Cellulosic ETHANOL

Jeff Broin of POET on the latest thinking in sustainable biofuel production

Interview
Stefan Jacoby, chief executive officer of Volvo Cars

First flight
Ricardo’s Wolverine3 engine takes to the sky

Flywheel award
Accolade for Ricardo Kinergy bus application
New generation, NOT re-generation

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Jaguar’s plug-in turbine supercar

UK carmaker Jaguar challenged its German premium rivals at the Paris auto show with the radical C-X75 plug-in hybrid supercar concept using twin micro gas turbines to provide extended range capabilities. The R8 eTron and SLS E-Cell studies by Audi and Mercedes-Benz use pure battery power and have operating ranges of under 200 km: Jaguar claims its 110 km electric only range is complemented by an additional 900 km using the variety of fuels on which its turbines are capable of running.

Jaguar has teamed up with Bladon Jets to develop the miniature axial-flow micro turbines; each spins at a constant 80,000 rpm, weighs 35 kg and produces 70 kW of power. Each of these is harnessed to a switched reluctance generator to charge the batteries on the move. In Track mode, the generators feed their power directly to the traction motors; under mixed driving the turbines, which have the benefit of reaching their operating temperature rapidly, can work in sequence or together. Exhaust gases from the turbines are channelled into the C-X75’s active aerodynamics system. The 19.6 kWh lithium ion battery pack takes six hours to charge from a normal domestic supply.

Power is fed to four separate wheel motors, enabling active control of the vehicle’s dynamics with four wheel drive and torque vectoring. With a claimed kerb weight of 1350 kg and each motor rated at 145 kW and 400 Nm torque, the C-X75’s predicted performance figures are impressive: zero to 100 km/h is clocked up in 3.4 sec, maximum speed is 330 km/h and overall CO2 emissions are kept to 28 g/km.

Unconfirmed press reports suggest that Jaguar may be contemplating a limited production run of C-X75s for road use – this would make the C-X75 the first roadgoing turbine car since the unsuccessful Chrysler Turbine of 1963.

New powertrain from Lamborghini

Following the unveiling of its all-carbon Sesto Elemento supercar concept at the Paris show, Lamborghini has given details of an all-new powertrain for the next-generation Murciélago in 2011. The new 6.5 litre V12 engine gives 700 hp and, says the company, offers not only breathtaking performance but moderate gas emissions. Linked to the high-revving engine is a “completely new transmission concept” for super sports cars: dubbed ISR, the new manual gearbox uses independent shifting rods to perform gear changes virtually in parallel, rather than in series – when one shifting rod is moving out of gear the second rod can already be engaging the next gear. The result, say Lamborghini engineers, is extremely fast shifting times, almost 50 percent shorter than with a dual clutch transmission.

EV batteries to help store renewable energy

Swiss energy technology provider ABB has teamed up with GM to explore alternative uses for electric vehicle batteries that no longer have sufficient storage capacity for full-range vehicle use. The companies are aiming to develop applications well before the expiry of the warranties on the first wave of Chevrolet Volt cars, which are just now going on sale in the US.

Batteries which have lost between 30 and 50 percent of their capacity may no longer provide enough range for automotive use but, say the companies, could form an important element in improving the effectiveness of the renewable energy grid, where energy density is not so critical. In addition, a thriving market for these so-called second-life batteries is important in establishing a resale value for semi-spent batteries and thus reducing the cost of ownership for EV drivers.

Among the applications under consideration for second-life EV battery use are: direct storage of wind and solar renewable energy; grid load management, under which utilities store electricity generated during off-peak periods; back-up power for communities, and time of use management for industrial customers to store energy during low-cost periods for use during peak demand phases.

News in brief

Wave-piercing offshore vessel
Rolls-Royce has landed an order from Farstad for an advanced platform supply vessel using a wave-piercing hull design. Previously, this configuration had only been used for high-speed catamarans and trimarans.

Japan’s 500 km/h maglev
Central Japan Railway is to build pre-production prototypes of a new superconducting maglev train capable of running at 500 km/h, with the first five-car trainset ready for trials in 2013.

US Navy tests biofuels
A Riverine Command Boat is being used by the US Navy to test an alternative fuel blend consisting of 50 percent algae-based fuel and 50 percent Nato F-76, a standardized marine diesel.

Wireless charging for EVs
Inductive technology developed by New Zealand’s HaloPT and Britain’s Arup promises to be able to recharge parked EVs with an air gap up to 400 mm as well as on the move, using EV lanes with inductive loops under the road.
Siemens Eurostar deal sparks controversy
France-based rail supplier Alstom has contested the decision-making process which led to Eurostar ordering ten high-speed Velaro trainsets from Germany’s Siemens for its London to Paris and other routes.

The new Pininfarina-styled e320 Velaro can carry 900 passengers at 320 km/h and would link London to Paris in two hours and London to Geneva in around five. The electrically powered train, says Siemens, consumes the equivalent of one coke can of gasoline per person per 100 km.

The issue is politically sensitive as Eurostar is dominated by French national rail operator SNCF and had previously favoured Alstom products.

A complaint from Alstom that the tendering process did not comply with EU public procurement rules has prompted the European Commission to launch a four-week review of Eurostar’s decision. Further criticisms concern changes of rules relating to the acceptance of trains with distributed traction in the Channel Tunnel.

Shortly before the Eurostar announcement, Alstom had lost out to Canada’s Bombardier in a major order to supply Italy with 50 very high speed trainsets.

US plans truck CO2 standards
For the first time, the US administration has made proposals to control the fuel consumption of heavy vehicles such as commercial trucks and buses. Presenting the proposals, transport secretary Ray LaHood said the measures would reduce reliance on oil, strengthen energy security and mitigate the effects of climate change.

The measures would not initially be applied to off-highway vehicles; just 4 percent of on-road vehicles would be covered, though these are responsible for 20 percent of all fuel consumed. The proposed new standards would apply to trucks and buses from model years 2014 to 2018 and would help save 500 million barrels of oil over the lifetimes of those vehicles, said the US DoT.

Among the proposals are a 20 percent cut in fuel use for articulated tractors, a 10 to 15 percent reduction for heavy-duty pickups and vans, and a drop of 10 percent for service vehicles such as fire engines. Both the DoT and the EPA point out that the extra cost of the lower-consumption trucks will be easily outweighed by fuel savings over their operational lifetime.

Medium and heavy trucks are the second largest fuel user in the US, after passenger cars.

Tesla-Toyota EV revealed
The first fruits of Tesla’s collaboration with Toyota were revealed at the LA show in the shape of the RAV4 EV concept. To be built in a limited run of 35 units for an evaluation programme prior to production models in 2012, the initial model has a mid-30 kWh lithium metal oxide battery and is targeting a real-world range of 160 km.

Toyota is known to be ultra cautious about battery technologies, especially lithium ion, though the companies say final battery specifications are yet to be decided.

Off-highway engines for Tier 4
German engine supplier Deutz AG has developed a new generation of off-highway power units able to dispense with closed particulate filter systems. The 2.9 litre V4 units span an output range from 25 to 56 kW.

MAN power for giant ferry
The world’s largest ferry, a 3200-passenger, 1060-vehicle vessel built by Daewoo of Korea for Tunisia’s COTUNAV, will be powered by four common-rail diesel engines from Germany’s MAN.

Nissan gets Smart in US
Faced with a decline in sales of its two-seater Fortwo in the US, Smart has commissioned Nissan to build a four-seater to provide showroom traffic for US Smart dealerships. The new model will be based on the Micra.

