VEHICLE DYNAMICS INTERNATIONAL

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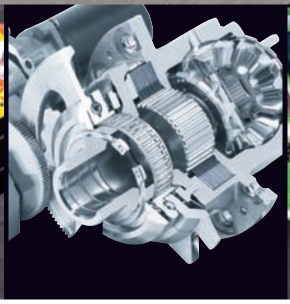
MAY/JUNE 2009

GT3

Lighter, faster, more adjustable: Porsche takes its trackday plaything to a whole new level

Behind the wheel

New series: John Miles road tests the Mk6 Volkswagen Golf



Touring force
The inside track on SEAT Sport's WTCC León TDI

Torque on corners
How electronic differentials can help dynamicists

Winning moves
On location with Ford of Europe's dynamics team

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A NOTE FROM THE EDITOR

Contrary to what some may think, the world of vehicle development hasn't stopped in its tracks. As the articles in this issue illustrate, talented engineers and dynamicists are hard at work on new products and technology, in technical centers and on proving grounds everywhere from Les Ulis to Lommel, and Michigan to Miyoshi.

Here at *VDI* we've also been developing new products. Our website, www.VehicleDynamicsInternational.com, was launched in April and features web-exclusive articles, news stories, test drives, industry opinion, and the full magazine in digital form. Speaking of the magazine, we're welcoming new writers such as Gene Lukianov and John Heider, and John Miles starts a new series of road tests with the latest VW Golf. Looking ahead, the 2009 winners of the *VDI* Awards will be announced in September. Now's the time to nominate the cars, people, and technologies you think are worthy of reward – turn to page 43 for more.

Stuttgart gave birth to the 911 GT3 featured overleaf, and it's also home to Vehicle Dynamics Expo 2009, which takes place on June 16-18. As well as a bumper program of presentations at the free-to-attend Open Technology Forum, there will be dozens of exhibitors in Hall 3 of the New Trade Fair Center, ready to share the fruits of their R&D efforts. Hope you can join us there!

Graham Heeps

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GRAHAM HEEPS
The Geneva Motor Show traditionally throws up some exciting new-car debuts, and this year was no exception. Two that caught the editor's eye were this issue's cover star, the Porsche 911 GT3 (p4), and the next Renault Mégane Renaultsport (p8)


JOHN HEIDER
Formerly Ford of North America's car dynamics chief, John is principal of Cayman Dynamics LLC, providing vehicle dynamics development, testing, and training expertise. Best of all, he's now writing for VDI! His new regular column (p76) is also published monthly online on the VDI website


JONAS JARLMARK
Jonas has worked as race engineer to fellow Swede Rickard Rydell in the World Touring Car Championship for the past 18 months. Beginning on page 52, he and his SEAT Sport colleague, Jordi Riba, reveal how the León TDI was developed into a title-winner


JON LAWSON
For this issue, Jon delved into the world of electronic differentials, which are increasingly being used in road cars as well as off-roaders. For mechanically minded Jon, who drives an Impreza WRX, it was a labor of love! His story begins on page 38


JOHN MILES
As John recalls in his column (p14), in the 1970s he road- or track-tested many vehicles for Autocar magazine. Some 30 years later, John is once again back behind the wheel of some new motors – for VDI. The first installment of his Behind the wheel series is on page 78

Weekend warrior

PORSCHE'S 2010MY 911 GT3 TAKES THE CONCEPT OF AN ADJUSTABLE TRACKDAY PLAYTHING TO A WHOLE NEW LEVEL OF SOPHISTICATION. BY **GRAHAM HEEPS**

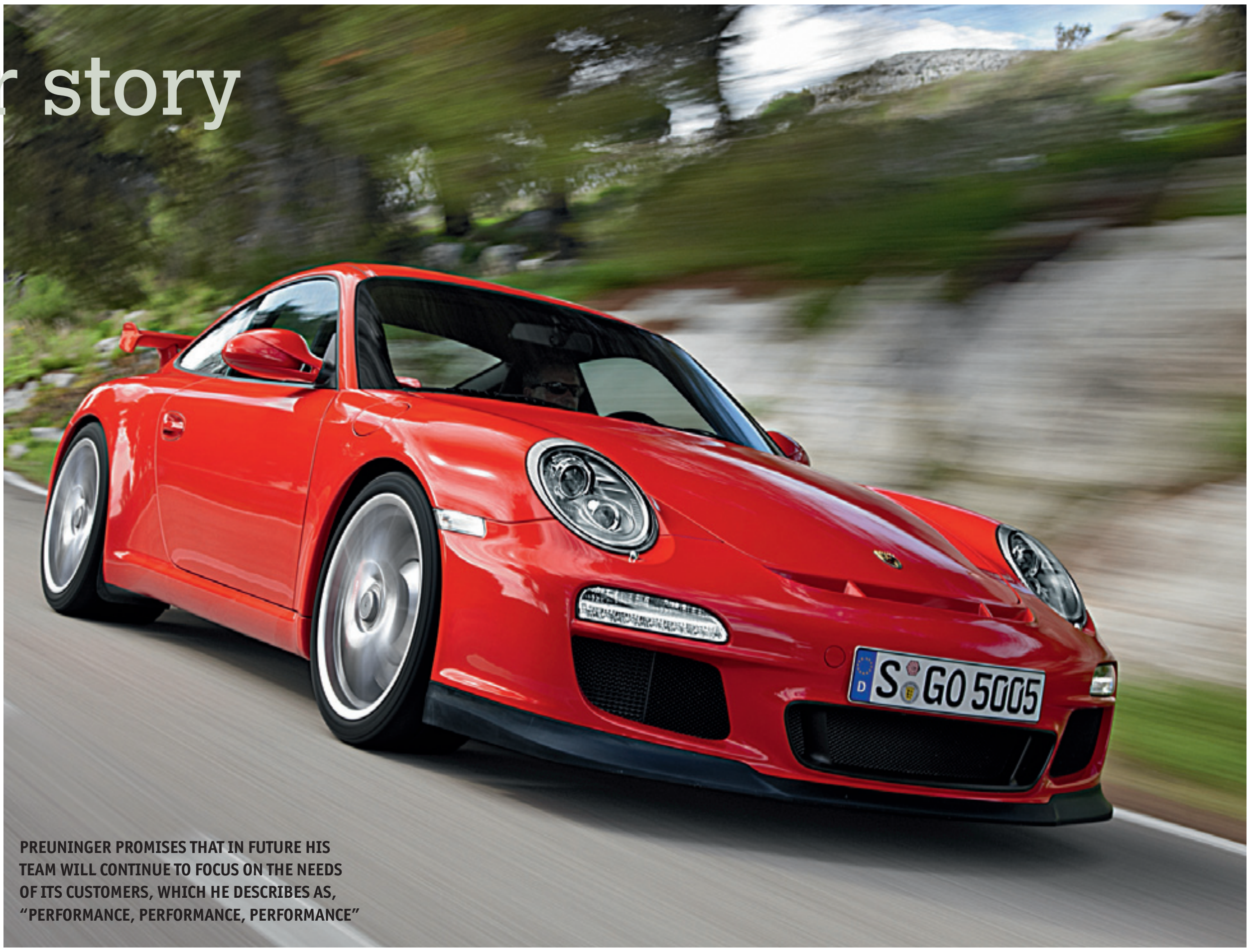
Improving on cars that are already seen as industry benchmarks is always a difficult task. But despite the fact that the current Porsche 911 (997) GT3 is widely respected and has been on the market for less than three years, a second-generation 997 GT3 will break cover for the 2010 model year.

There's no prospect of the current economic circumstances delaying this particular model launch. "Despite the credit crunch and the global warming discussion, trackdays and sport driving events are booming," observes Porsche's manager of high-performance cars, Andreas Preuninger. "It's not possible to drive as quickly on public roads anymore, so people buy a sporting tool such as the GT3 and spend their weekends on the racetrack. We know that 70% of GT2 or GT3 customers are frequently on tracks at weekends. For them it's not just a sporty means of transportation."

Efficiency is another buzzword of the moment. "I don't see any car in this class that's quite as efficient as the GT3," Preuninger argues. "It has 435 horsepower (20 more than the previous car), but when I drove down to Geneva for the motorshow, I managed 9.5 liters/100km [30mpg] on a 500km [310-mile] run, including 200km [124 miles] of *Autobahn*."

