

# **Jaguar X-TYPE 2.0D**

**Engineering support for  
Jaguar's first-ever diesel**

## **Interviews**

Mitsubishi design chief  
Olivier Boulay

Tom Keim, consortium  
director, MIT

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As director of the MIT industry consortium on advanced automotive electrical and electronic systems, Tom Keim is on a mission to make cars better for everybody – especially consortium members, including Ricardo. He spoke to **Tony Lewin** on his recent visit to Ricardo



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## ● in brief

### Higher safety standards

Selected automakers and importers in the US have voluntarily subscribed to higher safety standards giving improved head and neck protection for occupants. Companies will name those of their models which comply. In a separate move the US National Highway Traffic Safety Administration announced tougher rear-end impact fire protection standards. The new test uses a deformable barrier travelling at 50 mph (80 km/h).

### CO<sub>2</sub> dominates R&D spending

The struggle to reduce fuel consumption to meet 2008 CO<sub>2</sub> emissions targets is absorbing up to half the research budgets of European automakers and suppliers, according to SupplierBusiness.com. The newsletter estimates the annual spending at 35bn.

### Volvo's safety systems

Four safety systems have been announced by Volvo: a blind-spot information system mounted in the door mirror, a radar adaptive cruise control, a warning system which brakes automatically if there is risk of collision, and a door-mounted curtain airbag for convertibles. The blind-spot system will appear on a production car this year.

### Daytime lights save lives

Over 37,000 collisions have been avoided since daylight running lights (DLR) were introduced in 1995, according to GM. A study conducted in 17 states revealed statistically significant reductions in several accident types, notably vehicle-to-pedestrian, where 772 collisions were avoided in 2001. GM has sold 30m DLR-equipped vehicles in North America.

# Hybrids gain mainstream momentum

Products, concept cars and programmes announced at January's North American International Auto Show in Detroit reveal a quickening trend towards hybrid powertrains, even for volume selling models and mainstream brands.

The trend was highlighted two months previously, when the second-generation Toyota Prius hybrid was named North American Car of the Year 2004 by a panel of leading automotive journalists from the US and Canada. Toyota had announced it was to implement a third shift at the factory producing the Prius in order to cope with demand.

Both Ford and General Motors are due to begin series production of hybrid gasoline-electric pickup trucks this year, while Dieter Zetsche, chief executive of Chrysler, told the Financial Times that his group would come

to market with a hybrid within 2-3 years. The near-production Mercedes-Benz GST concept was exhibited in Detroit with a hybrid powertrain, technology which it is thought could be used in a Chrysler vehicle.

Perhaps the most significant developments come from Honda and Toyota, which have been making the running in hybrid passenger cars. Following the very favourable reception given to the small-medium sized Prius, Toyota has announced for late-2004 sale the first hybrid luxury SUV, its Lexus RX400h. This breaks new ground not only in its size and performance, but also in its use of electric drive to the rear axle to provide 4x4 capability. The rear motor, along with a similar unit powering the front wheels, provide a total of about 270

horsepower, demonstrating that hybrid operation

can be used to boost performance as well as economy.

Toyota also showed a large FTX full-size pickup truck concept, linking a V8 engine to its Hybrid Synergy Drive technology. This model is seen as a pointer to the 2006 Tundra replacement, giving Toyota a head start over the US domestic heavyweight pickups, which are not expected to offer a hybrid option until 2007.

Honda, whose mild-hybrid Civic IMA compact is a big success in the US, announced a V6 hybrid version of its larger Accord sedan, a model which is a regular contender for the title of number-one seller. Honda claims that the Accord, which also features cylinder deactivation for its 240 hp V6 engine, will offer superior performance to the V6 as well as the economy of a four cylinder car. A Honda manager, quoted in the FT, expects that 40 per cent of the company's sales will be hybrids by the end of the decade.

The Mitsubishi Eclipse Concept-E gives a different angle on hybrid thinking within the broader DaimlerChrysler alliance. Its sporty design uses a 270 hp gasoline V6 to power the front wheels and a 200 hp electric 'E-boost' motor on the rear axle to provide stronger acceleration and to fill torque interrupts during gearchanges.



Toyota FTX concept links hybrid with V8 gasoline power

## US may rethink CAFE rules

The US National Highway and Transport Safety Administration (NHTSA) is considering a major overhaul of the way it calculates the corporate average fuel economy (CAFE) levels which automakers must achieve in order to avoid paying gas-guzzler fines. Central to the overhaul is the distinction between light trucks and cars: at present, cars must average 27.5 mpg and trucks 20.7, prompting automakers to have their vehicles classified as light trucks wherever possible.

Under the NHTSA's definition a vehicle with a flat floor can be classed a truck, examples being almost all minivans and even the Chrysler

PT Cruiser. Vehicles over 3.8 tons such as the Ford Excursion and Hummer H2 are exempt from CAFE standards altogether.

Transportation Secretary Norman Mineta has called for a national dialogue on the issue. Some have argued that if trucks were reclassified as cars and had to reach higher economy standards they would have to be made lighter, and may be less safe. "The agency is interested in any suggestions towards revamping the CAFE programme in such a way as to enhance overall fuel economy while protecting occupant safety and the economic vitality of the auto market," said NHTSA.

Volkswagen: tipped for above-average growth this decade



## A message from the Chief Executive

In the eighty one years since William Lyons founded the company which went on to become the Jaguar we know so well today, its trademark 'leaping cat' adorned many of the world's finest sports cars and luxury sedans. A marque long synonymous with the application of technology in the pursuit of exciting products, the cars produced by Jaguar had one other thing in common: they were all powered by gasoline engines.

In the summer of 2003, however, a major milestone was passed with the launch of the Jaguar X-TYPE 2.0D, the company's first ever diesel product. The enthusiastic reception that this vehicle received from the press and public alike was demonstrative of the vision and foresight that Jaguar had shown in making this bold step forward. In the rapidly expanding European market for premium diesel products the X-TYPE 2.0D has great potential for commercial success as well as being a worthy addition to the Jaguar heritage.

In this issue of RQ I am grateful to Jaguar for providing permission to describe the assistance provided by Ricardo engineers to the in-house Jaguar teams as they developed and brought into production the company's first ever diesel car.

## Global growth forecasts

While Europe will enjoy significant medium-term growth, expansion in the region will continue to be sluggish over the next two to four years as new member states join the EU, according to an industry newsletter. The forecast, produced by PricewaterhouseCoopers, shows global vehicle assembly growing by over 16 per cent by 2010 to 65 million units. Eastern European volume is shown as rising by almost 60 per cent over the period compared with 39 per cent for South America and 20 per cent for Asia, most of it fuelled by China's dramatic expansion from 1.7 million units in 2002 to an anticipated 5 million in 2010. North America and western Europe are predicted to remain

relatively flat, each reaching 2010 with a volume of 17.5 million units.

In terms of capacity utilisation North America is forecast to retain its lead but improve only marginally on its present 85 per cent use; South America will not see 50 per cent utilisation until 2006 or later, reaching just 58 per cent by 2010.

The pecking order between the top eight automakers will remain essentially unaltered for the rest of the decade, according to the PWC report. Against an overall expected volume growth of 16.6 per cent, GM is forecast to expand its volume by 12 per cent, compared with Ford's 10.7; the biggest rises will be posted by Hyundai, up 45 per cent,

Renault-Nissan, up 30 per cent, and BMW, growing by 25 per cent according to the forecast. The only change in ranking will be the VW group, growing 22 per cent to take fifth place from DaimlerChrysler, expanding by just 5 per cent.

GM chairman and CEO Rick Wagoner, speaking at the Detroit show, remained upbeat about the group's prospects, predicting that it would increase its share in all of its four core regions and expand by 20 per cent in China. Overall industry sales would rise to 60m vehicles in 2004, he forecast.

"The winners in tomorrow's global auto industry will be those companies that best combine the efficiencies of global scale with a superb focus on local markets. And I like GM's position," he said.

## Diesel 'not the silver bullet', say US scientists

Gasoline vehicles are more cost-effective than diesel for reducing oil use and lowering global warming pollution, according to the Union of Concerned Scientists (UCS) in Cambridge, Massachusetts. While acknowledging that technological advances will soon enable diesel cars to lose their 'dirty' stigma in North America, UCS analysts advise consumers to think twice before committing themselves to the purchase of a diesel car. Claiming that their *Diesel*

*Dilemma* is the first "apples to apples" comparison of the competing technologies, UCS researchers give diesel strong advantages in maximum potential global warming benefit and cost-effectiveness, but mark it down on initial cost, a penalty of the expensive emission-control measures required to conform with tailpipe pollution standards.

More broadly, the UCS argues that the US corporate average fuel economy regulations are not fuel-

neutral: the rules are based on fuel economy, not oil use, says the UCS report; with each gallon of low-sulphur diesel fuel requiring 25 per cent more oil than a gallon of low-sulphur reformulated gasoline, CAFE figures do not compare the two fuels on an energy-equivalent basis. When evaluating a diesel vehicle's impact on oil dependence, consumers are advised to adjust the listed fuel economy downwards 20 per cent.