BMW power for Saab
Under a contract signed this autumn, BMW will supply engines to Sweden’s Saab from 2012. The four-cylinder power units will incorporate the latest emission-reducing technologies such as stop-start.
Why have Volvo sales stagnated in recent years?
When I was at VW in the mid 1990s, Volvo and Audi were on roughly the same level of 400,000 sales a year. Today, Volvo is still the same but Audi is one million plus. There are many reasons for this. Volvo managed to survive the economic meltdown with the help of Ford and has [now] managed a significant turnaround with profits in the first two quarters of 2010. Our dependence on Ford meant that our products could not be developed in the direction of luxury: I feel we have to a certain extent lost the distinctiveness of our products.

How much do you wish to grow in the future?
I’m not confirming it as a strategic objective but, as a vision, around 800,000 in ten years is something which is achievable.

What percentage of your expanded volume do you see coming from China?
Half of our extra business would be too much. It could be about 30 or 35 percent. I think we also have growth potential in eastern Europe as well as in our core markets in Europe and the US. We sold 130,000 vehicles in the US not so long ago – this year it will be just over 60,000.

You said your products had lost their distinctiveness under Ford because they could not be developed in the direction of luxury. Could you explain?
“In a world where everything is getting more complex I want to get into my car and immediately understand it – my dream is to have a car without a handbook”

I’m using the word ‘luxury’ because I hate the word ‘premium’. Premium suggests that as a customer you are paying something [extra] but not necessarily getting anything in return. Our competitors have managed to give their cars this kind of distinctiveness – you immediately realise you are sitting in a BMW or an Audi. This, unfortunately, is not the case with a Volvo, but it used to be.

So will future Volvos be luxury cars?
That’s exactly what we are working on. One of the first projects I have initiated is to define what the brand should stand for. This is a big contrast to my former employer, where everybody knows exactly what Audi, VW and Skoda stand for. All the employees of these companies represent their brand – and I have recognised that this is not 100 percent the case with Volvo. They know where the brand came from and what its foundations are: what’s missing is a clear understanding of where the brand should stand in the future.

Where do Volvo’s latest products stand?
We have made significant progress with the new S60 [sedan] and V60 [wagon]; the question is whether this is the direction we want to go in the future.

What is your vision of what Volvo should stand for, from a design point of view?
I would bring back more functionality and maybe not go in a direction that’s too sporty; I would move more in the direction of Swedish and Scandinavian elegance – which is clearly different to the English elegance of a Jaguar or Bentley. Simplicity is important: light colours, specific materials. We have already been working on the products due out in the next two years to bring more simplicity and harmony – put in some chrome, but not two or three different kinds of chrome.

So how would you summarise the new approach?
Instead of copying the Germans we should do it our way and be more Swedish than ever before – not in an arrogant way but so that we can best express what Scandinavia stands for. The second area is human values. Scandinavia has very high values for human beings – a strong social security system, solving the problems of integration. It is globally respected, and I think we should bring this human touch into our cars. The Germans are bringing in technology for its own sake: maybe we should bring in technology for human beings. We already do this with safety, where we set world standards, but there are other areas such as entertainment and air conditioning where we can be much more ergonomic and intuitive than we are today. So, not too sporty, more a logical enjoyment of luxury – plus functionality and the human touch.

Does this mean Volvo will move away from sporty and dynamic cars?
Yes.

Will you be changing the sizes and types of cars Volvo produces?
We will have to look at the benchmarks and what our competitors are doing, but we won’t necessarily go into the same sizes and packages as them; again, [what we have now] has been very much related to the use of Ford technology. These cars are good: the S60 is a vehicle that’s very dynamic to drive, very responsive and with a good match between the dynamics and the powertrain. The question is whether this is the area Volvo should be in: I tend towards having Volvo with bigger cars, where the functionality comes to life, instead of being at the lower end of the size range of the various segments.

Which of Volvo’s current or past models do you see as an example of the type of thing you want to do?
The best car we have in our range is the XC60 – this is the truest Volvo. The C30 is a fantastic car as well and has big potential: it is a very emotional car with an attractive design and incorporates a lot of Volvo heritage features – like the back. These are the two vehicles with the strongest Volvo values, and of course the XC90 is still a fascinating car: it set standards as to what a modern SUV should look like – and it’s another example model from Volvo.

Would you see a return to clearly identifiable a social role like the classic 240 station wagon had?
I like that. True identity is important in our vehicles. I don’t want to blame anyone for what happened in the past, and the S60 and V60 are probably the most competitive cars [we have had] in relation to our competitors. But I would have preferred a car which was truly Volvo and matched practicality, durability and functionality with modern elegant design.

How would you characterise Scandinavian design?
There is lots of beautiful Scandinavian design: IKEA is already a good example of functionality, and there is furniture, fashion, architecture, where you see the clear language and where you feel comfortable and in control.

Do you think functionality is a strong enough selling point?
If you combine it with elegance or performance, functionality can be very
“There is lots of beautiful Scandinavian design: IKEA is already a good example of functionality, and there is furniture, fashion, architecture, where you see the clear language and where you feel comfortable and in control.”

attractive. Just look at Apple: Apple is very functional – even my 18-month old son understands how to scroll the screen of an iPad. That shows how functionally Steve Jobs has designed and engineered his products. In a world where everything is getting more complex I want to get into my car and immediately understand it – my dream is to have a car without a handbook. And the more premium the car becomes, the thicker these handbooks are becoming.

Is there perhaps too much technology going into cars?
Maybe. But maybe it’s also that this technology isn’t made for human beings. I want to make it more human. Perhaps we need less upfront technology. When you open up a PC you really have to deal with the technology and you can’t deal with yourself. Once you have changed to an Apple product you will never return to a PC saying that the PC is more practical. To transfer this [intuitive operation] to an automobile would give us a unique selling point. I see this as simplicity, as a Swedish value.

Could Volvo be positioned as an ethical brand with cars that last a long time, are safe and environmentally responsible?
I’m not sure. I think it is more important to live these kinds of values: to promote yourself as being like this would be a mistake.

Where does Volvo stand on electrification?
A powertrain strategy aiming for increasing electrification is one of our core competencies. We are working on various initiatives: we will bring the C30 DRIVe into small fleets next year and the V60 will appear as a plug-in hybrid in 2012 with under 50g CO2 emissions. The C30 will definitely be a leasing model but we need to gain experience in order to know what the future business models should be. These are vehicles which are not yet competitive [on price] but we need to continue to invest in this technology as we will get economies of scale. The question is when we will reach the break-even point so that it makes sense for a broader range of customers to buy an electric vehicle.

Do you see economy and low CO2 as a major distinguishing quality of Volvos?
How can you compete with vastly bigger companies like Toyota?
We have done a lot of good development work already. One example: the batteries of our vehicles will be in the [centre] tunnel. This gives us good flexibility in the amount of batteries we put in: we tend to put in bigger batteries so we get 120 to 150 km range. This concept once again sets standards in the crash test: the batteries are not in the front or in the back, and are also protected in side impacts. This is the best place, and another advantage
is weight distribution – it drives like a go-kart.

The speculation is that you are hoping to develop all your future models off two platforms. Is that correct?
It’s an open discussion and, yes, this is what we are investigating right now. The original plan was actually to have all the models on one architecture, and that’s what we’re looking at. With our new owner we have other plans than under Ford, so we are checking with our R&D operation that we are using and investing in the right technologies. Apart from the cars already in the pipeline, Volvo’s future cars will be based on a technology which we have defined. It doesn’t always have to be our own technology: sometimes it makes sense to go to a partner who can generate greater scales of economy than we can – such as Saab’s engine deal with BMW.

How far will Volvo innovations spread to the products of your owner, Geely?
The possibilities are limited. Geely is a Chinese local brand operating in the entry segment. We are at the upper end of the scale but this does not mean we cannot co-operate in organising our entry on the Chinese market: Geely has already been a big support. We will also be bundling our purchasing where this makes sense.