The car's light weight is a major contributor to the surprisingly low fuel consumption. Further mass has been shed for the new GT3 in the area of the brakes. The front discs are 30mm wider than before at 380mm,


GT3
S GO 5005

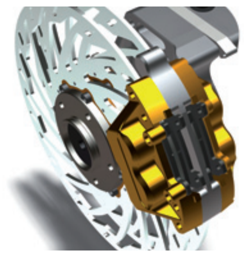


PREUNINGER PROMISES THAT IN FUTURE HIS TEAM WILL CONTINUE TO FOCUS ON THE NEEDS OF ITS CUSTOMERS, WHICH HE DESCRIBES AS, "PERFORMANCE, PERFORMANCE, PERFORMANCE"

VEHICLE DYNAMICS EXPO 2009

EXPO NEWS-IN-BRIEF

Spanish auto technology specialist IFR Automotive is making its Vehicle Dynamics Expo debut at the 2009 show. The firm has hit the headlines with its eye-catching Aspid, but it's as a consultancy not a car manufacturer that IFR will be exhibiting. A number of projects are already being started in partnership with OEMs, and the firm hopes to squeeze both an Aspid and its technology platform – chassis, brake system, suspension, electronics – onto the stand, where company founder Ignacio Fernandez will be among the representatives ready to greet visitors.



Once again ITI will be at this year's Stuttgart expo, featuring solutions in the field of hybrid and electric drives. Alongside the new SimulationX release, the company will be presenting an automobile-specific HIL test environment for visitors to try. Using practical applications, ITI's engineers will demonstrate the workflow of SimulationX to the real-time model.

but there's 2.2kg less unsprung mass at the front axle, and further weight savings at the rear, due to an innovative process whereby the steel discs and aluminum chamber are cast in a single mold. Stainless steel pins hold the two materials together. The brakes also benefit from better ventilation, while PCCB carbon ceramic brakes remain an option.

Further weight savings come in the form of the 19in centerlock wheels, with a motorsport-derived fixing first seen as an option on the 911 Turbo. "It looks good and works well," says Preuninger, "taking much less time to change the wheels. It's safer too because there's a mechanism inside that means you can't lose the wheel from the hub." The wheels are wrapped in Michelin Pilot Sport Cups with 4.5mm of tread. "They're still better than standard tires in damp conditions, but you have to watch out for standing water," he warns.

Even the suspension springs have been made lighter: "We were able to lower the weight of the rear springs substantially by saving material through fewer coils. They're quite difficult to tune, but we put a lot of effort into this, and succeeded, which was great."

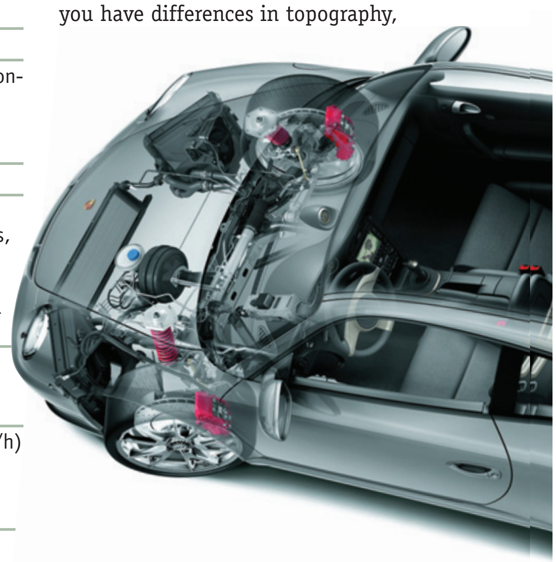
The springs are stiffer all round than on the outgoing car, up to 45N/mm from 40N/mm on the front, and to 105N/mm from 90N/mm on the back. The car also gets stiffer, thicker, anti-roll bars front and rear (25.4mm diameter), which can be adjusted in three ways on the front axle and four on the rear.

Indeed, anti-roll bar adjustment is the tip of the iceberg when it comes to personalizing the setup of your GT3. Preuninger describes it as, "a fully race-compatible suspension setup", in which camber, toe-in, ride height, and ARB settings can all be changed given the right lift equipment and expertise, or in a dealer's workshop. However, "The factory setup we put on the car is almost perfect for every use so most customers will never change a thing, even on the racetrack," he concedes.

SPECIFICATIONS
2010MY Porsche 911 GT3
Dimensions: 4,465mm (L) x 1,808mm (W) x 1,280mm (H)
Wheelbase: 2,355mm
Unladen weight (DIN): 1,395kg
Engine: 3.8-liter flat-six, 429bhp
Suspension: Front axle has MacPherson-type struts with the wheels mounted individually on trailing arms and wishbones
Steering: stock 911 Carrera
Brakes (standard): Front – six-piston monobloc calipers, 380mm steel discs, ventilated and cross-drilled. Rear – four-piston calipers, 350mm discs, ventilated and cross-drilled. Optional SGL carbon-ceramics. Bosch ABS 8.0
Wheels/tires: 8.5J x 19 (F), 12J x 19 (R); Michelin Pilot Sport Cup 235/35 ZR19 (F), 305/30 ZR19 (R)
Performance: zero to 62mph (100km/h) in 4.1 seconds; zero to 99mph (160km/h) in 8.2 seconds; top speed 194mph (312km/h)

"In dry conditions you could add some camber front and back, go to 2° or 2° 30', but [in the factory] we leave it at 1° 30' front and back and that's good enough for everything you can throw at this car. The more camber you have on the car, the more tire wear you have on the inside if you go fast on the *Autobahn*."

More easily adjustable, at the flick of a switch in fact, are the damper settings. The GT3's version of Porsche Active Suspension Management (PASM) was co-developed with Bilstein, resulting in bespoke adaptive dampers that have two ranges of operation corresponding to 'normal' and 'sports' modes. "We don't have 'soft', but there is 'firm' and 'firmer'," jokes Preuninger. "The default is for normal use and for example, the Nordschleife, where you have differences in topography,



SYSTEMS APPROACH

"It's no good just putting more power into a car," argues Andreas Preuninger (right). "You have to think of the whole system, and power is only one part of the equation; the others are the suspension, center of gravity, and grip. Look at the competition – some cars have almost 700bhp, but we eat them on a racetrack with 300bhp less because the car works as a system, through the curves as well as on the straight.

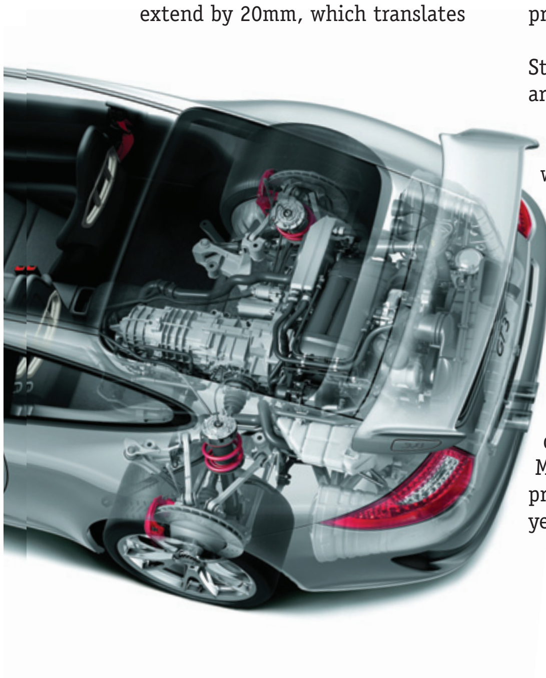
"The suspension is very important in this, especially the art of making the damper react in the same millisecond as the spring is compressed. We've got engineers such as Roland Kussmaul, who's a legend in the industry and a magician when it comes to suspension tuning. With his help we were able to make this car stiffer and decrease body roll in yaw, yet still keep the same level of residual comfort through careful damper tuning."

Now 65, Kussmaul, the former head of the performance department at Porsche, has retired from full-time employment at Weissach, but continues to contribute on a consultancy basis.

"The positioning of this car is very sharp so we're doing everything to get the best performance out of it without killing all of the day-to-day usability"

different types of tarmac, and bumps. On tracks like Hockenheim or Silverstone, grand-prix circuits with a very flat surface, you can take advantage of the firmer setting that allows less movement and body roll in yaw in the car."

The dampers also feature in a clever new system to improve the GT3's everyday usability. Compressed air can be used to raise the front of the car at up to 30mph (50km/h) to help negotiate steep ramps without damaging the chin spoiler. "The pneumatic system weighs about 5kg and is in the central tunnel, way down low so as not to harm the car's center of gravity," he explains. "It creates pressure in a pressure tank and there are two lines from that to the airtight front dampers. We blow them up so that they extend by 20mm, which translates to 30mm at the front lip, which is enough clearance for pretty much everything a normal Carrera can do as well."



