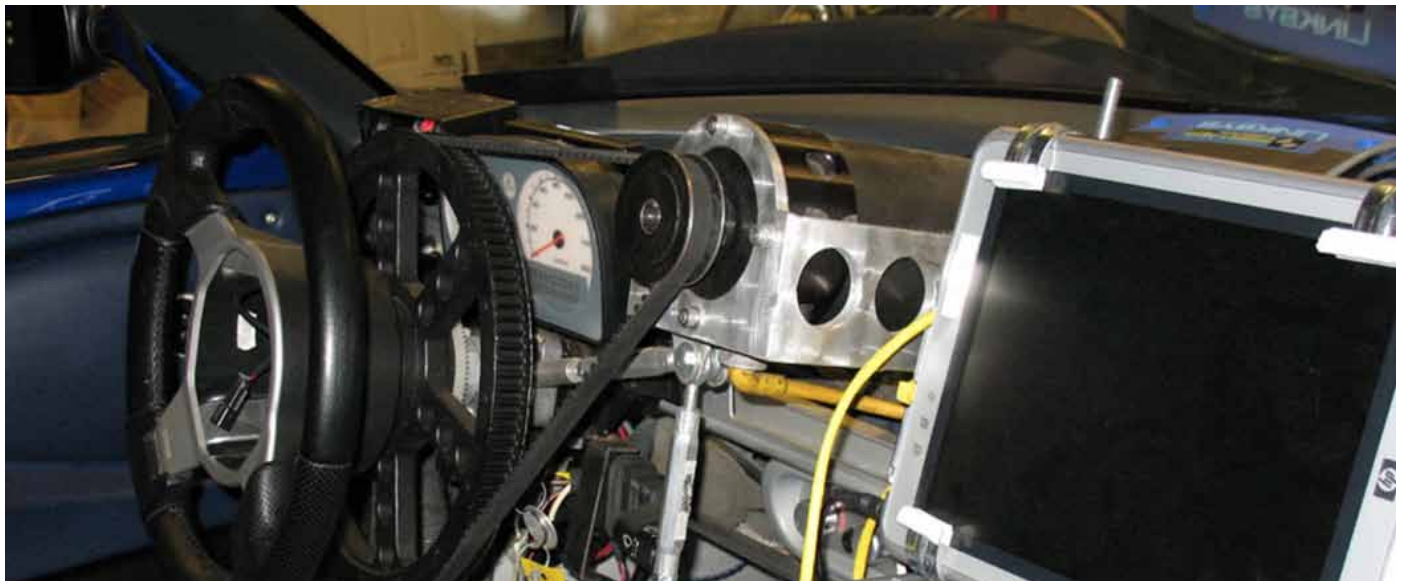
As well as being stealthy, hybrid vehicles can be made to be supremely manoeuvrable in tight situations; provided the vehicle in question uses an electric motor to power each wheel, then individual wheels can be programmed to be rotated individually, allowing the vehicle to about-face on the spot, in the same way that a tracked vehicle can. This is a clear benefit in the urban environment in which the military increasingly has to operate.

The quest for better fuel consumption in military vehicles isn't solely linked to engine technology, of course. Lightweight structures are a crucial complement to improved powertrains, and Lotus has a long history of not merely designing them, but manufacturing them, too. The multi-award-winning Elise sports car employs large aluminium

extrusions with minimal joints, marrying lightness with great strength, while Lotus' recent work with Versatile Vehicle Architecture (VVA) and other modular structures takes our lightweight chassis technology to the next level, where easy-to-facilitate modularity lends itself to producing several different vehicles from the same basic platform.

In a military context the virtue of lightness on its own clearly isn't sufficient; vehicles also need good survivability characteristics from rocket, ballistics and mine attacks. Lotus has vast experience of developing crash structures, particularly from lightweight composite materials, and lessons learned from motorsport can also be applied here – in a high-speed accident the open wheels of a Formula One car become sacrificial components, helping to dissipate the crash energy before it reaches the driver's compartment. Military vehicles could harness the same basic principle to provide extra protection against roadside explosives.