Will Volvo therefore develop all its new engines on its own?
Yes, we are developing our own new engine generation that will be compliant with the CO₂ requirements for Europe, the US and China. It will be a modular engine spanning a wide variety of capacities, both gasoline and diesel.

What would be a sensible upper capacity limit for a modern Volvo engine?
With every crisis, something in the auto industry dies. With this most recent crisis, now hopefully behind us, the eight-cylinder has more or less died. Even Formula One is now discussing limiting engines to four cylinders. Downsizing is definitely a tendency, and for us the question is now what happens with the six-cylinder engine. I include the five-cylinder with the four cylinders – even Mercedes has an S Class with four cylinders and 550 Nm. There’s now much more acceptance of downsizing, even in the US, and I think we can use electrification for future four wheel drives with a four cylinder engine and an electric motor of 50 or 60 horsepower. This is especially important for the future of big SUVs.

Will Volvo help Geely outside China?
I’m responsible for Volvo, not Geely, but it makes no sense to sell Volvo and Geely cars from the same outlets. Our Chinese shareholder understands clearly the strategy of keeping the brands separate.

Will [Volvo] cars built in China come back to Europe?
A good question. We need to ensure that the cars we produce in China have the same appeal, the same quality, the same fit and finish, smell, handling and materials as the cars we make here in Europe. It’s essential. I believe, not just for Volvo but for the whole industry, that it’s simply a matter of time before the first cars arrive from manufacturers’ Chinese production hubs.

Finally, in terms of styling, when will we see the first of these new Volvos and how different will they look?
We do need to sharpen the brand but it takes time. The first of these products won’t be until 2013 or 2014. They will have a stronger identity, but in a subtle, Swedish way. We are working on the new face: everybody in the company is surprised to suddenly see a CEO going into the design studio at seven at night – and staying for three hours, too. Our foundation, with engineers and designers, is good – but it needs leadership too. We will see the first steps in the next models in the launch pipeline.

Volvo used to have safety as its USP but now others have caught up. What do you see as the new reason for people to engage with Volvo?
Yes, we do need this and we will get it. It will be distinguished design, more Scandinavian than before, and it will be intuitive in use, human-centric and environmentally friendly. Maybe we will be the first luxury brand without an eight-cylinder engine; maybe we won’t even have a six-cylinder any more.

Stefan Jacoby
2010 President and CEO of Volvo Car Corporation
2007 Volkswagen Group of America Inc, President & CEO
2004 Volkswagen AG, Executive Vice President
2001 Mitsubishi Motors Europe BV, President and CEO
1997 Volkswagen Asia-Pacific Ltd., Deputy Director
1995 Volkswagen AG, Head of General Office of the Chairman
1992 Volkswagen AG, Exports Sales Planning Department
1990 Volkswagen Audi Nippon KK, Japan, Head of Controlling
1989 Volkswagen AG, Commercial Vehicle Division
ETHANOL EVANGELIST

In less than 25 years Jeff Broin has transformed POET from a farm-based operation into one of the world’s largest ethanol producers. Focusing on technology and innovation, he describes his vision of a sustainable future in which corn and cellulosic biomass wastes can replace much of the liquid fossil fuels we use today – and also provide additional food and co-products. Anthony Smith reports.

Despite its size and prominence within the renewable fuels sector – and a recent coast-to-coast brand-building television advertising campaign – POET is hardly a household name in North America. But while consumers may not know the company, most will have driven its product: POET’s ethanol is purchased by oil majors such as ExxonMobil, BP and Chevron, who blend it into standard pump grades of gasoline within the current 10 percent ethanol (E10) limit allowed by the Environmental Protection Agency. In addition to this, many retail outlets across the USA also provide higher blends of up to E85 on filling station forecourts for use in vehicles capable of flex-fuel operation.

POET’s rapid growth from the small spin-off business of a family farm to a major international energy provider is due in no small part to the vision of its founder and CEO, Jeff Broin. The son of a farmer from Southeast Minnesota, Jeff Broin developed an interest in small-scale biofuel production in the mid-1980s, more out of frustration with the restrictions on productive use of land for food than because of any particular motivation to replace fossil fuel use. “To qualify for direct support payments from government my father would take big chunks of the farm out...
of production as ‘set-aside’ acres. He really hated the sight of weeds and grass growing in place of crops and the waste that this represented. So when I was still in high school he and my brother built a small ethanol plant on our own farm. I joined with them and founded POET a couple of years later.”

With the experience of the early 1970s oil embargo still fresh in the collective memory and a surplus of land lying fallow under set-aside rules, Jeff Broin’s family were far from alone in going into farm-scale ethanol production. “There were lots of kit-based plants on the market at that time but the economics of these were questionable. At a capacity of 200,000 gallons per year, however, our farm’s plant was on a bigger scale and rather more of a commercial enterprise.”

The Broin family was also more far-sighted than many of its counterparts in farm-scale ethanol production in recognizing the potential for developing a new industry that would enable farming communities to develop new markets for their products and graduate from the culture of set-aside. As many of the less successful plants fell into bankruptcy there were some very valuable lessons to learn. “We spent a lot of time travelling to plant foreclosure auctions looking for deals on equipment we could use in our own facility. We spoke with many of the people who had run these plants and learned a lot from their mistakes. Then in 1987, we went to an auction in Scotland, South Dakota, where instead of coming home with some extra parts, we ended up buying the whole plant. We mortgaged the family farm and bought the whole thing for $70,000.”

So as an agricultural college graduate of just 22 years of age, Jeff Broin moved to Scotland SD to become the plant’s general manager and oversee the eight-month refit that would take it back into profitable operation as the nucleus of the company known today as POET. To keep costs low and ensure that he was on hand for all major decisions, he even lived in the plant rather than renting separate accommodation while the refit...
progressed. At the outset his aim for the new ethanol venture had simply been focused on getting the Scotland plant back into profitable operation.

“Even when we expanded the plant two years later, our intention had remained just to focus on the one plant,” he added. “However, when we had the plant to a size where our efficiencies of scale allowed us to compete with the leading players in the industry, we started looking into the possibility of building efficient plants for other people too. A lot of potential stakeholders in the ethanol industry were asking to tour our plant because it became widely known that we were successful in taking a previously run-down and bankrupt facility into profitable and efficient operation.”

Expanding production
POET’s second plant resulted from a collaboration with Farmland Industries – then one of America’s largest agricultural co-operatives. “They asked if they could see our financials and we were happy to allow this to prove that we were profitable. When they realized we were true to our word they asked us to consider building a plant for them. I had no prior experience to do so other than our own plant, but I said ‘sure’.”

In what has become something of a hallmark of POET’s operations, a new company was formed to design and build a new plant from scratch. Despite the fact that it was at an even bigger scale than the Scotland plant, the facility was brought in on time, to budget and was in profit from its first full month of operations.

In similar fashion, each successive plant has been developed in partnership with a different group of stockholders – primarily local investors such as farmers with a keen interest in its success. These are generally small investors as for all but just one plant, POET is the largest stockholder in almost all the facilities that it operates.

“We work with local communities from farmers to main street businessmen and, based on our record to date, it’s been attractive to all as the investors in POET have had a very good experience. As the industry continues to develop, our capital needs are going to be considerable so we are continually on the lookout for new investors who seek a solid return. It’s an easy sell as it’s all about renewable energy, and in my opinion renewable energy is the future.”

POET currently boasts a total of more than 10,000 farmer investors in its plants; takes deliveries of grain from these and a further 20,000, and employs over 1500 people across its network of 27 production facilities. These have an an annual capacity of 1.7 billion gallons of ethanol, as well as numerous co-products from polymers to high-protein animal feeds. The key success factors the company seeks in developing new facilities are available feedstock capacity after existing uses are accounted for, good road and rail infrastructure, and available water and power supplies. In terms of these last two criteria in particular, POET has led the way in using technology to optimize its facilities and processes.