Another novelty is the optional Porsche Active Drivetrain Mount (PADM), which firms up the mounts fixing the drivetrain to the body-in-white to reduce the effect of mass forces from the engine. "The less movement the drivetrain makes, the less influence it has on the suspension," he says. "The NVH means you can't have completely stiff engine mounts in a road car, but in certain race-like conditions with this car you can firm them up while still retaining a certain amount of residual comfort so that it's not ear-shatteringly loud. If you're cruising, you can soften the mounts to get rid of the vibration and harshness. It's a pretty cool system."

Also switchable is the Porsche Stability Management (PSM). There are three settings: fully on; stability control off but traction control on; and fully off. "We worked jointly with Bosch to develop the ESP and they did a great job," enthuses Preuninger. "The same Bosch guy has done the application for us since the first GT3 so he knows the car very well. He's part of our target group so he knows exactly what we want. He's almost part of our department!"

Like the rest of the car, PSM was developed at Weissach by Porsche Motorsport, in a development program that lasted two-and-a-half years. As Preuninger notes, "The technology transfer from motorsport to street car takes the shortest possible route – from one brain cell to the next – because it's mostly the same people working on race-car and street-car projects."

One area in which the team's motorsport expertise was particularly useful was in tuning the GT3's aerodynamic package, which goes far beyond road car norms. "Most cars generate lift, but we have serious downforce from this car," he promises. "By changing the underbody radically, adding the front lip spoiler and a rear wing with a 7° angle of attack, and managing the airflow to the coolers, we've created around 50kg of downforce at 200km/h, which is more than twice as much as on the previous car.

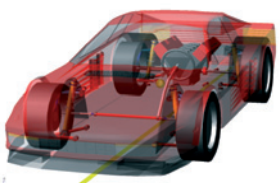
"We had to take this into account with the setup. On the Nordschleife, we're cornering in some cases at more than 240km/h so you have to think carefully about how the system fits together in terms of the suspension, mechanical grip, and aerodynamic grip. That's the development challenge and that's why we lapped the Nürburgring and other racetracks around the world so frequently with this car during development, to get this balance right."

VDI SAYS

The 911 GT3 may be far removed from the average consumer car purchase, but we can't help but admire its dedication to efficiency, – a true reflection of the motorsport brains behind its development.

EXPO NEWS-IN-BRIEF

Expo exhibitor, Delphi Corporation has entered into an asset sale and purchase agreement with BeijingWest Industries Co., Ltd. for the sale of its remaining global suspension and brakes business. Delphi had previously identified the division as non-core product lines that could become more profitable and competitive as stand-alone businesses or as part of another organization with the working capital to invest in them.



'Boost your simulation to real-time' is this year's theme selected by MSC.Software and its business partner, VI-grade. MSC.Software will host a booth in cooperation with VI-grade, which offers simulation tools and services to the racing and production automotive markets. The highlight of the booth will be the demonstration of how a real-time capable vehicle model can be derived from ADAMS/Car and, with the same accuracy, used as a foundation for HIL- and driving simulator applications.

Torque converter

THE FORTHCOMING RENAULT MÉGANE RS FEATURES AN UPGRADED TWIN-AXIS FRONT SUSPENSION AND NUMEROUS OTHER CHASSIS CHANGES, REPORTS **GRAHAM HEEPS**

After a shaky start, the outgoing Renault Mégane Renaultsport (RS) established itself as a benchmark among C-segment hot-hatches. That car required numerous revisions before it finally hit the spot (see *VDI*, October 2008, page 34). With the new Renaultsport 250 model, the third-generation-Mégane-based speedster that comes to market toward the end of 2009, the Renault Sport Technologies engineers plan to get it right first time.

Alongside a more powerful and torquier engine, and a more developed exterior style, class-leading chassis dynamics was one of the team's three main goals for the car. Taking the outgoing Mégane RS R26 as the car to beat, RS engineers also tried the largely FWD opposition. "We didn't find much inspiration in the 4WD cars we looked at," reports Stephen Marvin, deputy chief vehicle engineer.

In the project's favor was the fact that the base car was no heavier than before and its platform had been improved in terms of the steering, front-subframe location, and body stiffness. Other advantages came in the availability of parts dimensioned to suit bigger, heavier vehicles off the same platform, such as a power-steering motor to handle the diesel-powered Grand Scénic, plus the bank of experience built up in the team since the previous Mégane was originally developed more than five years ago.

The car retains its predecessor's independent-steering-axis front suspension concept to counter torque steer, but with no carry-over parts from the outgoing Mégane RS. The new design is similar to the Clio RS's, and a couple of ball joints are carried over from that car. The resulting hub level offset is 40mm.

"Our twin-axis front suspension is very similar to the ZF system that Ford uses, except that we have a ball joint at the bottom where they have a longitudinal bush," says Marvin.

"This means that we have a tie-bar that stops the steering turning around the ball joint, around the top strut axis. On the old Mégane we had a plain bearing at the top and a roller bearing at the bottom; using ball joints we don't have to be quite as tight in tolerances in terms of parallelism of the two machined axes where these bearings are fitted."

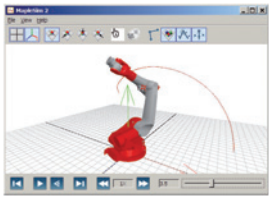
Another change is that the hub carrier is now made of cast alloy rather than cast iron, with a bolted-in bearing rather than a glued-in one. The unique front lower arms also have a change of material, from pressed steel to a Clio RS-like cast-alloy part from Saint Jean Industries, made using the Cobapress technique.

"It's like a diecast that is then pressed to give it its final form and toughen the material," Marvin explains. "It's lighter, but you retain

VEHICLE DYNAMICS EXPO 2009

EXPO NEWS-IN-BRIEF

Maplesoft has announced new releases of its core products. MapleSim 2 introduces 3D visualization and animation tools, which easily transform multibody models into animations, providing greater insight into the system behavior. Meanwhile, Maple 13 provides completely new 3D plotting facilities and expanded CAD connectivity that adds NX to the list of supported CAD systems.

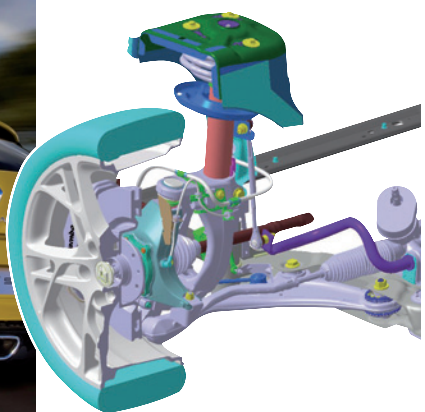


Returning to Stuttgart in 2009 is Swedish simulation expert Dynasim. The big news is that, following extensive work with development partner Modelon, the Dymola toolchain for vehicle dynamics and automotive mechatronics systems engineering has been expanded to offer modeling and simulation solutions for heavy vehicles and trucks, drivelines and active safety systems.

SPECIFICATIONS

- Renault Mégane Renaultsport 250
- Dimensions: 4,302mm (L) x 1,848mm (W) (70mm wider than Mégane II RS) x 1,393mm (H) (40mm lower)
- Wheelbase: 2,639mm (13mm longer)
- Track: 1,594mm (F), 1,548mm (R) (77mm/27mm wider than before)
- Engine: 2-liter turbocharged, 247bhp, 340Nm
- Springs: Unique to the RS 250. Mubea (F), Allevard (R)
- Ride frequencies: Sport chassis – 1.24Hz (F), 1.4Hz (R); Cup – 1.38Hz (F), 1.61Hz (R)
- Dampers: KYB, made in Spain. Bespoke to Mégane RS with larger tube diameter front and rear than the standard car
- Anti-roll bars: Mubea (F), Renault (R)
- Brakes: Brembo. Front discs 340mm (Mégane II: 312mm) and new caliper. Rear discs 290mm
- ESC: Conti Teves Mk60 (previously Bosch). Three modes: standard, sport, and disconnected
- Wheels/tires: 18 x 8.25J standard (19in optional). Sport chassis: 225/40 Dunlop Sport Maxx TT. Cup chassis: 235/40 Michelin Pilot Sport 2

THE RS 250 HAS BEEN TUNED TO BE VERY ADJUSTABLE – WHAT MARVIN TERMS 'MOBILE' – BUT STILL WITH AN ESC SAFETY NET



TOP AND LEFT: **RS HAS BEEN TUNED TO BE 'MOBILE'.** ABOVE: **MÉGANE 250 VERSION OF THE DUAL-AXIS STRUT FRONT SUSPENSION, SIMILAR TO THE CLIO'S**

the stiffness and shock resistance of a steel part."

Two different chassis setups will be available from day one, the standard sport chassis and the 'Cup' chassis. The Cup has more anti-roll, higher spring rates and different damper rates, as well as a standard LSD and different tires.

Most of the work done by Marvin's team was common to both, however.