# Mitsubishi's ambitious innovator

Frenchman Olivier Boulay is corporate general manager of the car product design office of Mitsubishi Motors Corporation. A former designer with Porsche, Mercedes-Benz and Subaru, he is a rarity in the Japanese car industry – a European who has spent the last 14 years in Japan. He spoke to Julian Rendell at the Tokyo motor show

## Where are you taking Mitsubishi design?

We are a small company, closest to Subaru in terms of product image, so we will not be like Toyota, a huge company. Our image targets are Audi and Alfa Romeo. But we have to succeed through product quality and emotion, interpreted in a Mitsubishi way. Upscale is the direction we must go, because we don't have the size of Toyota.

## What design influences are you looking at to define future Mitsubishi's?

There is a lot of creativity in this company and in Japan, but I think we have been following the US or European style too much. We need

to find a new Japanese direction. This is the time for us to be ourselves. The other Japanese car companies realise the same and have to do it, too.

## And how might that translate to cars?

There is the traditional and the modern: Japan has a great heritage in both. Japanese architecture has been very influential. And Zen design is known the world over. That's why the Space Liner concept had carpets woven like the swirls of a traditional Japanese gravel garden. These are the little details we can do.

## And what of the modern influences?

Think of the products recognised and well known around the world, like electronics goods from Sony, Panasonic and so on. Why not use these Japanese values in cars? And then there's food. Modern French cuisine has been inspired by Japan.

## In the past Mitsubishi cars have been criticised by some commentators for being bland and unexciting. Will you change this?

For too long we were very conservative and we were also unsuccessful. Now it's *banzai* and forward and we have lots to do. Spirit will be predominant. It is important to have a sense of humour when you do a car. People need some fantasy.

## Are there any current models or concepts that sum up this aim?

The CZ2 Cabriolet is the best example. It is very emotional. When I joined Mitsubishi, the Colt hatchback's design was too boring and cold and too close to the Audi world, so I added a bit more fantasy.

## When will this emotional design filter through to production cars?

Very soon. We will launch 14 new cars in Europe between 2002 and 2007. The Colt hatchback will come to Europe in May 2004. On the outside the nose will have a new grille. All have been inspired by the CZ2.

## Does platform sharing feature in Mitsubishi's future?

In several ways. The platform of the Colt, for example, is shared with the smart ForFour and next-generation Mercedes A-class. And we are working on a joint platform with Chrysler for our Lancer replacement in the C-segment.

## Will these be made in the same facilities?

The plan is to make the ForFour and Colt three and five-doors at NedCar in the Netherlands. Production of the five-door Colt starts in spring. We are refurbishing the plant ahead of Volvo pulling out the S/V40 and will have a total capacity of 280,000 units.

## Who is taking the engineering lead on the C-segment platform?

It is a Mitsubishi platform and the planning is well advanced. We have agreed the number of body variants, although it is not yet clear how many will be sold in Europe, for example.

## What about the D-segment, covered by the Galant nameplate?

We have a new Galant in the US, but we won't sell that in Europe or Japan – although it may go to Australia. It is too big for Europe and Japan, so we will develop a separate model for those markets. Incidentally, the US Galant is core to Project America, our recovery plan for Mitsubishi Motors North America (MMNA). The Endeavour SUV and Eclipse coupé, unveiled at last month's Detroit Auto Show, are the two other key products for Project America.



Mitsubishi i concept (above) and SE-RO (top) use novel underfloor engine architecture.



## Olivier Boulay

**1981** Graduated from ESAG (Ecole Supérieure d'Arts Graphiques et d'Architecture)

**1982** Masters Degree course, Royal College of Art, London

**1982-1987** Designer at several automotive companies including Idea Institute and Porsche

**1987-1989** Manager, Design, Daimler Benz AG in Sindelfingen. Projects include exterior of S-class and C-class

**1990-91** Chief designer, Fuji Heavy Industries. Main project - Subaru Legacy.

**1992-1998** General Manager of Mercedes-Benz Advanced Design Centre of Japan (Maybach concept)

**1998-2001** General Manager of DaimlerChrysler Advanced Design Germany

**2001** – Mitsubishi

### Can Mitsubishi get its new product development cycle times down to compete with Toyota, for example?

Computer technology is speeding development times and Toyota, for example, has many of the new B5 super-fast computers. You have to be very rich these days to make cheap cars! We have to go step by step.

### You showed the i city car concept at Frankfurt and Tokyo. Does this model have a production future?

Yes, the i will be built in two versions – one for Japan, where it will be a K-car, and another for Europe. The European version will be wider for greater stability at speed.

### Won't the i compete with the smart ForFour?

It will be a very different car in the A-segment and I think it will be different to the smart. The i is a little bit more sophisticated. And other car makers will take on smart. I think it's better that the DCX group has alternatives and doesn't just leave it to the others.

### It is a four-seater. Will you do a two-seater, based on the smart?

Two-seaters work very well in Europe because of the parking. But in Japan it is not such a problem. Every new building has an underground car park. It is much easier to park my car in Tokyo than it is in Paris. Most of the cars in Tokyo are big. And drivers

spend a lot of time in their cars because of traffic jams, so the interior has to be big. That's why the i and the SE-RO [a second i-based concept] are four-seaters.

### The i concept has an unusual under-floor engine layout. Will this make production?

That is the plan. The engine is a new lightweight 1.0-litre MIVEC and our engineers say it is 15 per cent more efficient than other small engines. It has a smart idling system to improve fuel efficiency. The i is also a low drag design with a Cd of just 0.24. We have tested the car in Germany at ADAC and we scored five stars for emissions and fuel consumption, equivalent to the 3litre/100km standard or 88g/km of CO<sub>2</sub> emissions.

### How does the underfloor location help?

It is needed because of new pedestrian safety impact regulations. Moving the engine under the body makes the nose of the car more pedestrian friendly.

### Europe will have pedestrian impact legislation in October 2005. What is your view of the EU's approach?

It is a headache for all of us in the industry, costing billions and billions of dollars. All this is for cars and nothing for trucks. And why not motorbikes?

### That is a very strong view. Why?

We are asked to make cars lighter, more fuel efficient and these guys come up with regulations that make cars heavier, more

expensive and with higher fuel consumption. Where is the logic in this?

### Do you have an alternative solution?

I think real safety comes through electronics. The car that can see. The car that prevents you hitting somebody.

### Both Toyota and Nissan have upmarket brands, Lexus and Infiniti. Do you have plans for an upmarket Mitsubishi brand?

We are a bit far away from that at the moment. But our Space Liner concept gave some ideas of how we might treat luxury. In ten years or more, Mitsubishi can be close to this without reaching the levels of Mercedes.

### What do you think of today's design trends?

I think interiors are weak. People talk a lot about precision. But so what? Interiors are all alike. Where is the content, like TVs and electronics? It is time to make this sort of equipment standard.

### When you talked about the engine in the i concept, you didn't mention GDI direct injection gasoline technology. What future does GDI have?

Our engineers are working on a new generation of engines for launch after this year [2004]. Innovation in powertrain is essential and we will convert all of our engines, including GDI. These are global powertrain programmes and will be shared with DaimlerChrysler.

# The

A silver Jaguar X-Type 2.0D is parked at a diesel fuel station. The station has a large sign that says "DIESEL" in blue letters on a black background. The background shows a snowy mountain landscape under a clear sky. The car is positioned on the right side of the frame, and the fuel pump is on the left. The overall scene is set in a winter environment with snow on the ground and mountains.

# cat goes diesel

**Jaguar's first diesel has earned praise for its performance and refinement and is already a major sales success. Anthony Smith talks to the Ricardo team who supported Jaguar to deliver the world-class X-TYPE 2.0D from first concept to Job One, a programme which, innovatively, included prototypes built at Jaguar's Halewood production plant**

There can be little doubt about the significance to Jaguar of the 2004 X-TYPE 2.0D. As the first ever diesel vehicle to be offered by the company since its foundation some 81 years previously, the car's place in history was perhaps already assured from the moment that the first production vehicle left Jaguar's Halewood plant in August 2003.

However that distinction is only part of the story – and a small one at that. Of rather greater importance is the commercial significance that this highly refined and well targeted product means for the Jaguar brand, taking it into a new and rapidly growing diesel market and extending Jaguar ownership to a much wider customer base. According to Jaguar Cars managing director, Mike Wright, "It is exactly what buyers want and for Jaguar it opens up a vital new market sector, presenting significant opportunities to capitalise on the rapidly increasing pan-European demand for premium diesel cars." This view, expressed at the time of the X-TYPE 2.0D's launch just a few

months ago, was reflected in the widespread and enthusiastic coverage of the vehicle in the motoring media. More importantly than this, it has been subsequently borne out by the widely acknowledged sales success of the product at Jaguar's European dealerships.

#### **An established track record**

With such a landmark product it was critical to get things right first time, and to understand how Jaguar achieved such a smooth entry to the market with its first diesel product it is necessary to turn the clock back. Jaguar had recognised the rapidly growing significance of the market for premium diesel products in Europe and had already evaluated a range of alternative concepts over recent years. The company had identified the X-TYPE as providing an ideal platform for its first diesel, but with an already demanding schedule of new model programmes Jaguar decided that it would be prudent to bring in additional engineering capacity to





**A powertrain is installed into a 2.0D X-TYPE at Jaguar's Halewood plant**

support the vehicle development programme. It was vital that the selected partner came with a track record in diesel engineering programmes.