Technology development and innovation
POET is very much a technology-led company, with new product and process innovation at the very heart of its DNA. From the well-equipped laboratories at POET’s headquarters at Sioux Falls, South Dakota – facilities which would rival many world-class university research laboratories – to the process-level research and development facility on cellulosic ethanol production at the Scotland plant, the strategic importance
of technology development is clear to see. “I believe that companies that develop and possess new technologies will play a very big role in this industry long term, and that’s why we invest so heavily in this area,” says Broin. “Because in making ethanol we are dealing with microbiological processes, our focus on research and innovation has allowed us to maintain an edge in this industry for decades. This has underpinned our rapid growth and we believe that as we continue to develop further new technologies it will continue to give us an edge in the future.”

One of the early successes of this approach has been POET’s patent-pending BPXTM technology. In a traditional ethanol production process the milled corn flour is mixed with water and held at an elevated temperature to enable the corn starch to be converted into glucose and other simple sugars ready for fermentation. The BPXTM process instead uses special enzymes to enable this conversion to take place at low temperature, thus saving a full 8-15 percent in the plant’s energy consumption while also reducing the need for cooling water. Developed at laboratory level, the BPXTM process was taken to commercial scale production in 2004 and is now operating in over 90 percent of POET’s ethanol production facilities.

Cellulosic ethanol production

A further significant research and development initiative is known as Project LIBERTY. While there has been much hype and speculation surrounding the production of biofuels from cellulose, POET has already developed its corn crop residue ethanol production process from a laboratory scale to a production prototype level at its Scotland research and development facility.

By analysing and optimizing every aspect of the production process, POET believes that there is an ideal balance of grain- and cellulosic-based production in a single integrated facility. “The ideal sizing of the cellulosic plant is about half the ethanol capacity by volume of the conventional grain ethanol plant. So if we have a 50 million gallon grain plant we would ideally want to build a 25 million gallon cellulosic plant alongside it to maximize efficiency.”

This balanced approach enables exactly the same land to supply both process streams. In harvesting, rather than taking just the grain, the POET process leaves the majority of the stalk on the ground both as a fertilizer source and to protect against soil erosion. The leaves, husk and cob are gathered as a separate stream to the corn grain and delivered to the plant as feedstock for the cellulosic production process. In addition to the ethanol production from this biomass, POET uses the residual wastes or lignin, and feeds these into a biogas digester from which the company can obtain sufficient biogas not only to power the heat energy requirements of the cellulosic facility but also to provide the entire requirement of a conventional grain ethanol plant of double its capacity. “In the approach we have already demonstrated in Project LIBERTY we are increasing the ethanol yield from the same acreage while also reducing the carbon intensity of the production process by displacing natural gas obtained from fossil sources with sustainable biogas derived from the cellulosic facility’s waste,” he says.

Having proven this process at its Scotland R&D facility, POET is planning to launch the first commercial-scale commercial implementation of its Project LIBERTY cellulosic ethanol process at the company’s plant in Emmetsberg, Iowa, in 2012. In addition to this, the company’s plants constructed in recent years have each been designed for similar expansion of cellulosic ethanol production once its commercial viability is proven.

But as with so many of the process innovations led by his company, Jeff Broin is keen to go further. “We are continuing with our research as there is clearly further scope for the use of biomass waste in this way. While the 50 percent facility sizing provides an ideal balance in terms of corn-based product from a given acreage of farmland, there is a clear potential to go beyond this if we start to look at non-corn biomass. In the future it is likely, for example, that we would look to building biomass-based production facilities close to other established energy users such as power plants or large manufacturing facilities that could use the renewable biogas by-product we generate. There are clearly limitations on how quickly we can roll this out ourselves so we will also look to license the technology to others too.”

High-protein food and other co-products

POET has championed the production of co-products from its ethanol production since its formation. “You have to remember that all we are
taking from the corn to produce ethanol is the starch – 30 percent by weight of the product goes back into the market as co-products such as high-protein food, oils and micro-nutrients.”

The main co-product is a distiller’s grain marketed internationally by POET as Dakota Gold®. By virtue of POET’s efforts in biotechnology and process development, this product meets a higher level of nutritional content and physical consistency than is possible with any other bio-refining process. Carbon dioxide is also sequestered from the fermentation process and sold as a product into the food and beverage industry and beyond.

Additional products include Voilà!, a low-free-fatty-acid corn oil recovered from distillers’ co-products which is a feedstock for biodiesel production and can be processed further for use in lubricants, motor oils and paint additives – all of which displace petroleum-based products – and Inviz®, a zein-based alternative to petroleum-based films, packaging, adhesives, coatings and glazes.

Global potential
Jeff Broin firmly believes that the POET business model – developed and proven in America’s mid-west – has potential to be replicated on a global basis. “There is a large surplus of previously tilled crop land around the world which is available for corn production – over a billion acres according to research published by Stanford University in 2008. Much of this went out of production due to the US and Europe subsidizing grain and hence removing the potential for developing nations to make money from growing crops. This is hardly surprising – if you can buy grain at two dollars a bushel less than you can grow it, why would you bother farming? I believe that land could potentially be used to produce – even at marginal yields – enough ethanol to displace all the gasoline in the world. And the by-product coming off that land would be sufficient high-protein food to feed every starving man woman and child on the planet. A billion people could benefit from 5lb of high protein a day each.”

Broin’s enthusiasm for the global potential of sustainable ethanol production is matched by his rejection of indirect land use change calculations as applied to modern agriculture and production processes. “We can show that every gallon of ethanol made in the US has come from higher yields on the same land – put simply, we do not need new land to make ethanol. Improvements in farming processes and biotechnology have doubled yields in the past decades and look set to double them again in the next twenty years. In addition to this, by using biomass wastes our Project LIBERTY process alone provides an increase in the efficiency of ethanol production per acre.”

Indeed, this view is supported by a US Department of Energy-supported supported analysis published in October 2010 by Oak Ridge National Laboratory, which concluded that in the years 2001-2008, feedstock for US ethanol expansion was mainly derived from domestic reallocation and increased yields and that there was no evidence found of effects upon US commodity exports or other crops or cropland expansion in the US.

The future
So where does Broin see POET five or ten years from now? “I believe we will continue to be the largest producer of biofuels in the world as we add both grain and cellulosic capacity. I see us continuing to put significant efforts into co-product development, creating new bio-chemicals and bio-polymers, extracting ever more value from corn. We are learning all the time how to better fractionate the grain and our
goal is to take all parts of the corn plant to their optimal end use.”

In terms of production, the American ethanol industry currently produces in the region of 14 billion gallons of ethanol from grain annually. In ten years Broin believes it could be at 30 billion gallons plus 10 billion from cellulose, rising in 20 years – given the right policy frameworks – to 50 billion and 80 billion respectively as additional biomass sources are commercialized. “If we achieve this it would just about be equivalent to replacing all the gasoline currently consumed by the US market.”

But the effort to innovate and develop new production technologies is relentless. “We must keep pressure on improving costs and increasing efficiency. We have cut water usage by 80 per cent since I joined the business and we are still driving it down further. Farmers use 77 percent less fertilizer per bushel than they did in the 1980s too, as well as far fewer insecticides and herbicides. Crops are far more drought-tolerant and the mechanisation of farming with the many GPS tools for planting and harvesting optimization has also played its part in driving up yields and improving efficiencies.”

Broin believes that the case for raising the blend ceiling on regular gasoline to E15 will open the market for ethanol expansion for a further five years, but beyond this consumers need to be given a practical incentive to use higher blends. “We need to develop flex-fuel technology much further than today and this is where we see technologies like the Ricardo EBDI engine as being very exciting. EBDI provides a very compelling cost advantage over the regular diesel in certain vehicle applications, as well as reduced engine-out emissions.”