"We paid a lot of attention to the geometry and the Ackermann on the front suspension," he reveals. "We reduced the Ackermann angle by 60% compared to the old car. The idea behind this was to try to get more traction from the inside wheel to get more performance out of corners. We wanted to optimize the amount of torque transfer through the diff, not lose all the traction on the inside wheel and therefore have to transfer all the torque to the outside."

On the rear axle, the outgoing car's closed-section H-frame rear suspension has been carried over in modified form.

"We can again benefit from the fact that there's a very heavy-duty version available for the platform," Marvin says. "We have some much higher anti-roll rates than existed on the previous Mégane so we've been able to go a bit softer on the spring rates (see Specifications) and maintain enormously high anti-roll bar rates. Even the version without the LSD corners very, very flat."

There have been extensive changes to the electric power steering, which came in for criticism particularly on early Mégane IIs. The TRW rack stays but NSK is the new column supplier.

"We already had experience with NSK on the old Scénic, and now it supplies the whole Mégane range," says Marvin. "The system has more bandwidth and much higher torque capacity than before. The steering ratio is also faster than before, 14.75:1 rather than 16.35:1 on the R26. That was done to make the car a bit more agile. We felt we could do it because we have higher camber stiffness on the rear suspension, which gives us a much more planted feel in maneuvers such as transient lane-changes."

The new RS also has what Marvin describes as "a lot more" castor than the previous-generation car, some 9° worth. "We wanted more natural self-centering in the steering. It feels nicer than electronic self-centering."

The Laguna's 4Control rear-steer system wasn't developed for Mégane. Cost aside, it would have demanded major platform changes and an impractically small fuel tank.

VDI SAYS

The Renaultsport 250 has yet to be driven by the media, but recent cars have shown that the RS engineers know exactly what they're doing with the Mégane chassis. There's every chance it'll be great to drive.

EXPO NEWS-IN-BRIEF

The free-to-attend Open Technology Forum will once more be a highlight of this year's Vehicle Dynamics Expo. Among the presentations on offer in Stuttgart will be one about the Lancia Delta's high-tech, real-time damping control system. Philippe Krief of Fiat Group Automobiles and Dr Michele Spina of supplier Magneti Marelli will speak. On day two, Peugeot Citroën's Benoît Parmentier will update the industry on recent advances in in-house software code. Also speaking will be Dr David Cole, a senior lecturer from Cambridge University, who will explain how the effects of steering feedback on driver and vehicle are being modeled. To download the full Forum program, head to: www.vehicledynamics-expo.com/downloads/programme.pdf

Social climber

THE NEW MAZDA3'S BENCHMARKS INCLUDED THE BMW 1 SERIES. **BUNNY RICHARDS** FINDS OUT HOW THIS BIG-SELLING AUTOMOBILE'S CHASSIS HAS BEEN REDESIGNED

The all-new Mazda3 follows in the tire tracks of the second-generation Mazda2 and Mazda6, which are also larger and better equipped then their predecessors, but are lighter and more fuel efficient.

Mazda's weight reduction program lowered the weight of as many components as possible. For example, 11kg was saved from the bodyshell by employing 17% more high-tensile and ultra-high-tensile steels. In all, the European version of the next-generation '3' is up to 15kg lighter than its predecessor.

As with the previous model, the Mazda3's platform has been jointly engineered with Ford. Its makers say the chassis has been improved in terms of its handling, roll control, and ride performance. To help achieve that, Mazda made the BMW 1 Series, Audi A3, and the Volkswagen Golf Mk5 its benchmark vehicles.

THE 3'S FRONT (TOP) AND REAR (ABOVE) AXLES

The car's premium aspirations are reflected in the attention paid to reducing road noise. New front suspension hanger brackets were introduced with a new gearbox mount at the center of the front suspension to suppress vertical vibration of the crossmember, while the rear suspension towers were joined to the D-pillars.

A MacPherson strut front suspension and Mazda's multilink rear suspension are mated to the more rigid body. At the front, a stronger, stamped-metal crossmember tower has been introduced; the structure here was changed to make the cross-arm thicker and the crossmember bushings were optimized to deliver lateral rigidity. Meanwhile, the stabilizer bar's mounting span has been increased by 20mm at the front axle, to deliver better roll control.

At the rear, a brace bar has been introduced to the rear suspension towers, and the 0.7kg-lighter multilink setup itself has a central member with a new shape that contributes to lateral strength and better roadholding. As on the front suspension, the mounting span of the rear stabilizer is longer, which improves roll control. The rear dampers are monotubes, just as they were on the outgoing model.

All versions of the new car, which will be available in hatchback and sedan body styles, are now fitted with fuel-saving, electrohydraulic power-assisted steering (EHPAS). The number of steering gear mount bushes has been increased from two to three, and the steering gear bushes have a softer setting in the straight-ahead position to reduce unwanted vibrations through the steering wheel.

SPECIFICATIONS
2009MY Mazda3 (1.6-liter gasoline engine, hatchback body style)
Dimensions: 4,460mm (L) x 1,755mm (W) x 1,470mm (H)
Wheelbase: 2,640mm. Track (15/16in wheels): 1,535mm (F), 1,520mm (R)
Suspension: MacPherson strut front with twintube dampers and 21mm ARB; ZF top mounts, TRW lower ball joints. Multilink rear with monotubes and 20mm ARB
Wheels: 15 x 6.0J (not USA), 16 x 6.5J or 17 x 7.0J
Tires: 195/65 R15 (not USA), 205/55 R16 or 205/50 R17
Steering: EHPAS with 2.94 turns lock-to-lock and 10.4m turning circle curb-to-curb
Brakes: ventilated 278mm discs (F), solid 265mm discs (R). Conti Teves calipers, booster, hoses and ABS/ESC

ON THE WEB
Coming soon to vehicledynamicsinternational.com: driving impressions of the Mazda3

VEHICLE DYNAMICS EXPO 2009

EXPO NEWS-IN-BRIEF

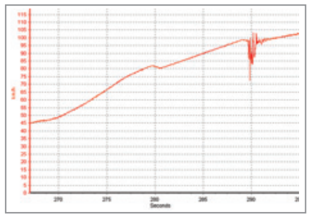
LMS International will be showcasing the intrinsic capability of its LMS Imagine.Lab AMESim platform, which is to simulate fuel efficiency and ride/handling at the same time. The software offers solutions for the simulation of an ICE, gearbox, and the design of individual chassis-system components (brakes, suspension, steering, anti-roll system and the vehicle itself) and integrates them into a single-system model to simulate and validate global chassis-control strategies.

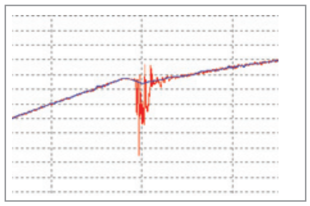
Altair Engineering will be presenting HyperWorks 10.0, the latest version of its CAE suite. A new set of 'Directors' supplements the Engineering Framework HyperWorks; these streamline and automate virtual testing for attributes such as safety, durability, NVH and vehicle dynamics, and also allow multi-attribute optimization. Fluidon GmbH, the HyperWorks Enabled Partner specialist for controls and hydraulics simulation, will also be at the booth to present its DSHplus software environment, which is complementary to Altair's vehicle dynamics simulation solution.

RACELOGIC'S **VBOX 3I WITH IMU INTEGRATION**

Quieter measurements

RACELOGIC HAS INTEGRATED INERTIAL SENSORS WITH GPS, RESULTING IN BETTER MEASUREMENTS IN SITUATIONS WHERE THE SKY VISIBILITY IS LESS THAN PERFECT





CLOCKWISE FROM ABOVE RIGHT: **THE VBOX 3I 100HZ GPS DATALOGGER CONNECTED TO AN IMU; GPS SIGNAL DROPOUT UNDER A BRIDGE; RED LINE SHOWS STANDALONE GPS DATA, THE BLUE LINE SHOWS THE EFFECT OF INTEGRATING THE IMU WITH GPS**

The consensus in the automotive industry is that GPS is the most effective solution for the majority of vehicle dynamics measurements, as shown by rising sales in GPS data-loggers. Survey-grade high-speed GPS, using Doppler shift, is the most accurate way of measuring speed there is – as long as there is a clear view to the sky. Problems arise when buildings or tall trees obstruct the testing ground.

If the GPS signal is interrupted, dropouts cause spikes in data (as shown top right, when the test vehicle drives under the bridge), which is not ideal when you are relying on a clean velocity signal. For example, during an acceleration test, any spikes in the data would cause inconsistent results, which would mean carrying out the test on a section of track without any bridges or trees, which is not always practical. Carrying out a coastdown test in an unobstructed environment is even more problematic, since a complete coastdown from 120km/h can take up to 3km. However, it is sometimes hard to find a real-world testing area where there are no such signal path obstructions. So how do you solve this problem where sky visibility is less than perfect?