"Ricardo assisted Saab in the introduction of its first diesel, the Saab 9-3TiD, and more recently we helped the Volvo Car Corporation in the development of its first ever in-house diesel engine, the D5," explains Howard Marshall, Ricardo business development manager. "At Ricardo we could offer expertise in engineering diesel vehicles and powertrains against the demanding targets of the premium brands."

**Proof of concept in a single vehicle**

Jaguar had access through its parent to a refined and highly efficient high-performance 2.0 litre diesel engine which appeared well suited to application in the X-TYPE. However, it needed to demonstrate that the two elements were capable of being brought together and engineered to the level of refinement and driveability that are the hallmarks of the Jaguar brand.

Even so, before committing to a model year programme the concept needed to be demonstrated in a tangible manner, and for this reason Jaguar asked Ricardo to assist in the preparation of a single vehicle concept



**'In every area, from refinement to driving dynamics, our aim was to make the first diesel-engined X-TYPE indistinguishable from a gasoline-engined X-TYPE'**

**– Jon Carling,  
Chief Programme Engineer, Jaguar**

demonstrator. The demonstrator was based on a production X-TYPE car and used the major diesel powertrain elements supplied by Ford as well as a range of bespoke components and systems required to effect the installation and deliver the premium brand targets. These included intake and exhaust systems, electrical harnesses, cooling pack, steering and chassis components, and a fundamentally new NVH pack.

In order to meet the stringent driveability standards set by Jaguar, the drivetrain calibration was adapted in order to create the characteristic Jaguar 'feel'. This was achieved, for example, by adapting the calibration of electrical signals from the throttle pedal potentiometer in order to optimise the relationship between pedal position and engine torque demand to more accurately reflect the particular driver expectations associated with a Jaguar vehicle.

**Establishing the project team**

As Jaguar's chief programme engineer for the X-TYPE 2.0D, Jon Carling had overall responsibility for delivery of the vehicle. A career man at Jaguar since starting with the company in the early 1980s as a student apprentice, he was already very familiar with the X-TYPE product, having been involved in the development of the original gasoline model. Jaguar established a joint project team with Jaguar and Ricardo engineers operating within the Ford global product development processes. The core of the team was based at a dedicated and secure project office and was empowered to draw upon specialist resources as necessary throughout Jaguar and Ricardo, as dictated by the requirements of the programme. Close integration between Jaguar and Ricardo, between the programme team and the nominated component and system suppliers, and between development and

manufacturing operations, was essential for project success. The team also needed to function effectively as an integrated part of the Jaguar product development community: with this in mind, secure links were established into Jaguar's engineering IT infrastructure enabling programme engineers to release new parts into the Jaguar system.

#### The Ricardo perspective

Within Ricardo, Bob Allsopp was appointed as product director for the X-TYPE 2.0D programme. A self-confessed "petrolhead", Allsopp is no stranger either to the management of large programmes or to the Jaguar brand. Like Carling, he also started his career with Jaguar as an apprentice and spent 18 years with the company before being appointed chief engineer of the then Range Rover product. He was subsequently managing director of GKN Technology before moving to Ricardo in 2000 to assist in the establishment of the vehicle engineering business.

"It was very much a collaborative effort", commented Allsopp, "with Ricardo engineers working alongside their Jaguar colleagues throughout the programme at both companies' facilities. The spirit of co-operation and enthusiasm that was developed in this team was fundamental in my view to the success of the programme. Not only did the Ricardo team have to work in an integrated manner within Jaguar, but they were also responsible for working with the nominated Jaguar suppliers – including Ford on supply of the engine – in order to bring their components and systems into production."

The Ricardo engineering team



**'It's a fantastic vehicle and very much a credit to the enthusiasm, hard work, and dedication of its Jaguar – and Ricardo – engineering teams.'**

**– Bob Allsopp,  
Ricardo**

Weight was also a major issue for the team, who used the OPTISTRUCT structural optimisation software to minimise the weight of key modified components. As Allsopp explains, the focus upon simulation and analysis is a fundamental aspect

of the Ricardo approach to a highly compressed programme: "Ricardo has invested significant resource in the development of CAE tools and applications in order to enable us to produce design work on a right-first-time basis. In a programme such as the X-TYPE 2.0D this is an important enabler in being able to deliver a high quality product to market without delay." The integration of control systems was also a major focus for the development team. As Ricardo chief engineer on the X-TYPE 2.0D programme, Kevin Harding was responsible for addressing this challenge: "Jaguar needed to

comprised a range of core specialist skills including CAD design, CAE, electrical integration and NVH. While much of the powertrain required only minor adaptation, many key systems and components needed to be re-engineered from scratch for the X-TYPE installation. Full component engineering programmes were needed for these and considerable analysis effort was used in, for example, the simulation and optimisation of the intake and exhaust systems and underhood airflow structure using the VECTIS Computational Fluid Dynamics (CFD) package.

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develop a unified communications structure and harnessing architecture to ensure effective operation of vehicle systems including DSC (Dynamic Stability Control), ABS, cruise control and HVAC. A significant aspect of this challenge was to define software interfaces in such a way that key operating parameters from both the existing X-TYPE 2.0L gasoline vehicle and the diesel engine were retained in order to minimise the amount of recalibration required." Close collaboration between Jaguar, Ricardo and supplier control and calibration teams was crucial to ensuring that systems could be developed and validated in parallel, reducing iterations and compressing the time taken by around 50 per cent.

Vehicle dynamics too was a major area of engineering investment. "A diesel installation in an existing gasoline platform presents some fundamental challenges," explains Harding. "The torque delivery of a diesel is entirely different from that of a gasoline engine and this needs to be reflected in the tuning of chassis systems in order to provide equivalent standards of handling and driveability to the baseline vehicle. In addition, the diesel powertrain brought the challenge of an increased front axle weight and the vehicle was required to be engineered with two alternative chassis tunes; respectively for 'sport' and 'comfort' derivatives." The success of the team in this aspect of the programme is reflected in the comments of Jon Carling, at the time of the vehicle launch: "In every area, from refinement

## Jaguar X-TYPE 2.0D in numbers

**Engine:** 2.0 litre 4 cylinder 16-valve turbodiesel with common rail injection  
**Max power:** 130ps (128bhp DIN)  
**Max torque:** 330Nm with the facility for 'overtaking' overboost to as much as 350Nm  
**Fuel consumption:** 5.6 lit/100 km (combined cycle) – gives a potential range of more than 1000km  
**CO<sub>2</sub> emissions:** 149g/km CO<sub>2</sub> emissions rating – a class-leading figure in the compact premium diesel segment  
**Max speed:** 202km/h  
**Acceleration:** 0-100 km/h, 9.5 seconds

to driving dynamics, our aim was to make the first diesel-engined X-TYPE indistinguishable from a gasoline-engined X-TYPE, especially in the way that it sounds, and in the way that it delivers effortless ground-covering performance – just like a Jaguar should."

Key vehicle performance, handling and NVH targets for the programme were established in two ways. Firstly a range of 'objective' competitor vehicles was identified, representing the market-leading products in the European premium diesel sector. Targets were established for key performance criteria of these competitor products, and it was these

benchmarks against which the new X-TYPE 2.0D was to equal or improve upon.

In addition to this, the results of development testing of the single concept demonstrator vehicle were also used to define programme targets. Moreover, the vehicle itself remained a performance benchmark for Jaguar throughout the programme and was frequently used as a direct comparator in development testing. While this approach represented a clear opportunity to build upon the work already carried out in advance of the programme, it also brought with it some unique challenges. In any aspect of measured performance there is naturally some level of vehicle-to-vehicle variability. This is typically addressed by testing a number of vehicles of nominally the same build and evaluating the likely range of performance against which targets should be set; this clearly cannot be an option for the single demonstrator vehicle.

A significant achievement of the NVH team was in the deployment of integrated testing procedures in order to provide an objective link between the base engine combustion noise, bulkhead sealing and the vehicle cabin noise levels perceived by the passenger. Using this approach the team was able to take account of engine and vehicle build variability in achieving key noise targets.

### Integrating development with production

Engineers from Jaguar's X-TYPE production plant at Halewood were involved from the first

build of prototype cars in the early summer of 2002. This early involvement of the production plant in the development process of the vehicle was viewed by Jaguar as critical to the achievement of the programme timing and quality targets. "They observed the build very closely," explains Ricardo build and launch manager, Dean Murden, "and they were able to highlight very early in the programme issues which might cause problems when the vehicle was carried forward towards production. The enthusiasm of the production team at Halewood was impressive – they embraced their early involvement in prototype build and were committed to making it work."

Unusually, Jaguar implemented the next prototype build within the Halewood

## '...tremendous refinement and exceptional economy and emissions...' Autocar magazine

manufacturing plant itself rather than in a specialist prototype workshop as would have been traditional practice. This was yet another first for Jaguar on the X-TYPE 2.0D programme: bringing the new model into the production plant one full prototype stage ahead of the company's usual product development sequence.