So, given the growth of POET and the global potential of sustainable ethanol production to displace large quantities of gasoline, diesel and petroleum by-products, does he think that oil companies should be nervous? “In my opinion, given a level playing field, grain and cellulose ethanol provides renewable and sustainable biofuel that will easily be able to compete with oil in the future,” predicts Broin.
Raising the ethanol ‘BLEND WALL’

A landmark research study carried out by Ricardo for the Renewable Fuels Association assesses the potential impact upon older vehicles in the US fleet of raising the ethanol blend limit of standard pump grade gasoline from E10 to E15. Anthony Smith reports.

On 13 October 2010 the US Environmental Protection Agency (EPA) formally began a regulatory process that could pave the way towards the commercialization of a 15 percent blend of ethanol (E15) in standard pump grade gasoline. Since 1979, a blend of up to 10 percent ethanol (E10) has been available for all conventional cars and light trucks and non-road vehicles; with this announcement the EPA has formally waived the limitation on sales of fuel for use in vehicles manufactured from the model year 2007 onwards.

“Thorough testing has now shown that E15 does not harm emissions control equipment in newer cars and light trucks,” said EPA Administrator Lisa P. Jackson. “Wherever sound science and the law support steps to allow more home-grown fuels in America’s vehicles, this administration takes those steps.”

The EPA has separately stated that a decision on the use of E15 in model year 2001 to 2006 vehicles will be made after it receives the results of additional Department of Energy testing, which is expected to be completed towards the end of 2010. However, as of now, no waiver is being granted for E15 use in model year 2000 and older cars and light trucks: this is due to the lack of test data. This presents an enduring obstacle to the full commercial rollout of E15 on the filling station forecourts of the United States on account of very practical issues of product labelling and storage. Clearly this obstacle would be minimized by an extension of the waiver to older vehicles.

Quantifying the risks

While significant research efforts have been made by government and industry bodies evaluating the potential impact of E15 on 2001 model year and newer vehicles, minimal engineering analysis has previously been focused on earlier model year vehicles. This is potentially problematic as the proportion of vehicles manufactured in this era but still in use today is significant; the model years 1994 to 2000 inclusive represent a total of 62.8 million vehicles or approximately 25 percent of the current overall US light duty vehicle fleet.

With the interests of such a potentially large stakeholder group overlooked by previous studies, an examination to quantify the risks to older vehicles of a proposed increase from 10 to 15 percent ethanol content would clearly be very timely. The Renewable Fuels Association (RFA) is a national trade association – and an important voice for – the US ethanol industry that promotes policies, regulations and research and development initiatives that will lead to the increased production and use of fuel ethanol.

In order to address the research deficiency with respect to older vehicles, the RFA asked Ricardo to carry out a specific study of the 1994 to 2000 model years. While the later year limit of this analysis was clearly set by the extent of research on-going by the DoE, EPA and others, the rationale for selecting the starting model year was strongly influenced by the fact that 1994 marked the effective start of Federal Tier 1 emissions regulations. The avoidance of interference with the operation of the early generations of emissions equipment installed on this
era’s vehicles is clearly a priority. In keeping with the spirit of Environmental Protection Agency’s longstanding policy, a “reliable statistical sampling” approach to the analysis of the national fleet was used. Sales trends by both calendar year and model year were studied to identify the highest volume sales of the automotive manufacturers between 1994 and 2000. Six manufacturers – Chrysler, General Motors, Ford, Honda, Nissan and Toyota – were identified as representing the overwhelming majority (in excess of 87 percent) of vehicles sales for the study period, and the 10 top-selling platforms of these manufacturers thus became the focus of the study.

**Engineering analysis**

This approach enabled Ricardo to carry out engineering analysis without individually inspecting or testing each of this very large number of vehicles. Key fuel system hardware changes that occurred during the 1994-2000 period were considered – indeed a number of EPA emissions regulations modifications during this period increased the tolerance of fuel and vapour-handling systems to ethanol blended fuels. The study included a detailed interrogation of EPA emissions certification data in order to evaluate tailpipe emission effects, as well as aftertreatment systems and vehicle calibration data. Consideration of the particular characteristics of E15 that might affect hardware durability (in comparison with E10) was also given, based on a detailed assessment of the materials used in fuel systems manufactured during the study period.

Finally the study team procured a range of end-of-life hardware for the fuel systems of a selection of vehicles from the 1994-2000 model years, enabling a detailed examination of the effects of the E10 fuel to which they had been exposed throughout their working lives.

Based on the engineering analysis performed, the conclusion of the study was that the adoption of E15 as the blend limit for standard US pump grades of gasoline should not adversely affect vehicles manufactured between 1994 and 2000 in terms of their performance and durability, based on normal specifications and usage profile. It can thus be reasonably concluded that these vehicles do not represent an obstacle to raising the blend limit to E15 from the E10 that currently forms the basis of much of the commercially available US gasoline fuel.

“Older vehicles represent a significant yet previously comparatively under-researched element of the US national vehicle fleet”, said Ricardo, Inc. president Kent Niederhofer. “In considering the potential risks and benefits of increasing the current ethanol blend ceiling in regular gasoline from 10 to 15 percent it is crucial that the interests of the potentially very large stakeholder group represented by the owners of these vehicles are investigated. While many previous studies by Ricardo and others have evaluated the impact of higher ethanol blends on newer vehicles, this study demonstrates for the first time that raising the blend ceiling to E15 is likely to have a negligible impact on vehicles manufactured between 1994 and 2000.”

Based on the findings of the study, the RFA is redoubling its efforts to persuade the EPA to extend the recently announced E15 waiver. “This analysis provides conclusive evidence for the EPA that there is no reason to limit the availability of E15 to newer vehicles only,” said Bob Dinneen, RFA President.

“This analysis, together with affirmative results in reports from the Department of Energy and other academic and private testing institutions, shows that there are no significant issues with the use of E15 in virtually all vehicles on the road today.”

A copy of the report of this study may be downloaded from the Renewable Fuels Association web site (www.ethanolrfa.org).

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**Common Fuel System Materials – Locations and Compatibility**