Addressing this issue, Racelogic has come up with a solution whereby GPS signals can be supplemented with inertial sensors (*g*-sensors and gyros), which enables a far better measurement of velocity to be made during sections of poor satellite visibility. This is achieved by connecting a VBOX 3i 100Hz GPS datalogger to an Inertial Measurement Unit (IMU), as shown above. Incorporating three accelerometers and three gyroscopes, the IMU measures pitch, roll, and yaw rate up to ±150°/s, and longitudinal, lateral, and vertical acceleration up to ±1.7*g*.

The results of IMU integration are shown above right, where the blue velocity trace is the result of combining GPS and IMU data, compared with the red line, which features the noisy stand-alone GPS data as it passes under the bridge. The integration allows for far greater accuracy and test reliability in a wider range of conditions than has been achieved before.

The advantage of the Racelogic system is that VBOX 3i runs a Kalman filter in real time, which seamlessly blends the GPS signals with the measurements from the IMU. This results in a smoother velocity trace with even higher dynamic capabilities, due to the mutual corrections occurring between the two data sources. This ensures more consistent results than would be achieved by GPS alone.

The use of separate modules allows for flexibility in vehicle placement, with a number of mounting options available, while the simplicity of the system means that users can swap the equipment between vehicles easily, meaning more time on the test track and less time setting up gear. Analysis software – VBOX Tools – is included, allowing users to generate graphs such as the ones above. The software is intuitive to use, yet has powerful features that enable users to carry out in-depth analysis. The system is supported by a dedicated team and free training can be supplied at the Racelogic UK headquarters.

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On the job
Crunch times

THE ECONOMIC DOWNTURN CONTINUES. **JOHN MILES** HAS SEEN IT ALL BEFORE

Yes, we've got it bad with the credit crunch, but oldies like me remember late 1973 when the UK stock market lost no less than 70% of its value. It was a familiar story: collapsing property prices, trouble in the Middle East (the Yom Kippur war), and a four-fold increase in oil prices imposed by OPEC. Inflation was running at more than 8% yet petrol was just a few cents a liter! A temporary 50mph speed limit was introduced to save fuel, but the moves for a total ban on motor racing were shelved when it was pointed out that the whole UK race season only used about the same amount of fuel as a jumbo jet flying one way across the Atlantic. Motor racing was saved but for me it was time get a regular job.

My savings had been trashed, but at least rich boys in their Jags and Mercedes were hurting a bit too as I passed them on my Triumph Bonneville on the way to work building Gp1 Capri Essex V6 race engines. By 1977 I had somehow persuaded Ray Hutton to give me a 'proper' job as assistant technical editor on *Autocar* magazine, but that was only after learning to type above a sex shop in London's Oxford Street along with a collection of girls…

This was the start of my ambivalence toward supercars, which rarely seemed to deliver. The De Tomaso Pantera and Lotus Esprit Turbo had chassis that worked, but most were cumbersome devices, especially the horrid – and far slower than claimed – Ferrari 512 BB 'Boxer'. The road test was not very complimentary about the difficult handling either, and the whole thing caused a storm of protest from the UK importer, Maranello Concessionaires and Ferrari owners alike. A few years later, Ford had the wit not to contest the universal panning given to the newly launched FWD Mk3 Escort, which would go down any bumpy road in a series of bunny hops and lurches. Thank the Lord for Rod Mansfield's SVE department, which fettled the car into the XR3i, which at one time represented 10% of all Escorts sold.

Heading toward the ghastly 1978-9 'winter of discontent' in the UK, labor relations had sunk to an all-time low and strikes led by union men like 'Red Robbo' were crippling the motor industry. Looking back it seems I was having a having a good time at *Autocar* (apart from learning to write), driving everything from the Ferrari Dino 246 and Maserati 250F Grand Prix cars to road testing a Lada Riva (dreadful) and Citroën Dyane (very French). Inflation was coming down, petrol was 26p/liter, and I was being paid three times what I earned as an F1 driver, which at £300 per race was hardly generous, considering I had to pay my own expenses! Most of the British motor industry was in a terrible state, deservedly so, due to mediocre design and build quality, lack of investment, bad management, and awful labor relations. How we produced something as embarrassingly bad as the Austin Allegro I will never know.

> "Neither the dot-com bubble bursting nor the World Trade Center disaster affected the motor industry. What we face today is entirely different"

The Escort debacle aside, Ford was in quite good shape. It not only had decent (reliable) products, but ruled in every aspect of motorsport, from F1 with the Cosworth DFV, F2 Cosworth FVA, and F3 Lotus Twin Cam variants; Formula Ford; BDA in the Escort for rallying, and the 'boat anchor' Essex V6 for the British and European Touring Car Championship Capris, which had been persuaded to give 220bhp on one twin-32mm choke, downdraft carburetor.

The 1980s saw privatizations under Margaret Thatcher, but also the death of Colin Chapman in 1982 and the purchase by GM in 1986 of the struggling Lotus Cars. I had rejoined the rapidly expanding Lotus Engineering and ended up heavily involved with the FWD Elan and about 30 external engineering projects over the next 18 years. The lessons learned, coupled with two seasons seconded to the briefly resurgent 1992 and 1993 Team Lotus of the Herbert/Häkkinen/Zanardi era was the bedrock of all I have done since, particularly with regard to damping, and micro management of compliance and kinematically controlled wheel steer (and therefore tire slip angles).

Later came the 2000-2002 dot-com bubble bursting and the World Trade Center disaster. Neither event affected my work at Lotus and Aston Martin, nor it seemed the motor industry in general. Apart from the credit crunch, what we face today is entirely different. Even nuclear power to make hydrogen or electricity relies on a finite supply of uranium. Then what?


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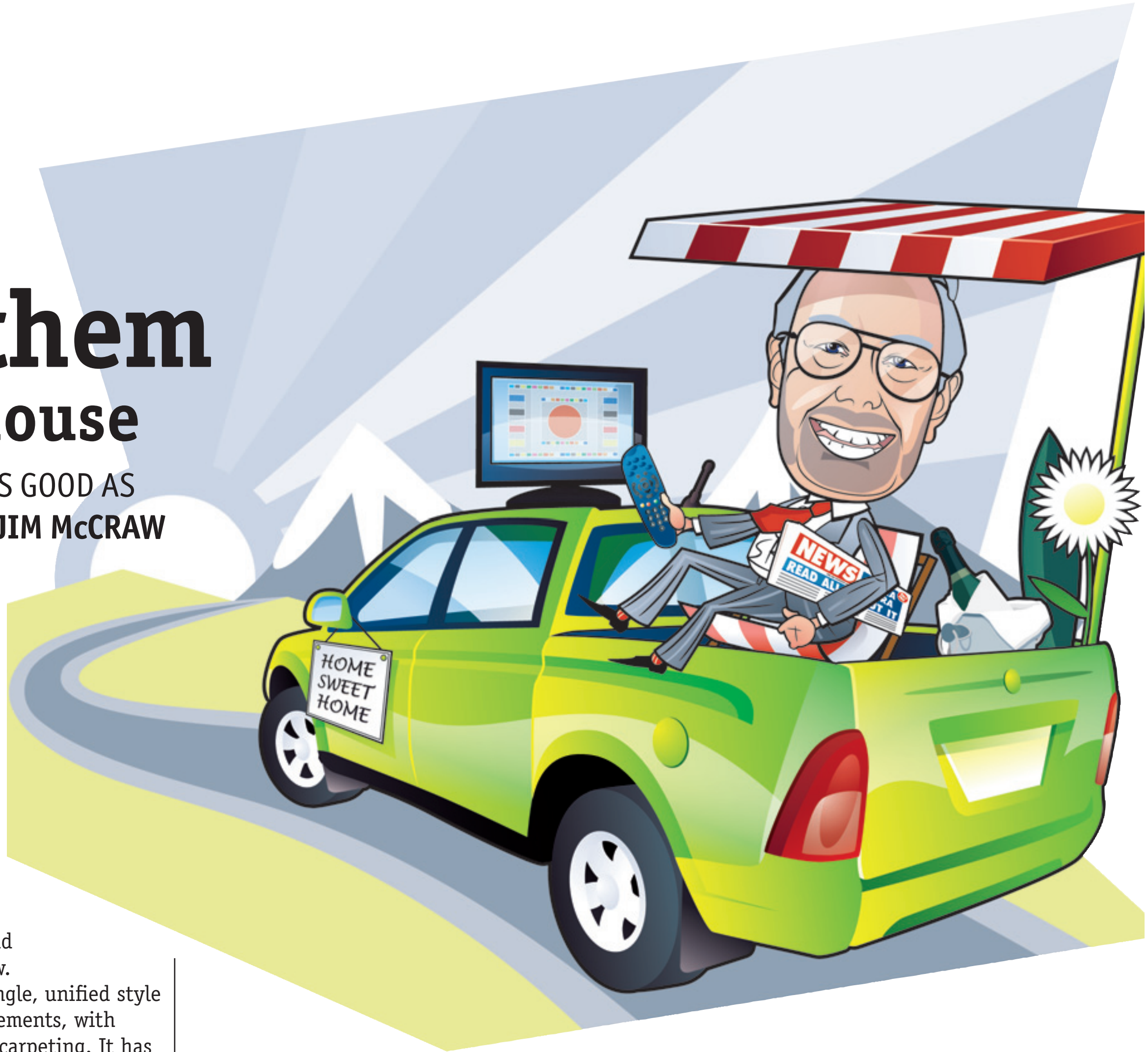