The programme team prepared assembly kits for each of these prototypes at Ricardo and shipped them to the Halewood plant ready for the prototype build. Key members of the team relocated to Halewood for the duration of the build process, which was run in a highly controlled manner in parallel to the main X-TYPE production line. The parts for each assembly operation were delivered to each station and were fitted to the vehicle by the production staff.

"Taking this level of prototype into the plant was an excellent way to identify as early as possible any problems and difficulties which may arise during production implementation," recalls Murden, "but it created a bow wave of issues to be identified and addressed by the team much earlier in the programme than might normally have been expected at this stage." All of these problems were logged in Jaguar's quality systems to ensure that they were dealt with and closed off in an acceptable manner through root cause identification and solution implementation.

The effect of identifying so many issues at once posed some short term capacity

difficulties for the team – Jaguar has clear guidelines on the number of identified problems that can be handled by each programme engineer – but it enabled the team to make significant progress in developing the vehicle ready for production. Moreover, the considered view of the programme team was that the ability to address these problems at an early stage enabled their resolution at lower cost and risk than would have been the case if left unresolved until a subsequent prototype stage. By the late spring of 2003 the full benefits of the compressed approach were realised as the remaining level of problem identification fell below that which might usually be expected.

### Job One and beyond

The Job One vehicle was produced to time in August 2003. As if the accolade of being the first ever Jaguar diesel were not distinction enough, the X-TYPE 2.0D achieved another important record on entering production: according to the standard metrics used by Jaguar to assess build quality, it achieved the highest rating of any new product launched by the company.

As the team continued to work towards the completion of Ricardo's engineering support at Job One plus ninety days, the response to the X-TYPE 2.0D was already apparent in the flow of customers into Jaguar showrooms throughout Europe. In the first year of production alone, Jaguar estimates that the 2.0D is likely to account for almost two thirds of X-TYPE sales across Europe and up to fifty per cent within the UK. Delivered to cost and time, the programme has exceeded expectations in many areas of targeted performance, and the

## Key programme achievements

- Quality, time and cost targets all met
- High levels of integration between OEM and external engineering resource
- Exceeded product performance expectations in key areas
- Considered by many to be best-in-class on NVH

X-TYPE 2.0D is clearly on path to becoming a very successful Jaguar product.

For Ricardo there are many lessons that Allsopp intends to take forward to other vehicle programmes. He cites the demonstrator vehicle as not only establishing a tangible proof of concept but also proving extremely useful as a vehicle level benchmark throughout the programme, augmenting the established development targets. He views the intensive use of CAE as particularly beneficial in developing the design to a comparatively mature level before the first prototype vehicles were produced. The enthusiastic and early involvement of the production staff and the implementation of early prototype builds in the plant environment were in his view clearly significant enablers of a time-efficient programme. Most of all, however, Allsopp sees the X-TYPE 2.0D as an achievement of focused team work: "It's a fantastic vehicle and very much a credit to the enthusiasm, hard work and dedication of its Jaguar – and Ricardo – engineering teams." ■



# Analyse, advise, deliver

In 2002 Ricardo launched its Strategic Consulting business in response to growing client recognition that technology, product and business issues were interdependent and crucial to success. Eighteen months later, Ricardo Strategic Consulting numbers some of the world's leading carmakers, Tier 1 suppliers and investment banks among its clients. Tony Lewin reports on a unique service that's expanding rapidly

Pick up a financial newspaper or flick through a motor industry journal, go to any automotive conference, seminar, motor show or other auto industry gathering and the challenges of being at the forefront of one of the world's few global industries leap out.

Most automakers concede that the business is tough and that the pressures are at an all-time high; component producers at all levels of the supply chain are likely to agree, too. But it would be a mistake to assume that such pressure automatically leads to across-the-board economic melt-down: the best-placed and most skilfully managed companies can frequently exploit their greater inventiveness and adaptability to benefit from a crisis and gain competitive advantage over their rivals.

The squeeze is clear: legislation in areas such as safety and emissions control is making cars more complicated, increasingly sophisticated customers are demanding more functionality in their vehicles, leading to ever more technical content in vehicles – and no-one wants to pay for it. At the same time manufacturers are trying to boost the appeal of their products to consumers by launching more and more niche derivatives, more rapidly and – this is the real crunch – at ever lower cost.

But while the dilemma is easy for anyone to see, it's an infinitely trickier task to find a profitable way out. It is here that the objectivity, clear vision and specialised expertise of an outside consultant with deep industry knowledge and product insight can make the difference between success and failure.

Deciding the way forward on engineering issues has never been simple: each technology has to be evaluated, developed and deployed in the most effective way possible to gain competitive advantage. The key here is the ability to make an informed choice between competing solutions and to gain insight into implementing such solutions effectively.

Yet as the business pressures on the world's car and component makers have intensified in recent years, Ricardo has become increasingly aware that the questions its engineering clients are asking are taking in broader strategic issues as well as purely technical matters. In effect, successfully aligning technology, product and business performance has become one of the critical success factors for vehicle manufacturers and their suppliers. No longer is it



**'Ricardo has always undertaken strategic consulting for its clients, but probably never fully recognised it.'**  
– Steve Parker, Ricardo

simply a question of deciding, say, between product attributes A and B: now, the decision needs to be based upon product performance, customer value, make-or-buy, product profitability and many other criteria.

## Deep industry knowledge

In response to these needs Ricardo has expanded its offer to clients by introducing a new consultancy division, Ricardo Strategic Consulting (RSC), to focus upon the broader business and economic issues that form the backdrop to the engineering decisions which the company already advises on.

Steve Parker, recruited in August 2002 as managing director of RSC, is clear about the principles upon which the new business operates:

"Our policy is to give the client clear, clinical analysis and implementable solutions which are right for the client's business and the markets in which it operates," he makes clear. "We believe Ricardo is very different from most of the traditional management consulting firms. We take into the equation very deep, detailed industry, product and technical

knowledge that the current management consulting firms lack.”

Parker’s colleagues in RSC all have the depth of background you would expect of people with this approach to business: strong academic qualifications, automotive industry careers across most disciplines, and backed by consulting experience with premium management consulting firms.

“As a result we get to a solution which is right for the client, and we get there with great efficiency,” says Parker. “We take into assignments industry expertise that is unparalleled in our sector. Our clients get real solutions expressed in clear language that can be implemented in a seamless manner, with or without our support.”

### Major strategic issues

The global auto industry is facing unprecedented challenges on many fronts, but all stem in some way or another from the biggest strategic imperative of them all – the need to deliver increasing value to increasingly sophisticated customers whilst continuously reducing costs to improve returns. These demands, says Parker, are the most powerful drivers of all, yet the solution is made all the more challenging by the impact of legislation and new technology.

Markus Doerr, leader of RSC’s European practice, believes a deep understanding of the vehicle development process is crucial: “This allows us to address the technical, organisational and logistical issues involved in delivering new product to market in an effective manner,” he explains. “A client will realise that the increasingly rapid changes in technology, in product and in the market are having an impact upon his current products, organisation and business model. So it’s

natural for that client to follow through from the product issues and ask the question ‘what else do I need to address upstream or downstream?’” As evidence of this trend, recent RSC projects have included business and market strategies, organisational design, product development effectiveness, and total cost reduction across the supply chain.

### Out-of-sector clients

Not all RSC customers would count themselves part of the automotive sector or, indeed, as industrial companies at all. Investment banks and private equity houses already form an important element in the RSC client list, as Steve Parker explains:

“Investors particularly value the deep knowledge we bring to the analysis behind any transaction, whether it be an evaluation of technology, products, markets or the effectiveness of assets for the future needs of the investor.”

One recent project focused upon supporting a group of banks in evaluating the fitness for purpose of a large automotive manufacturing facility.

Louis Bailoni at RSC’s Chicago office explains: “A second project saw an RSC team working with a client aiming for top-line growth through acquisition, with RSC identifying and evaluating opportunities both to add value to current products and to diversify into associated product sectors using the client’s core competencies.”

Bailoni and his team specialise in supporting suppliers to improve top- and bottom-line growth.

### Rapid growth path

Though Ricardo Strategic Consulting is barely eighteen months old, the amount of work – and the demand for the organisation’s services – has surprised all concerned, even MD Steve Parker.

“The volume of business that has been pushed to us by both existing Ricardo clients and new clients has been astonishing,” says Parker, “and the most remarkable thing is that even in today’s tough consulting market we haven’t had to go out and seek business.”

“The second pleasing aspect of the new business has been the reaction of the clients we have worked with over the past 18 months. They have been delighted at the level of content they have received, the practicality of the solutions and the efficiency of the process by which we delivered it. All this is already leading to a high level of repeat business.”

As a result of the initial success of this extension to its traditional business portfolio, Ricardo Group soon decided to expand the business into the United States. January 2004 saw offices opening in Detroit and Chicago, with Andy Chien as leader of RSC’s North American practice and Louis Bailoni leading the Chicago office. Both offices are already actively engaged in client projects for North American vehicle manufacturers and suppliers.

In parallel the RSC team in Germany, led by Markus Doerr, is expanding quickly and will be moving to new offices in the Stuttgart area in early 2004.