<table>
<thead>
<tr>
<th>Material Class</th>
<th>Materials Used in Fuel Systems 1990-Present</th>
<th>Fuel System Containing this Material with E0</th>
<th>Compatibility Issues</th>
<th>Directional Change from E10 to E15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrile Rubber</td>
<td>Fuel pressure regulator, hydraulic actuator seals, hydraulic pump seals, water pump seals, carburetor seals, transmissions seals</td>
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<td>Fully Compatible</td>
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<tr>
<td>Viton</td>
<td>Fuel Injector O-ring</td>
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<td>Fully Compatible</td>
<td>Fully Compatible</td>
</tr>
<tr>
<td>Acetal</td>
<td>Fuel line Fittings, gas caps, fuel rails</td>
<td>Fully Compatible</td>
<td>Minor swelling and mass less</td>
<td>Minor swelling and mass less</td>
</tr>
<tr>
<td>Glass Filled Nylon</td>
<td>MRA cap, sensor bodies</td>
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<td>Fully Compatible</td>
<td>Fully Compatible</td>
</tr>
<tr>
<td>HDPE</td>
<td>Fuel Tank</td>
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<td>None</td>
</tr>
<tr>
<td>Nylon 12</td>
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<tr>
<td>Nylon 6-6</td>
<td>Fuel Lines</td>
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<td>O-rings, gaskets, seals and coatings</td>
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<td>Aluminium</td>
<td>Fuel Injector</td>
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<td>Minor discoloration</td>
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</tr>
<tr>
<td>Brass</td>
<td>Fuel level sensor</td>
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</tr>
<tr>
<td>Copper</td>
<td>Fuel Pump &amp; Level Sensor</td>
<td>Fully Compatible</td>
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</tr>
<tr>
<td>Gold</td>
<td>Fuel level sensor</td>
<td>Fully Compatible</td>
<td>Fully Compatible</td>
<td>Fully Compatible</td>
</tr>
<tr>
<td>Solder – 60% tin / 40% lead</td>
<td>Fuel level sensor</td>
<td>Fully Compatible</td>
<td>Minor discoloration</td>
<td>Minor discoloration</td>
</tr>
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<td>Fully Compatible</td>
<td>Fully Compatible</td>
<td>Fully Compatible</td>
</tr>
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</tr>
<tr>
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Fuel tank assembly from a 1998 Ford Taurus, one of the end-of-life vehicles from which components were studied.
U nmannered aerial vehicles, better known as UAVs, are becoming an increasingly important tool for the military. Designed to fly autonomously, they can perform complex missions without putting the lives of a crew at risk – and they can do this at a much lower cost than a full-scale aircraft. The Federal Aviation Authority (FAA) has now classified the UAV as a UAS (Unmanned Aerial System), making the important distinction that these complex devices are not mere aircraft but are, as the name suggests, complete systems. Despite the undeniable sophistication of these systems, however, one crucial fact has undermined the appeal of the smallest UAVs intended for surveillance: the lack of a robust, purpose-built engine capable of operating on standard military grade fuel. Enter Ricardo with the Wolverine3. UAVs started life as little more than sophisticated model aircraft whose airframes and propulsion units reflected their humble origins. Stephen Cakebread, Ricardo project director for unmanned systems, explains: “UAV propulsion units were typically derived from light industrial gasoline engines or from radio controlled model aircraft – hardly the epitome of the high technology and robustness usually associated with military equipment.” Because of this, the UAV engine has become something of a weak link, not just because of mechanical frailty, range limitations and limited performance,
but because of the engines’ reliance on a fuel we tend to take for granted – gasoline.

As Dr Ron Storm, director of military market development at Ricardo, adds: “What the military really wanted was a UAV that could be propelled by heavy fuel, also know as Jet Propellant 8 or JP-8. Most military vehicles are increasingly becoming compatible with JP-8 as the military moves towards a single fuel for all of its equipment. Shipping gasoline to theatres of war especially for UAVs is both expensive and risky, with varying quality and octane ratings jeopardising reliability.”

The market for UAVs is a significant one and, not surprisingly, the US is the largest market for them, as Storm goes on to explain: “In the next 10 years, it is estimated that 76 percent of all research, development, test and engineering costs of UAVs will be spent in the US, which will also take 58 percent of the end product,” he says. The global market for UAVs is estimated at $4.9bn and is expected to grow to $11.5bn within the next 10 years and may reach $55bn in 20 years time.

Engine shortcomings
Conducting a detailed market study in 2009, Ricardo conclusively identified the shortcomings of existing UAV propulsion units and the military’s dissatisfaction with the type of offerings currently available. To understand the specific needs of UAV customers and pilots, Ricardo worked with military and civilian experts, including Rick Scudder, director of the University of Dayton (Ohio) Research Institute’s Center for UAV Exploitation, and Larrell Walters, director of the University of Dayton-led Institute for Development and Commercialization of Advanced Sensors Technology. As Cakebread explains, “This was an exciting and extremely informative collaboration for Ricardo. As we learned more from people with hands-on UAV development and in-field experience, we realized that an engine that isn’t purpose-built for aviation is going to be inherently compromised from the standpoint of performance, weight,
package efficiency and durability.”

The next step was to lay down the basis of a dedicated engine family and gain a foothold in the market. It began with a research and development programme aimed at the integration of the first 3 hp engine into an airframe - the Nightwind 2 of UAS Inc. The rationale for the initial focus on this particular size of engine was that it represented the most technically challenging of the proposed family from a combustion system and weight perspective. At the same time Ricardo was able to build directly upon some highly relevant experience of the development of a lightweight 2-stroke engine intended for military applications.

In the early 1990s the company developed an Auxiliary Power Unit (APU) ‘Backpack’ engine for infantry use, based on a Commercial Off The Shelf (COTS) 24 cc 2-stroke unit, spark ignited and with direct fuel injection. A 3.1 hp version was later built, this time based on a larger 100 cc COTS engine. The APU was a rope pull-start, air-cooled 2-stroke engine lubricated by oil injection. Like the Wolverine3, the APU also ran on JP-8 heavy fuel, providing Ricardo with an extremely valuable experience on which to base the development of its first purpose-built UAV engine.

**Wolverine family**

This first engine of the Wolverine family – the Wolverine3 – was to be demonstrated in a UAS Nightwind 2, a ‘flying wing’ type aircraft with a two-metre span, whose fuselage is blended into the wing itself. A 2-stroke cycle was chosen for high output and low weight – 83 percent of engines in the sub-30 hp bracket are two-stroke while 82 percent of those over 60 hp are 4-stroke. Although heavy fuel (JP-8) is now used right across the US military portfolio of equipment, only three percent of UAV engines are capable of running on it. And while UAVs vary dramatically in size, performance and endurance, they all have one thing in common: extended range flying means their propulsion units must achieve the best brake specific fuel consumption (BSFC) possible.

In general for the combustion engine class of aircraft, a lightweight spark ignition engine like the Wolverine3 is most suited for missions of up to five hours in length, while high-efficiency compression ignition engines are suited to missions of greater than five hours. There is a close relationship between the cruise BSFC, engine weight, fuel weight, the total weight of the engine and fuel and the overall system weight, so all of these must be taken into account when optimizing the entire propulsion system.

**The global market for UAVs is estimated at $4.9bn and is expected to grow to $11.5bn within the next 10 years and may reach $55bn in 20 years time**

Dr Ron Storm, director of military market development, Ricardo

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**Unmanned Aerial Vehicles**

The UAV market explained

There are a number of different platforms for UAVs. The Strategic UAV operates at high altitudes and long endurance for target acquisition and weapons delivery. Tactical UAVs are used for reconnaissance, surveillance and targeting support. The small UAV is less sophisticated but nevertheless used for close range surveillance, reconnaissance and target acquisition. The Commercial (non-military) UAV is typically used for law enforcement, border patrols, forest fire surveys and research purposes and, finally, the Logistic Support UAV is used for the supply of equipment.

Performance is defined by three basic operating classifications of UAVs – Tactical, Medium and ‘HALE’ (High Altitude, Long Endurance). As the name suggests, the most demanding class is HALE, represented by UAVs such as Global Hawk, and is capable of operating in excess of 60,000 ft (18,288 m). The Medium classification includes aircraft such as the Predator which can have an endurance greater than 35 hours at up to 40,000 ft (12,192 m). Tactical categories include aircraft such as the Eagle Eye, Fire Scout, Hunter
aircraft package. A significant amount of engineering effort was required by Ricardo in the integration of the Wolverine3 engine into the Nightwind 2 – including cooling duct optimization, airframe to engine electrical interface development, EMI compliance, engine mount design, lubrication system development, propeller drive design, calibration refinement and fuel delivery system development.

The Wolverine3’s final specification is impressive. Running on JP-8, JP-5 or Jet A1 fuel, the horizontally opposed, direct injection, spark-ignition, two-stroke twin develops 3.1 hp at sea level and with simulations predicting 1 hp cruising at 20,000 ft (6,096 m). Its rated speed is 6000 rev/min while the maximum rev/min is 7000 rev/min. The engine has a crankshaft-mounted generator rated at 500 W and yet the entire engine weighs only 7 lb (3.18 kg) including all its ancillaries. The generator also has the provision to start the engine with the appropriate power electronics in place. Its dimensions are diminutive, too: at 10.5” (267 mm) wide, 6.9” (175 mm) in height and just 7.6” (193 mm) long, the Wolverine3 is indeed a tiny, yet sophisticated, aviation power house with a capacity of just 88 cc.