US and them

A very fine house

US SMALL CARS SHOULD BE AS GOOD AS THE PICKUP TRUCKS, THINKS **JIM McCRAW**

With apologies to David Crosby, Stephen Stills and Graham Nash, I'd like to tell you about our very, very, very fine house. It's a place we don't live in full time, you understand, but a very fine house indeed.

It's a big house, high off the ground, built on only one level. Three rooms (the front room, the back room, and the back porch) are painted in a modern deep blue with grey accents. And, although it has its roots in a 1924 design, it has been updated, upgraded, and modernized, and is as modern as tomorrow.

Our very fine house is decorated in a single, unified style using leather and wood as its two main elements, with glass and plastic accents and wall-to-wall carpeting. It has very tall windows on all four sides to let the sun shine in, and the windows on three sides open to the fresh air, with one large, fixed, picture window at the front of the house that takes full advantage of the elevation to capture the ever-changing view outside. The back porch is mainly used for storage, so it isn't carpeted.

Our humble house has more modern conveniences than most, because that's the way we wanted it to be, and so that's the way it was built. It uses a very simple water-to-air heating system with forced air for heating, but it also has a small air-conditioning system for the two main rooms. The interior décor of our part-time home is highlighted by high-efficiency lamps and fixtures from the ground up.

The home entertainment equipment provides an endless variety of entertainment through a high-end surround-sound system with a large mass-storage device for digital music storage, a 500W amplifier, a subwoofer, and nine separate speakers. We have an AM/FM radio that can receive satellite broadcasts, a CD player, and a DVD player that can also receive television and play video games.

We don't live in it all the time, so it has a security and alarm system, and a pair of locked trunks on the porch to keep our tools from being filched when we're not around. We don't have a landline telephone there, but it's well within reach of the nearest mobile phone tower, so we're not cut off from the outside world.

Astute readers have already figured out that we are talking about a vehicle – a full-size US-style pickup truck, invented in 1909 and built in the USA, and sold in the millions. Now the Big Three each have new pickup truck offerings for 2009, including an all-new line of Ford's best-selling F-150 pickups, a brand new line of Dodge Ram pickups, and an updated line of GM's Chevrolet and GMC pickups, including two-mode hybrid versions.

> "It's no wonder Americans have had a love affair with pickup trucks for so long. The Big Three have given customers all they have asked for in a truck"

All three offer pickup truck options that put the total number of buildable combinations up into the hundreds of millions. By the time you calculate engine size, engine type (diesel or gasoline), drive system (two- or four-wheel drive), cab style (regular, extended or four-door crew cabs), bed length (5ft, 6ft, or 8ft beds in most cases), bed style (flat-sided or fendered), you're already talking thousands of combinations. Multiply by trim levels, paint colors, axle ratios, and load capacities; and then multiply by the enormous number of available packages and options from floor mats to trailer hitches to DVD players, and you're up in the multimillions.

It's no wonder Americans have had a love affair with pickup trucks for so long. The Big Three have, over time, given the pickup truck customer – whether construction firm, cattle rancher, forest ranger or cost accountant with a boat or a horse – everything he or she has asked for in a truck. Four-door pickups, the so-called crew cabs, used to be reserved for military, railroad or forestry use, but now anyone can buy one. Likewise, all-wheel-drive pickup trucks weren't seen in cities or suburbs for years. Now they're everywhere. The vaunted Japanese industry hasn't even made a tiny dent in the US pickup truck market, because they don't know how.

If the US Big Three can build huge pickup palaces on wheels that can also haul a 14,000lb trailer load and last for a quarter of a million miles or more, building far less complex, small, stylish, economical, and safe cars for the masses should be a walk in the park. So let's get on with it!

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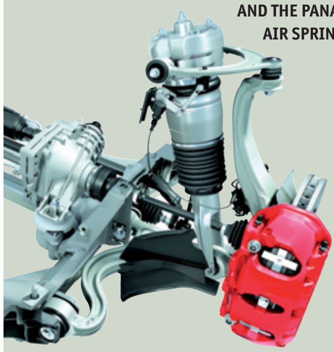
Air supplier

WITH A FITMENT ON THE NEW PORSCHE PANAMERA, CONTINENTAL'S AIR SUSPENSION SYSTEM IS RIDING HIGH. CONTI'S DR PETER LAIER TALKS TO **JONATHAN LAWSON**



DR PETER LAIER (ABOVE) **AND THE PANAMERA'S AIR SPRING** (LEFT)

Supply contracts don't come more high-profile than a fitment on Porsche's first four-door coupe, and the Automotive Group of Continental is in the fortunate position of being the air-suspension supplier to the new Panamera.

The Panamera can be optionally equipped with an adaptive air-suspension system (standard on the Turbo model). Newly developed in partnership with Porsche, the system has an innovative capability for additional air volume on demand. This increases the range of the chassis characteristics, with an additional plus in comfort on the one hand, and sporty driving dynamics on the other.

The German Tier 1 already supplies other luxury cars such as the VW Phaeton, Bentley Continental, and BMW 7 Series, as well as premium SUVs such as the Audi Q7 and Mercedes-Benz trio of ML-, GL-, and R-Class models.

But in recent years the system has also appeared in mid-size vans such as the Fiat Ducato, Citroën Jumper, and Peugeot Boxer, and ahead of the supplier's appearance at Vehicle Dynamics Expo 2009, Dr Peter Laier, executive vice president of Conti's Chassis Components Business Unit, points to a "clear trend toward vehicles in the C- and D-segments", particularly as a rear-axle fitment.

Comfort functions such as easy loading or easy entry are also driving air suspension's popularity, but, unsurprisingly, Continental engineers are continuing to refine the air-suspension system and extend its functionality.

"For the first time, the switch valves and supplementary volumes can be integrated into the suspension strut (front axle) or the spring module (rear axle)," Laier explains. "This is only possible using a weight-, package- and cost-optimized valve.

"The regulated dampers are particularly effective in combination with the air spring and switchable volumes," says Laier. "We're currently working with various damper suppliers on integrating the dampers into a complete system, acting predominantly as a Tier 1."

Air suspension has carved a niche for itself where conflicting dynamic demands must be met. High-performance SUVs are an obvious example, and as a four-seat Gran Turismo the Panamera itself is a vehicle seeking to marry comfort with excellent handling performance.

Laier believes that in the future, Conti's technology will do an even better job of blurring the divide: "Upcoming systems promise to block out the compromise between dynamics and comfort," he says.

"We think that the scalability of such systems will be enhanced, and modular systems employed. Materials advances will help to make systems smaller and lighter, for example, the intensified use of synthetics and aluminum will result in a more intelligent materials mix."

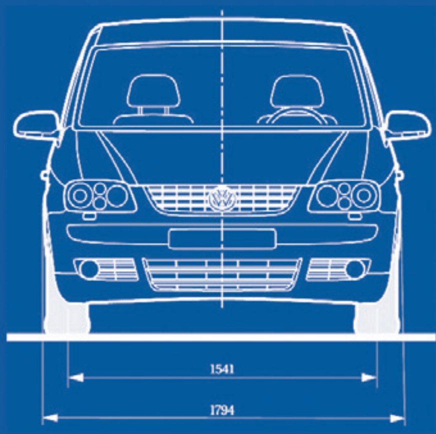
Elsewhere in the portfolio of Laier's business unit, the second-generation chassis and safety controller central control unit will also be on show at the Expo in Stuttgart, which takes place on June 16-18.