Ricardo’s strategic consulting operations are proving to be just what the auto industry has been needing: a carefully-structured balance between challenging but soundly-based strategic consulting and in-depth technology consulting, itself founded upon deep industry, product and technical knowledge – backed of course by the widely-acknowledged capability to deliver those solutions to a world-class engineering level.



Ricardo Strategic Consulting: expanding in UK, Detroit, Chicago and Stuttgart, below

# 'Real solutions delivered in clear language'

*Steve Parker was appointed Managing Director of Ricardo Strategic Consulting in August 2002. Previously, he was a vice president of AT Kearney's Global Automotive Practice and was based in London. Prior to that, he held senior positions in Perkins Engines Group Ltd and PSA Peugeot Citroën.*

## **On a broad level, what is the most pressing issue for the auto industry today globally?**

One of the biggest issues the industry has to face is the very high cost base that it retains, and the continued pressure on costs from all sides. There are legislative pressures and an ever increasing demand for greater functionality and reliability on vehicles, all of which demand increasing levels of technology and changes to production and product life cycle management.

## **What are the most important synergies between strategic and engineering consultancy? Is this what Ricardo is now doing, lining up the two together?**

My view is that Ricardo has always undertaken strategic consulting for its clients, but probably never fully recognised it. Identifying, developing and implementing innovation strategy for an automaker or Tier One (T1) is strategic, I would even say critical. This is classical Ricardo work and something the industry has valued over the past 80 years. If you also work with the automaker to restructure his operations to accommodate the new technologies and realign his cost base to the new market needs, this is also strategic. It's one element of our new, seamless service offering.

## **How has the relationship between T1 suppliers and automakers changed over the last few years?**

Over the past years carmakers have been trying to do three key things that have had a major impact on T1 suppliers. They've been trying to leverage supplier capability in terms of technology, supplier investment and supplier knowledge to enhance their own products whilst removing the necessity for them to invest in those things

themselves. That's number one. As a result they have also been refocusing on core competence, which you can define both in terms of areas of the product which are core to their brand or skills. By implication this opens up requirements in the "non core" areas for suppliers, who are fulfilling it by increasing module size or taking system responsibility. Finally, many carmakers have become increasingly sophisticated in the purchasing processes and are demanding and securing ever larger cost reductions based upon the total value of the product or service provided. So T1 is a very uncomfortable place to be: it always has been, but it is now getting even more uncomfortable.

## **What is the impact of this shift in core competency?**

It depends on the carmaker's strategy, but there is a clear need within the automakers' own operations to divide technology and the associated product attributes into technologies that do or don't deliver incremental customer value. Some technologies allow the carmakers to generate additional value in terms of base model pricing and options pricing; other technologies are simply those which must be delivered to stay in business but from which they can derive little or no added value, as the customers won't pay for it. Emissions compliance is one of these. Carmakers are keeping, and in some cases bringing back in-house, technologies which are key to future product performance and profitability – an example is control and electronics. To stay ahead of these trends T1s need to be even smarter in the way they evaluate, acquire and deploy technology.

## **Do automakers want to have these incremental competencies on board as part of their portfolio rather than buying it from a T1?**

It depends on the automaker. Automakers are looking very hard at which core competencies they require – that's number one. Number two is that they are looking then to acquire and fill gaps in their own skill base and requiring that from T1s. The needle has now moved further because a



## **Parker: 'Automakers are much more sophisticated buyers of services than they used to be.'**

lot of the innovation these days is also coming from T2s and T3s. So an automaker's ability to acquire, evaluate and deploy technology and make profit from deployment of technology is becoming a core competence in its own right.

## **Has the change in T1 relationship with the automakers affected service providers in a different way to systems providers?**

I think it clearly has. Automakers are much more sophisticated buyers of services than they ever used to be and they are looking for value-based services. So they are looking very clearly to spend their money in a way that they can get a return on investment in consulting fees or services fees. They are looking for consultants capable of implementing in the detail, not firms who merely identify levels of savings or improvements targets and leave the automaker to deliver. And they're looking for service providers that have capability above and beyond the automaker's capability. The future for service providers is deep content and delivery capability and not just process.

## **Who is your typical client?**

We are currently working for clients who produce extremely high value, high performance vehicles, premium and volume car manufacturers as well as commercial vehicle manufacturers. In addition our current business includes T1 suppliers as well as businesses looking to acquire or dispose of assets. In some cases the work is across their global operations – so we have a pretty interesting portfolio of clients and some demanding but satisfying projects.

# Improving profitability through Warranty Management

For many vehicle manufacturers the average cost of warranty runs between 4 and 5 per cent of revenue. To put this into perspective, this represents approximately the same amount of money that many spend on their entire product development.

But the true cost of warranty is only understood when the impact on customer satisfaction and loyalty is considered. Customers will not make a repeat purchase if their experience of the brand is clouded by reliability problems and if the warranty service was unpleasant or unprofessional.

The pressure on warranty is expected to even increase further. Significant extensions in the level of coverage have been offered by most manufacturers in recent years, triggered by legislation, erosion of market share and rising consumer expectations. In the USA, some manufacturers offer 10 year/100,000 miles warranty coverage as a point of competitive differentiation. Unlike rebates or financing, extended warranty coverage has the potential to positively influence customers on a continuing basis beyond the initial purchase. At the same time the rising complexity of vehicles is increasing warranty cost to an all-time high, even for vehicle manufacturers once renowned for their superb quality. In parallel with these trends, consumer expectations are also at unprecedented levels – while 10 years ago a warranty incident was a vehicle failing to start, today's customer might turn to the dealership to get a squeak or rattle fixed.

Despite the huge likely financial impact, many vehicle manufacturers find it difficult to address warranty management in an appropriate manner – warranty always implies “fault” and many concerns can only be addressed if different functions in the company and suppliers work together. Best-in-class companies have found that they can turn improved warranty performance into a source of competitive advantage by addressing it both today and tomorrow: quickly find, fix and eliminate the current sources of warranty cost, and keep the problem from happening in the future. Companies that excel in warranty performance win twice: they will have the highest customer satisfaction and loyalty and the lowest expenditure. Ricardo works closely with clients to take warranty costs in hand and turn this into a source of competitive advantage, performing two complementary types of activities on both



current and future products: Total Warranty Management and High Value Problem Resolution.

**Total Warranty Management** consists of a warranty control centre as the focal point of co-ordination of six substantive modules which have been proven in many client programmes to pull the key levers of warranty improvement: First Time Quality, Fast Resolution, Incentive Alignment, Surfacing Waste, Service Excellence and Policy Alignment (see diagram).

The warranty control centre front office is responsible for the retrieval, analysis and prioritisation of warranty concern data from the field, manufacturing plants or external quality monitoring groups. The back office oversees an effective problem resolution process that involves all required stakeholders and handles the warranty concerns in priority order as determined by the front office.

Clients who have fully implemented Total Warranty Management have seen a dramatic improvement of their warranty performance.

The total potential of this approach is a reduction of warranty cost by up to 40-50 per cent, even in high-performing companies. While full implementation takes approximately four years, significant savings can be achieved in the first year from the reduction of warranty reserves, making Total Warranty Management a self-funding project.

**High Value Problem Resolution** is a structured approach that is applied to major and typically long-standing quality concerns. Ricardo strategic and technical consultants work side by side with the client until a permanent corrective action is identified and lessons learned are captured to prevent recurrence. Ricardo is well positioned to resolve almost any automotive warranty concerns through its expertise in engine, aftertreatment, transmission, controls and electronics, software and vehicle engineering.

The approach comprises the following key steps:

- Set up a cross-functional problem resolution team populated by leading subject matter experts
- Analyse the problem in a MECE (Mutually Exclusive Collectively Exhaustive) manner to understand the failure modes
- Define and implement the interim containment actions
- Determine root cause utilising systems engineering approaches
- Develop and implement the permanent corrective action
- Institutionalise the learning to prevent recurrence

Joint client and Ricardo teams typically resolve even very long-standing problems in less than 90 days. The interim containment actions are often put in place much more rapidly, so that the customer is protected and the cash drain is stopped. ■

# The mentor from Massachusetts

The Massachusetts Institute of Technology's Industry Consortium on Advanced Automotive Electrical/Electronic Components and Systems has over 40 member companies, including Ricardo. Its mission is to improve the performance of automobiles using innovative and advanced electrical technologies. Tony Lewin spoke to consortium director Tom Keim when he visited Ricardo recently

**Does the consortium concentrate its work on commodity items that are essentially platform neutral?**

We're working on things that don't differentially benefit, but I hate the word commodity. Commodity suggests price but no incremental value: what we're working on are items which are potentially accessible to all manufacturers – nobody can hope to use consortium work to derive a competitive advantage. They can hope to use knowledge they derive from working with the consortium to develop for themselves systems which they can sell for competitive advantage: they can take away knowledge but they can't take away specific technical tricks.

**So you're helping raise the baseline?**

Yes, we're making cars better for everybody and hopefully making our members wiser than our non-members.