Lotus Engineering's active control was mentioned earlier in this article, and with recent developments in software and hardware, the technology is now even more appropriate to military applications. On gun-firing vehicles active ride provides a stable and therefore more accurate platform from which to shoot while on the move. And the ability to smooth out the ride across rough ground has great benefits for troops being transported swiftly to the battlefield: because they're not being buffeted around violently inside the vehicle, they arrive at the front line less fatigued and with far less chance of being injured by their own transportation.



Inside Lotus Engineering's Autonomous Elise, nicknamed Lone Wolf

Delivering troops in the freshest possible condition to the battlefield has become a major consideration with the armed forces, and in addition to active ride, Lotus Engineering's active noise control system perfectly addresses this concern. The din inside a noisy vehicle can fatigue troops both mentally and physically – the active noise control system reduces that stress, while at the same time making it easier to hear what's going on outside the vehicle.

In its role as a passenger car engineering company, Lotus is accustomed to engaging in whole vehicle development programmes that encompass varied legislative requirements from around the world. This capability and our wide experience of working on many different projects, means, that we are well placed to develop military vehicles from concept to production. Having had to design the new Lotus Evora to accommodate the 99th percentile male frame and a mid-engined, 2+2 layout within an agile performance car , Lotus is more accomplished that most at balancing ergonomics against packaging – and the modern male soldier, after all, is physically larger and has to carry more equipment than in earlier eras.

Creating a military vehicle from scratch, rather than adapting current versions or modifying commercial vehicles for the task, can bring many advantages.

A truly purpose-built military vehicle using Lotus Engineering's approach to new vehicle architectures would from the outset have modularity in both its means of construction and the way it could be re-

Military precision – How defence departments are turning to the automotive industry

configured in the field – the needs of a vehicle in Afghanistan are different from those in Iraq, which in turn are different to those deployed in a peacetime role. And with so many electrical systems to run for 21st century weaponry, it is possible to optimise the type of batteries and generators used, where they are placed for best weight balance and protection, and the installation of low-energy electronics; if switching to hybrid propulsion, it is possible to rethink the air-conditioning and the way the ancillaries work and are positioned. Powerplants generate heat – if a vehicle is engineered specifically for a task, the heat signature can be minimised. Even the engine management set-up for specific theatres and types of operation could be easily changed.Current military vehicles tend to have a variety of systems that don't always communicate effectively with each other.

From its extensive automotive hybrid and electric vehicle experience, Lotus Engineering is hugely knowledgeable in integrating all manner of control systems, expertise which would lend itself to integrating military system. There is the potential for integration of everything within the vehicle to operate at peak efficiency and with simplified controls – the simpler it is to operate equipment in a hostile environment, the easier it is for troops to concentrate and implement the correct strategies. At the moment, for example, a command vehicle may have as many as five different monitors for a controller to evaluate – we already have the technology to combine all of those inputs into a single monitor, warning screens flashing up only when there's something serious to warn about. Combine that technology with active noise and we could then incorporate voice-controlled systems, freeing the operator's eyes and hands for other activities.

Of course, the best way to keep troops out of harm's way is not to place them there unless it's absolutely necessary. To that end, the US military has publicly stated that by 2015 it wants one-third of its ground forces to be autonomous: the Defense Advanced Research Projects Agency (DARPA), the US military's advanced research organisation, hosts challenges to outside organisations to create vehicles that will drive without human interaction, either inside the vehicle or by remote control. In the last challenge, set in a busy urban environment, Lotus Engineering's Autonomous Elise, created in collaboration with Insight Racing and nicknamed Lone Wolf, finished in the top 15 teams from a field of more than 100 entries from around the world. Further research work into a new generation of autonomous vehicles continues in Lotus Engineering's US offices.

Lotus Engineering's Defence Division has in its arsenal not only a wealth of technical expertise, but also reaps the benefits of being part of Group Lotus; it designs, develops' tests and manufactures cars and components both for itself and for a multitude of outside clients. On the commercial battlefield, few can rival that sort of firepower.

Source: Lotus Engineering

In the early 1990s Lotus Engineering developed an Active Track Tensioning Programme for the Scorpion tank

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