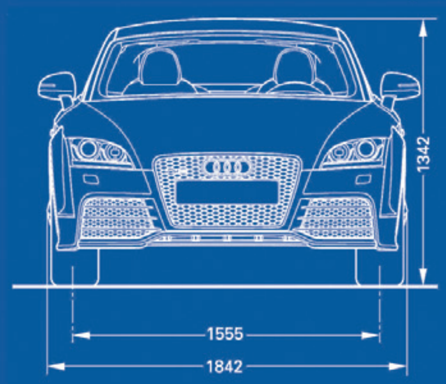
"The capability of the network managed by the controller is greater than the sum of its individual components," he stresses.

The unit brings together the individual assistance and safety systems that fall under the 'ContiGuard' umbrella, and ensures that they do not conflict with each other. Data on the road ahead from onboard cameras or the car's navigation system can be used as an anticipatory measure. It can optimize chassis tuning or activate the rear-axle steering and, by gently intervening in the engine management, it can ensure that a tight bend does not become an accident risk.

Laws of motion

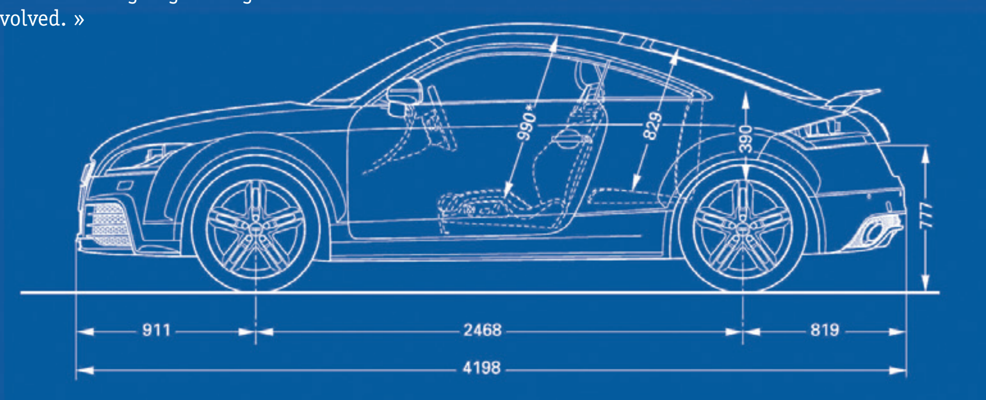
TUNING IS ALWAYS IMPORTANT, BUT **GENE LUKIANOV** ARGUES THAT A VEHICLE'S FUNDAMENTAL ARCHITECTURE WILL SHAPE ITS DYNAMIC PERFORMANCE FOREVER





Style and image sell vehicle programs and vehicles, but over time it's the daily performance that establishes a vehicle's reputation and longevity in the market. The daily dose of satisfaction a customer experiences from his vehicle comes from the driving pleasure, the comfort level and the lack of irritations the vehicle delivers.

A vehicle's fundamental driving character starts to get established early in the product conception and design process cycle before any suspension design and tuning occurs. An unintended commitment to a vehicle's dynamic character may easily happen before vehicle dynamics tuning engineers get involved. »



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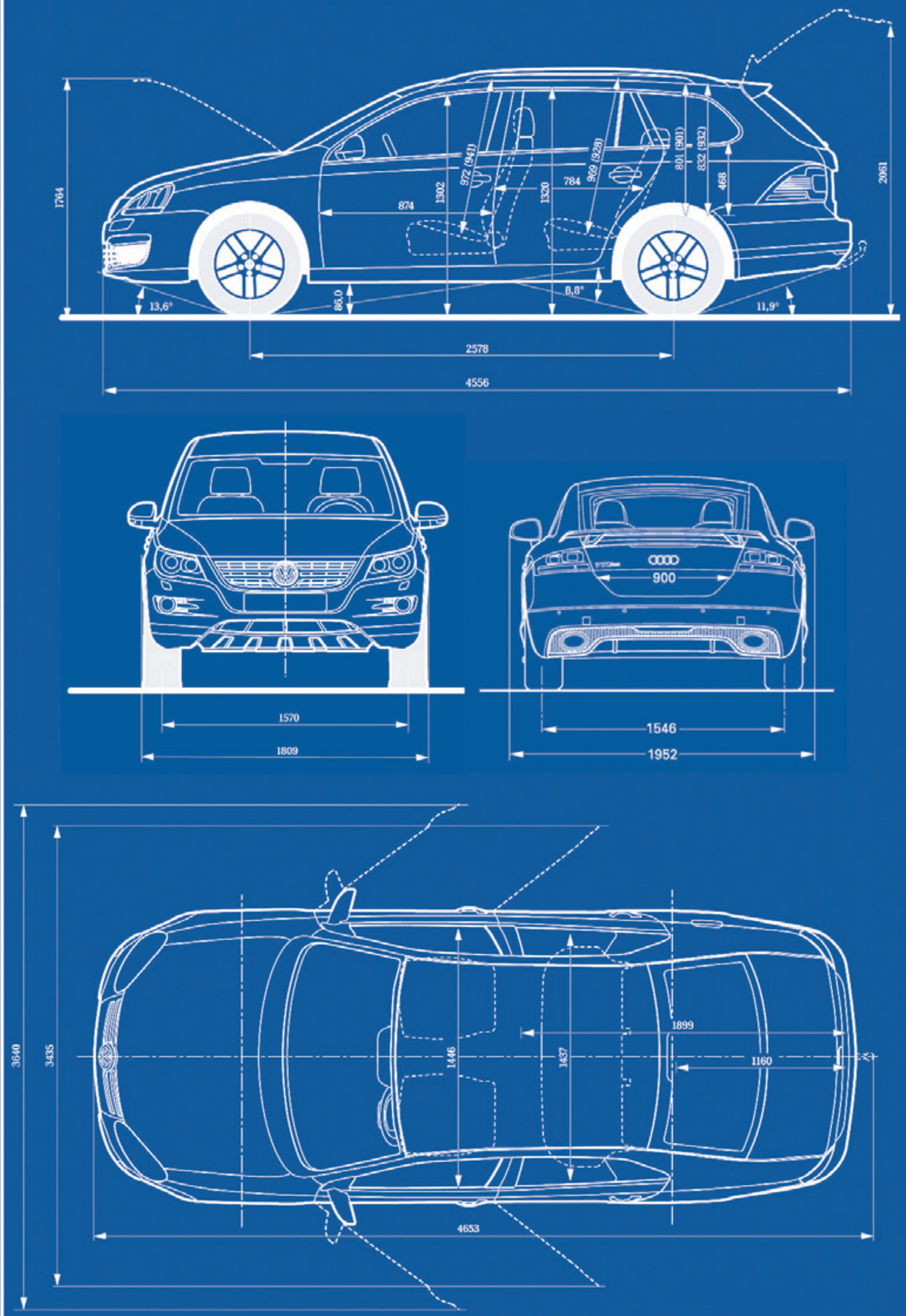


SIMILAR PLATFORM, DIFFERENT VEHICLES (FROM TOP):

LEFT-HAND PAGE – VW TOURAN AND AUDI TT-RS

THIS PAGE – GOLF VARIANT, TIGUAN, TT-RS, JETTA

The dynamicists might be far away from their desks, out in the world investigating, tuning, and developing the dynamic character of a soon-to-be-launched vehicle. It is easy to miss being part of the basic vehicle architecture evolution that occurs early on in the development process.

Once the basic size, shape, and drive of a vehicle is committed, a considerable amount of the dynamic character of the vehicle has been established. If the decisions made conflict with the expected character of the vehicle in the market, the dynamicist is forced to make the best of a handicapped situation, and ultimately there is more probability that the vehicle will not be admired in the marketplace.

Different vehicle segments possess dynamic characteristics that define the segments. Vehicle dynamicists can feel and expound at length on the tuning trade-offs made by manufacturers within the segment population. Crossover or SUV-type vehicles have a distinct character shift from the base sedan vehicles from which they evolved. Framed pickups are a distinct shift from sedans and crossover SUVs, and pickup-based SUVs continue the character shift.

The final, production tuning setup may well illustrate the corporate decision made regarding the bias of the tuning preferred, but in reality the range of choice was established early in the vehicle design cycle. The final tuning will be a positioning of the vehicle character along a continuum of predetermined potential performance. This does not mean the tuning details are unimportant, indeed they are critical for success. However, the general character is predetermined by the early decisions.

This fundamental character of a vehicle is not confined to just broad differences between vehicle categories. The same shifts in dynamic character take place within specific vehicle segments as the vehicle architectures are compared. Fundamental vehicle comfort and dynamic character is established in part by a combination of the general layout of the vehicle and the basic architecture of the suspension.

Vehicle properties such as weight, length, wheelbase, track, powertrain details, horsepower, and drive configuration are primary characteristics that everybody loves to discuss and compare between products. The impact of these choices has been discussed at length at various benches throughout the world: longer vehicles turn more slowly; narrower vehicles tend to have less grip and roll more; front-wheel-drive vehicles tend to be more front-weight biased and develop gobs of limit understeer; taller vehicles tend to feel more tippy and under-damped; heavy vehicles feel just that – heavy; and four-wheel drive in its various configurations introduces extra understeer.