**It strikes me that the consortium is mainly looking at electrics rather than electronics. Do you believe that by improving familiar items of electrical hardware such as the alternator we can make useful gains? Enough to keep pace with tightening requirements for fuel consumption?**

They are not going to solve all the problems that the auto industry faces in terms of meeting the declining carbon dioxide emissions. We are still going to need improved prime movers, but all these improvements in auxiliaries really do help. In the past, people were always able to build more efficient alternators: the problem is that they would weigh more, they would cost more, and the car company wouldn't buy them. So what we need is first off to do the system design and decide whether the likely



improvement in efficiency is worth the weight penalty it imposes.

**While batteries are steadily improving, they are still by no means ideal for automotive use. What do you think of ultra capacitors?**

An ultra capacitor is a far better power source than a battery and a far better energy source than a capacitor: it provides a combination of power and energy that you can't get by any other means. A couple of years ago I went to a conference where it became apparent to me that in some applications ultra capacitors were going into production, were finding places where they were good enough to justify building factories. The whole industry was talking about the cost reductions which were just around the corner. The prices the manufacturers were projecting they could get

to were still not good enough for widespread automotive use. But when I made some enquiries, I found that none of the materials in an ultracapacitor is inherently very expensive, which means that one might be optimistic that the manufacturers' projected cost reductions could eventually be exceeded. When I added my own optimism factor on top it began to look like we could use them.

**Stopping the engine when the vehicle is stationary is an obvious way to save fuel, but at present the engine is used as a power source for many of the vehicles accessories like air-conditioning. You have presented proposals for a fuel-burning thermophotovoltaic device (which directly converts heat from burning fuel into electricity) as an auxiliary power source for use when the engine is stopped. How does it compare in attractiveness to fuel cells?**

Firstly, you need to make certain that you are using reasonable weights and volumes of whatever materials you are using. The fact that it is very expensive to make today does not matter because the automotive industry is one of the most prolific manufacturing industries in the world: they build things in such quantities that they will figure out how to make it in a way that doesn't cost much more than the cost of what goes into it. So if there's something inherently expensive in it like cobalt or platinum, (as there is in most fuel cells) then I am not too interested. Also, a thermophotovoltaic device will work with gasoline or diesel fuel.

**You have suggested efficiencies of up to 40 per cent for a fuel-burning thermophotovoltaic device, and that the**

## Don Newton Director, Control and Electronics for Ricardo

We were very pleased that Tom took the time to visit Ricardo and we welcome his provocative views on technical matters. As a technology leader in automotive electronics we are part of the MIT consortium in order to contribute to the debate and to understand trends and technology developments.

Tom discussed the issue of dual voltages in vehicles. The idea of using a 5v/42v architecture makes sense from a technological perspective, perhaps using a 6v vehicle bus to allow for electrical transients while still being able to provide a regulated 5v to parts within ECUs that still require it, as well as allowing efficient reduction to the



microprocessor core voltage (typically 3.3 to 1.8v). With careful design this approach should have other benefits, for example it would reduce the "key

off" power drain from the vehicle, which is an issue even with today's 12v systems and it would reduce costs by allowing the use of lower voltage parts and eliminating many parts currently used to suppress transients (including load dump).

However, what is preventing a change to 42 volts is the volume of re-engineering of legacy electrical systems and components that would need to take place, an issue that is magnified by moving away completely from 12 volts. The blend of the technical and economic impacts is critical, and is why Ricardo's Control & Electronics and Strategic Consulting groups are collaborating on a number of projects.

Our work with the MIT consortium helps to keep Ricardo at the forefront of industry thinking, and we look forward to continued participation.

### **obstacles to volume automotive use of fuel cells are fairly formidable. Does this mean you could scale thermophotovoltaics up to form a propulsion system?**

One can do calculations that say 40 per cent, but in order to do that one must make some assumptions I am not sure can be achieved. But if you are at 15-20 per cent you are really competitive. However as a prime mover it doesn't have enough potential over the internal combustion engine. The internal combustion engine is already a great way of going from fuel to mechanical work. Going from fuel to heat to radiation to electricity to mechanical work is probably making two too many conversions, but I am very optimistic about it as auxiliary power and even for cogeneration for industrial heat.

### **Are the emissions issues manageable in an automotive application?**

I am not an emissions expert but in general continuous combustion – external combustion – is easier than internal combustion to make clean. We also have the benefit that we have a catalytic converter and a complete automotive exhaust gas system available to us when this thing is running, and maybe we can get some bonus points for keeping the catalyst warm when the engine is stopped. I have to believe the people who cleaned up an internal combustion engine can clean up an external burner.

### **Amid all the talk of dual voltage systems as a stepping stone to 42 volts you suggested that if you were going to choose to have a dual voltage system and 42 volts was going to be the higher voltage, you would probably chose something other than 14 as the lower voltage. You mentioned 5 volts as being a better alternative for running the controller systems on a vehicle. Can you explain?**

Well, let's try to divide the world into loads that you could rebuild to work off 42 volts and those that you could not or would rather not. Almost any load that is above a couple of hundred watts can be efficiently converted to 42 volts. I am not talking about development costs, I am talking about the incremental cost of building one more unit after recovery of all development expenses, some day far in the future. Lamps are a problem: 42 volt lamp filaments are unpleasant to contemplate. PWM (pulse width modulation) for lamps works pretty well. Really small motors such as those that work the window lifts in a luxury car may not be good on 42 volts either, but PWM works pretty well for those too. So as I go through the list of the things which are on the list for the 14 volt car and start looking at what can move to 42 volts and at what price, the problem that stares at you the hardest is the micro-controller.

### **Why would micro-controllers benefit from a lower voltage?**

In a luxury car there might be more than a hundred micro-controllers. If you look at

their internal workings, the chip that's inside there doesn't work at 5 – it works at 3 volts. The voltage at which these chips are working is going down, down – down faster than model years are advancing.

What those devices have inside them for prime power today is a linear pre-regulator. With the pre-regulator, if one wants 50 milliamps at 3 volts to drive the computer one takes 50 milliamps at 14 volts from the bus and one burns off those remaining 11 volts so most of the power that flows into the power terminal goes away as heat.

To do this at 42 volts with a linear regulator it would be worse still because now less than 10 per cent of the power is driving the computer – the rest of it is just being burned away. The 3 volts that drive the thing can be precisely regulated because this linear regulator has very fast dynamics so if the bus voltage bounces the linear regulator doesn't allow this to pass through to the low voltage bus.

At 42 volts people would probably go to a different type of technology, a switch mode pre-regulator. That is a cost increment but maybe for performance it is necessary. For the cost of a hundred switch mode pre-regulators, each of them inside their own individual chip, we can consider going back to making a linear regulator – and while we're at it let's go back and make them easy, that's where 5 comes from. At 5 volts one can easily make a linear pre-regulator twice as efficient as it is at 14. ■

# Ricardo-Judd race diesel t

As we reported in the Spring 2003 RQ, Ricardo has been actively looking at ways of developing a suitable diesel engine to take advantage of the new regulations for the Le Mans 24 hour race, issued by the ruling body, the Automobile Club de l'Ouest (ACO). The new rules will permit diesel-powered entries in the top LMP1 prototype category, starting in 2004.

A number of approaches have been explored by Ricardo, including that of a totally new design. However, following discussions with Engine Developments Ltd (EDL), manufacturers of the Judd range of race engines, the two companies agreed to explore the possibility of a conversion of the GV5 V10 Judd gasoline engine.

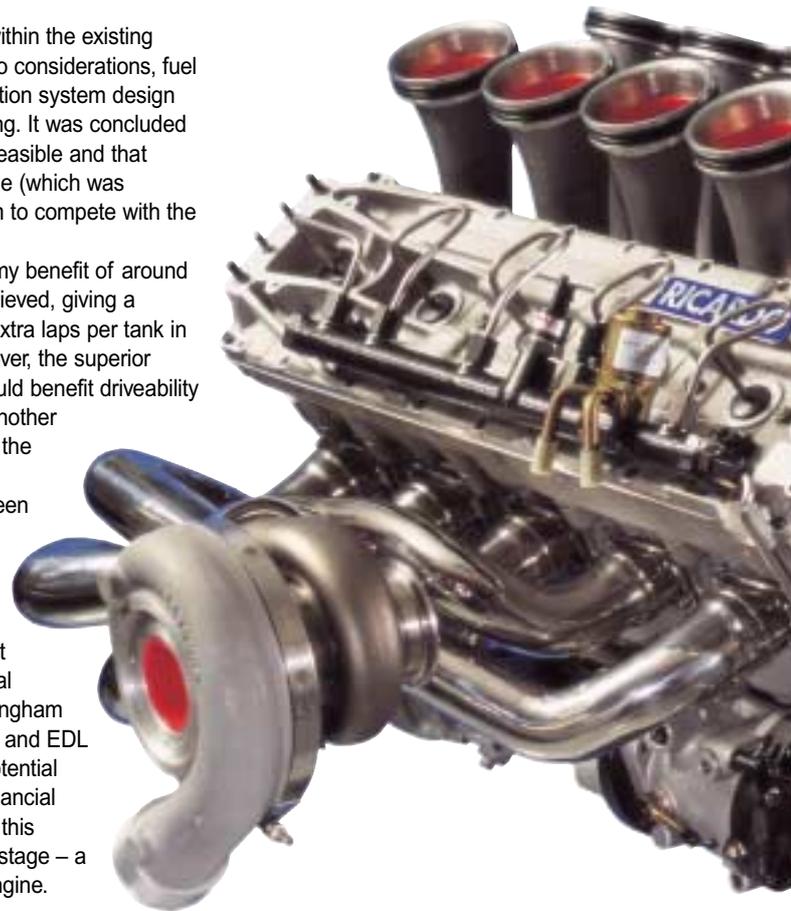
"We immediately recognised the potential of this engine as an attractive prospect for a diesel conversion due to its robust lower crankcase structure and the shallow valve angles," explained Steve Sapsford, engines manager, Ricardo Motorsport. "As a diesel adaptation, this would be the first truly dedicated lightweight race diesel: all other current racing diesels are conversions from road diesel engines and consequently relatively heavy."