Design pedigree

Designed from a clean sheet of paper specifically for its role in this class of UAV, Wolverine3 draws on Ricardo’s immense experience in engine design and analysis to incorporate the most sophisticated technologies available. The combination of all-aluminium construction, direct fuel injection and a crankshaft-mounted generator is usually only found in the very latest automotive designs. But perhaps most important of all, Ricardo’s huge experience in combustion systems has made this lightweight twin the equal of its gasoline counterparts when it comes to power and economy – no mean feat considering the difficulty of atomising and combusting heavy fuel efficiently.

So how did Ricardo achieve this? Work started with a small, single cylinder, industrial 2-stroke engine as a research ‘Mule’. The Mule engine was selected based upon having the same cylinder bore size as the proposed Wolverine3 engine. The cylinder head containing the combustion chamber was removed from the integral cylinder head and barrel, enabling the fitment of prototype Ricardo cylinder heads equipped with direct injection. A number of combustion chamber and piston designs were run and evaluated using the Ricardo VECTIS CFD analysis tool to overcome the challenges of fitting direct injection to such a small bore (40 mm) engine.

“The main thrust of the work was to avoid fuel wetting the narrow cylinder bore,” says Cakebread, and the final design would feature a fairly tall, narrow combustion chamber enabling a sufficiently long spray path to assist with the evaporation of the fuel. The existing crankcase was retained for these tests, the direct injection fuel pump being belt-driven from the crankshaft.

Engine layout

Once the fundamental design and analysis tasks were complete and the combustion system design fixed, work started on laying out the basic engine architecture. The twin and Pioneer, operating up to 12,000 ft (3,658 m) for five to 12 hours. Payload capabilities vary dramatically, too, and while the largest UAVs are capable of carrying more than 5,000 lb (2,268 kg) the smallest might carry just a few pounds of surveillance equipment.

Propulsion systems

Within the various UAV platforms, a number of propulsion units are used including electric, internal combustion (IC) engines and gas turbines. The largest category by volume is for IC engines used in Tactical UAVs of various sizes and performance levels. Electric motors are the least common; used between 0.1 hp and 2 hp, they are employed in 16 platforms. Turbines power 22 of the larger platforms and produce between 97 and 950 shp (shaft horsepower). But IC engines producing between 1.5 hp and 135 hp are used in no less than 67 UAV platforms and 70 percent of all UAVs powered by IC engines are used by the military. So there are many categories to deal with and a considerable need for a family of dedicated UAV engines like the Ricardo Wolverine.
Designed from a clean sheet of paper specifically for its role in this class of UAV, Wolverine3 draws on Ricardo’s immense experience in engine design and analysis to incorporate the most sophisticated technologies available. It is horizontally opposed to achieve the most satisfactory packaging in the aircraft. A cam on the crankshaft would drive the integral high pressure fuel injection pump which would also incorporate the 500 Watt generator. Reed valve induction was incorporated to control the ingress of air directly into the bottom of the crankcase. The relatively long fuel injectors were fitted perpendicular to the cylinder bore, trailing from the cylinder heads rather than sticking out in line with the cylinders. This avoided compromising the overall package size of the engine but necessitated the design of an injector incorporating a 90 degree nozzle.

The Wolverine3 is a ‘big bang’ engine with both cylinders firing at once. This means both cylinders can share the same crankcase (two-strokes use crankcase compression to transfer intake air to the cylinders) and leads to a simpler, lighter design. “Approximately 20 concepts were considered for the cast aluminium alloy crankcase,” Cakebread continues. “The final choice was two vertically split crankcases which incorporated integral bearing support, cylinder barrel and head bolted together.” The structure was modelled in CAD and outputted to a third party software tool to determine load paths for weight optimization. Once the basic structure had been defined, thermal and mechanical loading were applied using Finite Element Analysis (FEA) which assisted in deriving acceptable cover factors through design iteration.

Cast iron cylinder liners were avoided to save weight: the bores were Nikasil plated instead. The crankshaft has been substantially optimized for weight too. Three bearings were considered initially, two to support the cylinder loads and a third to take the load from the fuel injection pump. This proved too heavy and further analysis made it possible to dispense with the third bearing altogether. The crankshaft counterweights were deemed too heavy, so the conventional integrated weights were omitted in favour of much smaller external weights added to either end of the crankshaft assembly. The final design was manufactured using premium alloy steel, with needle rollers being used for the big and small end bearings and roller bearings for the mains for robustness and low friction. Simple two-strokes generally use 2-stroke oil pre-mixed with the fuel. The path of the fuel is usually through the crankcase and this is enough to lubricate main, big-end and small-end bearings as well as the piston and cylinders. This is not possible with a direct injection engine, the fuel being delivered directly into...
the combustion chamber, so the Wolverine3 is equipped with a total loss oil system which injects lubricating oil stored in a tank on top of the engine, directly onto bearings and the cylinder walls. The Wolverine3 also employed a commercially available ECU in order to provide full sensing and control at any altitude.

First fire and first flight
Based on highly relevant military engine experience, Ricardo was able to take the Wolverine3 engine from concept to production readiness in just six months. Following its first fire in May 2010 at the Ricardo Detroit Technology Campus, the Wolverine3 was integrated with the NightWind 2 airframe ready for its first flight on 12th October 2010 at the National Nuclear Security Administration’s Nevada National Security Site. “Once launched, the aircraft completed its prescribed flight plan, having achieved all of its objectives perfectly,” concludes Cakebread. Having run and proven its first heavy fuel UAV engine, Ricardo will continue to test and develop the Wolverine3 as it discusses opportunities with several potential US military and defence sector clients, as well as a number of interested parties in Europe.

Having established its expertise in this exciting new field, interest in Ricardo is already growing amongst potential customers. As the number of requests for UAV-related work increases in line with the growing market, Cakebread and his team intend to remain right at the heart of the action.

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Flybus technology wins award

The Flybus consortium, in which Ricardo collaborates with Torotrak, Optare and Allison Transmission, has been announced as a winner of this year’s UK Low Carbon Vehicle Partnership (LCVP) Technology Challenge. This project involves the demonstration of a flywheel hybrid powertrain based on Ricardo’s advanced Kinergy flywheel technology, linked to a Torotrak continuously variable drive that makes the link between the flywheel and the vehicle transmission. The complete powertrain is being installed within an Optare Solo bus with an Allison transmission.

The LCVP Challenge this year identified technologies that can reduce the carbon footprint of heavy goods vehicles such as trucks and buses. The consortium is developing a low-cost, easily installed flywheel hybrid system that reduces CO₂ emissions by around 20 percent during urban stop-start operation.

“The judges were particularly impressed with the system’s potential to be retro-fitted to existing buses and trucks. The technology is a smart combination which allows a clever C0₂-reducing solution to many vehicles and fleets,” explained Low Carbon Vehicle Partnership programme manager Roy Williamson.

A unique feature of the Ricardo Kinergy technology used in the Flybus project is that it incorporates a patented magnetic gearing and coupling mechanism that dramatically reduces external input and output speeds for more manageable handling by the Torotrak CVT. Moreover, this coupling avoids the need for a mechanical linkage to the high speed flywheel and allows the unit to be retro-fitted to current vehicles.

‘EconoMark’ evaluates market leaders

Benchmarking by Ricardo provides a valuable mechanism for automakers and Tier 1 suppliers to judge in a highly objective and informed manner the competitiveness of their own products through the meticulous analysis and assessment of their competitors. The EconoMark programme was introduced recently by Ricardo and specifically aims to evaluate through a series of in-depth benchmarking studies the performance, fuel economy, CO₂ and regulated exhaust emissions of passenger cars considered representative of the current technological state-of-the-art.