Ricardo and EDL started a feasibility study early in 2003 to examine factors such as

potential for conversion within the existing structure, bore/stroke ratio considerations, fuel injection system, combustion system design and turbocharger matching. It was concluded that the conversion was feasible and that some 600 hp was possible (which was considered as a minimum to compete with the top LMP1 gasoline cars).

Crucially, a fuel economy benefit of around 15 per cent would be achieved, giving a significant advantage in extra laps per tank in endurance events. Moreover, the superior torque characteristics would benefit driveability out of corners and add another competitive advantage to the diesel.

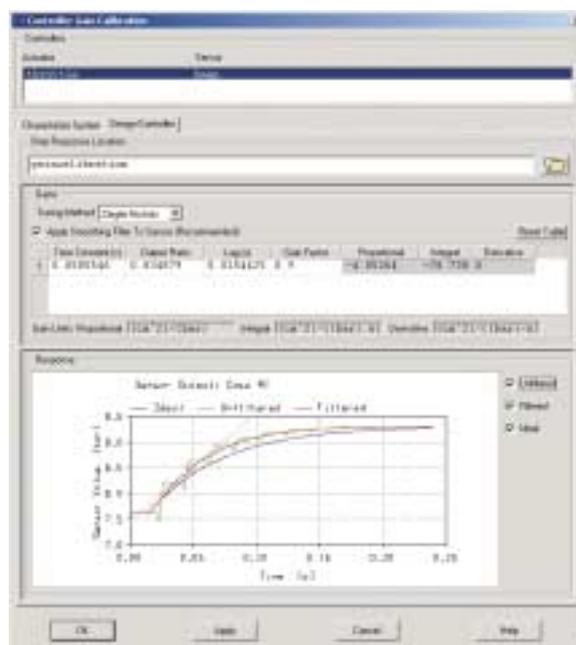
A 3-D assembly has been constructed and was displayed for the first time at the Indianapolis PRI show in December 2003 and subsequently at the Autosport International motorsport show in Birmingham in January 2004. Ricardo and EDL are actively looking for potential technical partners and financial sponsors in order to take this unique project to its next stage – a demonstration running engine.



## Map-based running heads list of enhancem

Ricardo has announced the release of WAVE v5.1, the latest addition to its market-leading WAVE engine performance and gas dynamics simulation package. WAVE v5.1 builds on the comprehensive feature base of version 5 (described in RQ Winter 2002/2003) but adds new functionality in the modelling of transient operation, control, co-simulation and fuel injection.

A new map-based running feature provides users with the ability to perform transient vehicle analysis using WAVE-generated look-up maps of engine performance. The maps are developed 'on the fly' as the data is needed and use a multidimensional sparse data map filling and interpolation algorithm, which enables the



PID Controller Gain Tuning

trade-off between simulation accuracy and calculation effort to be optimised. All data generated to populate the maps can be re-used in the same and subsequent simulations, allowing maximum efficiency for long transients and iterative design optimisation.

Further co-simulation of WAVE with mechanical systems is now possible using the new interface with VALDYN, Ricardo Software's valve train simulation package. This enables fully interactive time-step coupled simulations involving detailed engine and valvetrain models. In this way, the influence of valvetrain dynamics on engine performance can be modelled to a high degree of accuracy.

The representation of 2-phase effects in the modelling of gasoline engine performance has long been a weakness of 1-D

# takes shape



## Improvements in WAVE v5.1

simulation codes. This has been solved in WAVE v5.1 by adapting the Discrete Droplet Model (DDM) developed for VECTIS, Ricardo Software's 3-D computational fluid dynamics software. This model accounts for a full spectrum of droplet sizes and velocities and provides a wall film model that experiences heat and mass transfer, transport and gas phase re-entrainment.

The correct representation of these phenomena enables improved accuracy in the simulation of highly transient events such as cold starts.

Additional enhancements include a unique built-in gain calibration tool allowing users to efficiently tune PID controllers. This feature completely automates the finding of optimal gains, allowing the engine analyst to save time while starting the simulation with a higher degree of confidence.

### International User Conference

Ricardo Software will host its 9th annual International User Conference on March 11-12, 2004 at the Westin Hotel, Southfield, MI, USA. Further information may be obtained at [www.ricardo.com/software/iuc](http://www.ricardo.com/software/iuc).

## New tools for control software engineering

Engine and vehicle control system engineers have long used commercial simulation tools such as Simulink® and Stateflow® for algorithm design and rapid prototyping. In the past, simulation models created with these tools were used to test and optimise algorithm concepts that were subsequently used as a starting point for the production control system design. This process of translating the software specification derived from the simulation models into production level code is extremely time-consuming. Despite the skill of more experienced software engineers at spotting inconsistencies in model design, the process is also prone to interpretation errors.

In recent years the use of the simulation models directly in the production system process has become commonplace. This approach avoids any inconsistency of approach between development and software engineers and also reduces the risk of misinterpretation of specification implied by the model. However the potential for human error has merely been transferred to a higher level and, with the use of increasing complexity of simulation models, there is a strong need to ensure that disciplines of model generation are rigorously defined and applied.

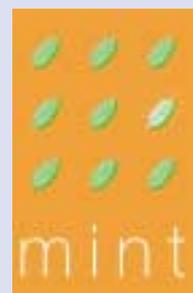
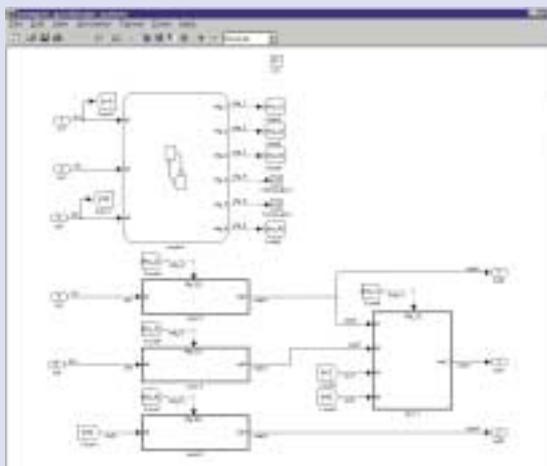
In February 2004 Ricardo Tarragon will announce the launch

of version 4.0 of its highly successful MINT software, a product which provides robust and controlled support for the generation of high quality production software using Simulink® and Stateflow®. Using MINT, control system software engineers are able to follow pre-determined corporate style guidelines for model generation and review. Compliance is more readily verifiable with corporate guidelines, as is compatibility of the model with the user's selected automatic code generation package.

Version 4 of MINT builds upon the integrity checking and ease-of-use of previous versions but provides much greater flexibility for customisation to the precise requirements of model-based software development processes.

Commenting on the release of this new version, Dr Steve Montgomery, managing director of Ricardo Tarragon, said: "Using MINT to check against a suitable style guide, engineers can be confident that their models will generate good target code and will plug-and-play with other models developed to the same style. I am very pleased to see MINT V4.0 bringing significant improvements to the management of tests and style guides as well as other functional improvements."

For further information regarding MINT V4.0, go to [www.ricardo.com/MINT](http://www.ricardo.com/MINT).

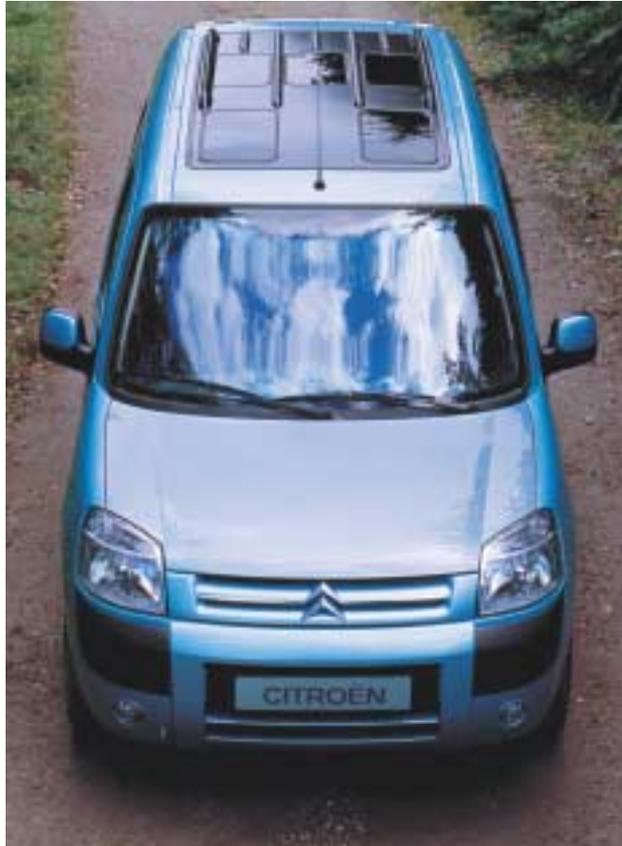


# Rising to the challenge of ultra-low CO<sub>2</sub>

Following their successful submission to the UK government's Ultra Low Carbon Car Challenge, PSA Peugeot Citroën, Ricardo UK Ltd and QinetiQ have revealed plans for their £3m (\$5.4 m) project, codenamed EFFICIENT-C, to develop a C-segment passenger car capable of ultra-low CO<sub>2</sub> emissions while delivering competitive standards of vehicle performance and refinement.