Each assessment includes detailed vehicle-based testing, engine testing on a dynamometer, and a thorough engine design review. From this research, detailed analyses are possible of performance and economy, emissions, engine mapping and friction breakdown, as well as a more qualitative evaluation of the design against Ricardo guidelines and prevailing industry norms and best practice.

Ricardo EconoMark benchmarking studies have now been completed for a range of market-leading vehicles. The first three completed studies were of the VW Golf 1.6L Diesel BlueMotion (certified at 107 g/km CO₂) VW Polo 1.2 L three cylinder Diesel BlueMotion (87 g/km CO₂) and Mercedes C250 CDi BlueEfficiency, while further evaluation of the BMW 320d ED (109 g/km CO₂) diesel is currently in-progress and many more are planned for 2011.

“We designed the EconoMark programme on a consortium basis,” explains project director within the Engines Group, Philip Hore, “to enable it to be driven by the interests of participating members. These companies – which are drawn from across the international automotive industry – are able to express in advance the key considerations of vehicle performance and the technical attributes they wish to see assessed in future studies. The LCVP Challenge this year identified technologies that can reduce the carbon footprint of heavy goods vehicles such as trucks and buses. The consortium is developing a low-cost, easily installed flywheel hybrid system that reduces CO₂ emissions by around 20 percent during urban stop-start operation.

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Ricardo joins PMI Global Executive Council

The world’s leading project management member association, the Project Management Institute, has appointed Ricardo to the organization’s Global Executive Council. The council represents an elite group of industry-leading decision makers who are using project management to identify opportunities for process improvements in project, programme and portfolio management; to exchange best practices and to increase the percentage of successful project-related investments within their own organizations.

“We are delighted to join the PMI Global Executive Council,” said Mark Garrett, Ricardo plc chief operating officer. “Reviewing research, exchanging benchmarking data, and sharing best practices with this premier group of market-leading organizations will ultimately deliver both client and shareholder value that leads to long-term results.”

“Performance is a key element of Ricardo’s strategic vision,” said Fred Payne (above), vice president and global programme management director, Ricardo’s representative on the Council and member of the Research Advisory Committee. “Our membership in the PMI Global Executive Council demonstrates our company’s commitment to excellence in programme performance.”

PMI is the world’s largest project management member association, representing more than half a million practitioners in over 185 countries. As a global thought leader and knowledge resource, PMI advances the profession through its global standards and credentials, collaborative chapters and virtual communities, and academic research.
ILMS victory caps glowing career Peugeot 908 HDi FAP

Ricardo was quick off the mark to congratulate Peugeot when the French automaker secured the Intercontinental Le Mans Cup (ILMC) for 2010 – the first year of this newly created series – and on the announcement of the new 2011 car with which it will defend both its current ILMC and Le Mans Series titles.

The illustrious racing career of the Peugeot 908 HDi FAP was capped on Sunday 7th November at the 1000 km race at Zhuhai, southeast China, when the car driven by Stéphane Sarrazin and Franck Montagny took first place followed in fourth position by the second 908 of Sébastien Bourdais and Simon Pagenaud. With this victory, Peugeot also took both the Team’s and Manufacturer’s titles for the newly-created series – and on the Intercontinental Le Mans Cup (ILMC) for 2010 – the first year of this new series.

In parallel with the 2010 race programme based on the 908 HDi FAP, Peugeot Sport has been working on the design and development of the 2011 car which it is currently codenaming as 90X. “Ricardo is proud to have played its part in engineering and supplying the highly optimized transmission system for the Peugeot 908 HDi FAP,” said Ricardo director of high performance transmission products Mark Barge. “This is a car that will go down as one of the landmark cars of Le Mans history. We congratulate Peugeot and we look forward to continuing our work on the transmission for the 2011 90X, which we believe will continue the proud race- and series-winning heritage established by its predecessor.”

The Peugeot 90X which will supersede the 908 HDi FAP in 2011.

Open architecture ECU collaboration

Ricardo and Pi Shurlok have announced a collaboration that will enable their customers to benefit from the ability to develop new products based on world-class control technology that can move quickly and seamlessly from concept to production, enhancing the potential of, and reducing time to market for, new powertrain and hybrid vehicle innovations.

Under the terms of the collaboration, the two companies have agreed to work closely together to provide customers in the automotive, commercial vehicle, off-highway equipment and defence vehicle sectors with a completely new service.

Together Ricardo and Pi Shurlok will offer the option of a comprehensive and fully integrated solution ranging from the development of powertrain products incorporating new ECUs by Ricardo, through to high-quality volume electronics manufacture and supply from Pi Shurlok.

This joint service will be based upon a choice of Ricardo’s open architecture “Morfeus” controller and Pi Shurlok’s OpenECU technology, for which a wide range of production-ready ECUs is available for new vehicle innovation programmes.

Ricardo wins Green Innovation Award

In early November Ricardo was named as the 2010 winner of the ‘Green Innovation’ award of TheGreenCarWebsite.co.uk, an accolade designed to recognize companies which have made an outstanding contribution to the innovation and use of greener technologies or ideas within the car industry.

“Ricardo has made an outstanding contribution to the wider industry’s drive to cut emissions and increase energy efficiency,” said the website’s editor Faye Sunderland. “It has helped a huge number of car manufacturers by delivering everything from complete vehicle solutions to efficient drivetrain and engine products, while also contributing to research into the field of alternative fuels. Its whole market approach means that it has a broad and in-depth knowledge, allowing it to excel in creating the motoring solutions of tomorrow and to be at the vanguard of the drive to cut emissions.”

Commenting on the selection of Ricardo for the 2010 Green Innovation award, the company’s chief technology and innovation officer Prof Neville Jackson said: “This award recognizes the hard work, dedication and innovative spirit of the Ricardo team. Together our aim is to provide the technologies and solutions that will help create a more sustainable and lower carbon future for transportation in all the markets we serve around the world.”
Seminars & Events
Related to the automobile and clean energy industries

Advanced technology seminars, workshops and training courses

Ricardo is recognised worldwide as a leading authority in the development of the latest power systems for automotive and clean energy applications. While best known for our engineering and consulting programmes, an increasingly popular service is our regular series of seminars and training courses through which aspects of the company's knowledge and expertise can be shared with customers. These events are typically hosted at Ricardo Technical Centres and are led by some of our most experienced engineers and research scientists.

We constantly strive to develop new seminars and courses reflecting the very latest thinking and most topical areas of power systems technology and product development. We also strictly limit delegate numbers in order to create an environment conducive to discussion of aspects of particular interest to participants. Modestly priced, our Ricardo seminars and courses provide exceptional value for money but are consequently in high demand.

Our current programme of seminars is listed below. Most of these will be hosted at the Shoreham Technical Centre, further presentations may also be made at other Ricardo facilities or at customer sites subject to demand.

Seminar programme:

Two one-day seminars covering the fundamentals of gasoline and diesel engine combustion and technology. The seminars are aimed at engineers who wish to gain a broad based knowledge of engine technology, and who wish to broaden their understanding of engine combustion, emissions and related issues.

Automotive Transmissions Fundamentals: 16-17 February 2011
A two day seminar covering the fundamentals of automotive transmission technology. The seminar will cover the main types of automotive transmission and is aimed at engineers who wish to gain a broad understanding of transmission technology, applications and future trends.

Batteries for Automotive Applications: 22 March 2011
A one-day seminar discussing recent developments in battery technology for hybrids, plug-ins and electric vehicles. Covers the latest in electric motive technology and an overview of recent trends and advances in battery pack technology, the key enabler of the electrification of the vehicle network.

For more information about our current seminar programme or to discuss individual company-specific training requirement, please contact: seminarinfo@ricardo.com.
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For more information contact us at cleanenergy@ricardo.com