The Ultra Low Carbon Challenge invited proposals from individual companies and consortia to demonstrate the feasibility of a family sized ultra-low carbon car in the UK. In addressing this challenge EFFICIENT-C will involve the development and demonstration of a highly efficient parallel hybrid powertrain system installed in a Citroën Berlingo Multispace passenger car. Development of this vehicle is expected to take 18 months. The partners will also take into consideration the potential for delivery in future products available to customers. The first phase of the programme will comprise a feasibility study, which will define the final vehicle architecture. Key technologies envisaged for the EFFICIENT-C vehicle include:

- An efficient PSA Peugeot Citroën HDi common rail diesel engine, delivering peak performance of around 90 bhp while achieving Euro IV emissions levels with low-cost aftertreatment technology.
- A high output Direct Current (DC) electric motor-generator enabling stop/start operation of the diesel engine, torque assist, efficient



electrical power generation, regenerative braking and all-electric traction at low speed.

- An automated manual transmission (AMT) delivering high standards of refinement and driveability in a cost-effective manner.
- An advanced energy storage system using NiMH (Nickel-Metal Hydride) or Li-ION (Lithium-Ion) batteries, possibly combined with supercapacitors, to achieve the energy and power densities required for efficient operation of the vehicle.
- Advanced control and electronics architecture, enabling the many constituent

technologies of the hybrid vehicle to operate at optimal efficiency.

The EFFICIENT-C vehicle is targeted to achieve CO<sub>2</sub> emissions of 89.5g/km over the combined ECE + EUDC drive cycle (this equates to a well-to-wheels CO<sub>2</sub> emissions level of 100g/km, using pump grade diesel fuel). Legislated exhaust emissions will be within Euro IV levels. Vehicle performance targets include a 0-100km/h acceleration time of less than 13 seconds and a top speed in excess of 150km/h.

The EFFICIENT-C team represents a unique mix of skills in the development of hybrid vehicle technology, expertise which will be used for the benefit of the project. PSA Peugeot Citroën will provide its expertise in vehicle architecture. It will deliver the base vehicle hardware and engineering support to the integration of hybrid technologies, including powertrain, energy storage and associated control systems. The company will also provide guidance to ensure production and cost feasibility and consumer acceptability.

Ricardo will contribute its programme management and hybrid vehicle systems integration expertise together with powertrain and vehicle control/electronics development, demonstrator vehicle build and production cost-benefit analysis. The final partner in the programme, QinetiQ, will bring expertise in the areas of energy storage, power electronics, battery management and hybrid powertrain modelling, and will also provide prototype energy storage and management hardware to support the demonstrator vehicle. ■

## Ricardo GmbH joins prestigious FVV in Germany

In January 2004 Ricardo GmbH was granted membership of the prestigious German internal combustion engines research association, the Forschungsvereinigung Verbrennungskraftmaschinen e.V. (FVV).

Founded in 1956, the FVV comprises over 100 member companies who are engaged in

the design and manufacture of internal combustion engines (both reciprocating and gas turbine) and axial and radial flow compressors. The association includes manufacturers of automotive and industrial engines, as well as component suppliers and engineering technology partners such as

Ricardo. To date the FVV has conducted nearly 800 collaborative research programmes, many of which include contributions from some of Europe's leading academic institutions. Membership of the FVV is primarily made up of companies with a German origin or substantial German presence.

According to Detlev Baudach, managing director of Ricardo GmbH, "membership of the FVV is extremely beneficial to Ricardo, enabling us to contribute to debate and research in areas of advanced engine technology together with our partners throughout Germany." ■

**The world's first dedicated international showcase exhibition and conference for vehicle dynamics engineering and components**



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- Ride and handling consultants
- Integrated corner module engineering
- CAE design packages
- Time compression technologies
- Proving grounds
- Engineering services
- Chassis & suspension components
- Simulation and modelling

## CONFERENCE

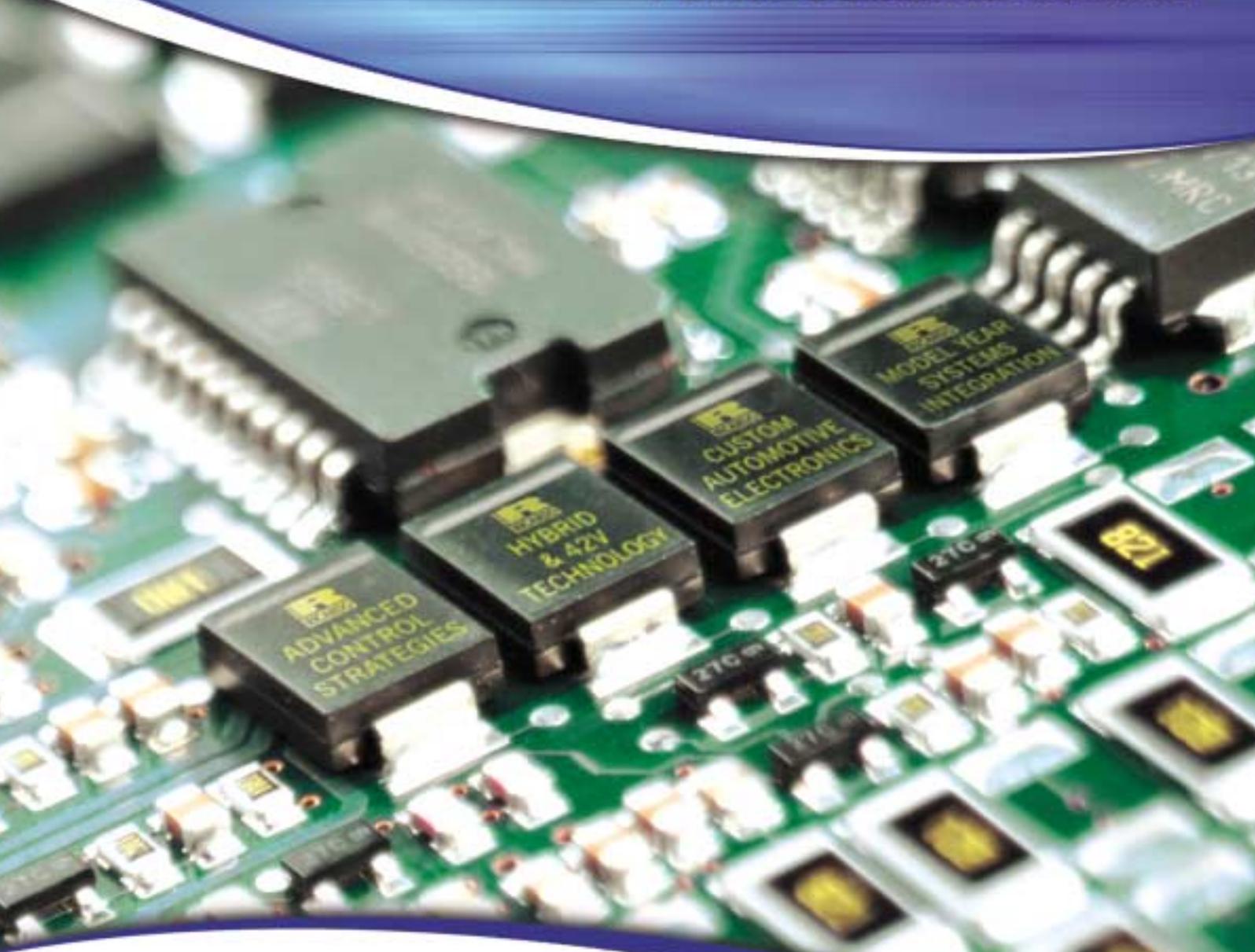
Running in tandem with the exhibition will be a 3 day conference focusing on all aspects of vehicle dynamics engineering. Held in a purpose built conference centre next to the exhibition hall, prospective speakers will soon be invited to submit papers for inclusion in the programme. More details to follow.

**25, 26, 27 MAY 2004**  
Stuttgart Messe, Stuttgart, Germany

For more information on booking a stand/booth contact Robert Hull on:  
Telephone (44) 1306 741200 or Fax (44) 1306 743755  
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