For similar weight, wheelbase, track, powertrains, and so on, what are the reasons for differences in

"If the decisions made conflict with the expected character of the vehicle in the market, the dynamicist is forced to make the best of a handicapped situation"

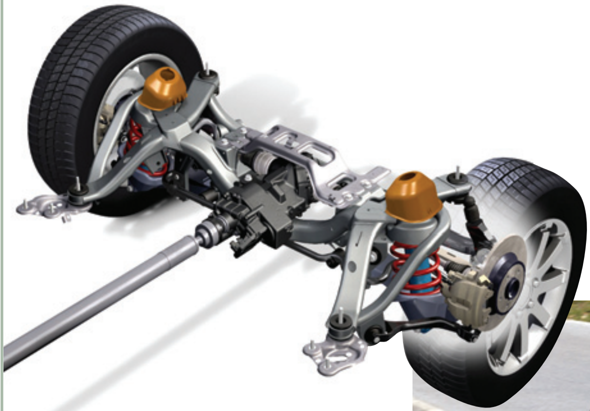
VEHICLES OF DIFFERENT SIZES, HEIGHTS AND WEIGHTS SHARE THE CD3 PLATFORM FIRST USED ON THE MAZDA6 FROM 2002. CLOCKWISE FROM ABOVE**: LINCOLN MKX CROSSOVER, FORD FUSION SEDAN, AND SECOND-GENERATION MAZDA6 ESTATE**

The roll damping challenge

Why is getting the inertias right so important?

When the inertias are out of proportion between themselves and the ride masses, there are conflicting demands for shock tuning. Finely tuned shocks have much to do with delivering admired ride and handling character, and they should not be under appreciated. But the passive shocks are a single solution for a multitude of physics problems involving vibrations, rotations, displacements, and so on. It's amazing that shocks provide as refined a level of performance as they do. However, as vehicle design and architecture drives the inertias to disproportions between each other and the ride masses, the single damper curve solution starts missing the mark.

Adequate roll damping is almost always a challenge, and can be a conflict with excessive stiffness in ride. Lower vehicles seem to have a better balance of damping for ride, pitch, and roll damping. With crossovers, the roll and pitch inertias start pushing up relative to yaw inertia and the ride masses. The crossovers and SUVs start facing a challenge in achieving a good balance between ride comfort and roll damping for transients. Here there's a choice to be made. For example, such a choice was made for the original Volvo XC90, which was damped lightly in roll for ride comfort, in contrast to the original BMW X5, which was damped tightly in roll and delivered a firm ride.



SIMILAR VEHICLE CONCEPTS, BUT TWO DIFFERENT TUNING APPROACHES TO ROLL DAMPING: ORIGINAL BMW X5 (RIGHT) AND THE VOLVO XC90 (BELOW), TOGETHER WITH ITS REAR SUSPENSION (ABOVE)

feel between segments, and why do some vehicles feel better than others? If the other critical details of suspension architecture, vehicle structure and tuning are set aside, part of the reason is due to the basic vehicle architecture. But first a little physics review…

The vehicle dynamics engineer is fully capable of using Newton's Second Law, F = M x A, to his advantage by tweaking forces and accelerations. F = M x A also has a parallel in rotation: Torque = I x Alpha. Here things get a little more complicated because inertia is a calculated value based upon mass and mass location squared. Therein lies the difference with just plain mass. Small changes in radius of location have a greater effect on inertia than mass. The F = M x A situation occurs during cornering and various translational motions while the T = I x Alpha situation comes into play when there are angular accelerations present such as during turn-in, roll transients, brake/acceleration transients, and road-induced pitch/roll motions. Steady-state cornering, acceleration, and braking are F = M x A types of situations, where analysis using mass is adequate.

Boxing the masses and inertias into reasonable windows based upon the market segment and performance expectations is one of the keys to delivering an admirable vehicle in the marketplace. An overweight or high-inertia vehicle will feel heavy and less nimble to the customer compared to the rest of the segment. Tuning will be able to mask some of it, if frequencies or damping is pushed higher, but the price paid will be in ride stiffness, harshness and relative lack of comfort. Ultimately the vehicle will still feel heavier than the admired competition. So let's take a look at significant contributors to inertia.

Positioning more weight high in the vehicle, such as extra roof height and glass roof panels, which square for square are heavier than metal panels, place mass highest in the vehicle at the maximum vertical inertial radius. Inertias in roll and pitch are greatly affected. Yaw inertia is not so much affected because the roof is centered more or less over the wheelbase. Stuff in the vehicle roof, vertical passenger positioning and potentially cargo all have a dramatic effect on vertical mass (CG) location as well as inertia, so it's a double hit. It begs the question: why do we have some vehicles with roofs high enough for a driver to wear a top hat?

Rear overhang and cargo location can be detrimental to a vehicle's dynamic in both equations. Rear wheels that are too far forward force more of the cargo weight onto and behind the rear axle, and start unloading the front axle when loaded, setting up an ungainly loaded character and forcing stiffer rear springs that hurt at curb ride. A cargo floor above the vehicle curb CG drives the loaded CG and loaded-roll inertia up and compromises the loaded-roll feel and limit performance.

Battery mass and its location is one factor that is often overlooked. Batteries are heavy, often positioned high at the corner of the front fender, which increases yaw, pitch, and roll inertia.

Bumper mass is always hung out at the ends where the radius is highest, affecting yaw and pitch inertias. As drivers have a tendency to bump into things, we ought to have some protection for ourselves and our property, so let's just minimize the mass on the ends.

Engine mass is a serious factor. Diesels are increasing in popularity, and with hybrids and alternative motive sources, there is now the challenge of dealing with some seriously heavy stuff being packaged into the vehicle. Historically, the Porsche 912 with the light four-cylinder hung out in back can be compared with the 911 with an extra 90kg or so out there. To this day, the 912 is admired for its balance and drivability, while the 911 is known to be tail-happy in many circumstances. The opposite can happen in a front-engined vehicle: a light engine up front can be expected to result in a quicker vehicle – not always ideal.

Vehicle dynamic character is ultimately the combined effect of many different aspects of vehicle design and tuning. But the devil is in the big picture as well as in the details of execution.

THE 1965 PORSCHE 912 (BOTTOM) **HAD THE LIGHTER FOUR-CYLINDER ENGINE FROM THE 356. THE 911 (SEEN** BELOW **IN 1967 TARGA FORM) RETAINS A FLAT-SIX TO THIS DAY**

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Ghosts in the machine

ROBOTS ARE TAKING THE PLACE OF HUMAN DRIVERS IN AN INCREASING NUMBER OF VEHICLE TEST SCENARIOS. **KEITH READ** INVESTIGATES SOME EXPENSIVE R/C TOYS

Considerable growth in the development of sophisticated new advanced driver-aid systems (ADAS), coupled with an increase in extreme maneuvers, abuse and durability testing, has brought demand for a new recruit to the world of vehicle dynamics testing – the robot driver. For UK-based Anthony Best Dynamics (ABD), a well-established producer of steering, braking and throttle robots with more than 160 sales worldwide, moves to driverless testing have opened a new market opportunity.

Technical director Mat Hubbard is confident that successful integration of GPS-corrected inertial motion packs from Oxford Technical Solutions, GeneSys and iMAR with ABD's existing robot driver equipment gives the company a healthy lead over the handful of rival companies.

Developing the ABD driverless robotic test system was not too complex. "What was difficult was making it safe so that proving grounds around the world would allow engineers to run tests with this equipment. The safety system is the most important aspect. Operators have to be able to stop the car remotely and have no doubt they're never going to have a run-away car."

The equipment's base-station system is operated through carefully selected high-quality radio links that allow operators to remotely drive the car (via a computer gaming console steering wheel) and configure tests. It also facilitates starting and stopping tests for one or more vehicles. If the test vehicle (or vehicles) goes outside radio range, it stops. It also stops if any onboard processors fail.

"Everything has redundancy and is self-checked," says Hubbard. "Safety has to be paramount because if there was ever an accident it would end the product or, at the very least, make people stop and think about how and when they used it. To date, we've had no problems."

ABD has sold three of its driverless robot testing systems to German vehicle manufacturers, and another to a French vehicle maker. One German manufacturer is using the system to conduct extreme abuse tests. Later this year ABD will deliver a system to a major Japanese manufacturer.

"We see it as a growing market," says Hubbard. "In terms of accuracy, we can control to 2-3cm laterally. Control longitudinally depends on what speed you are travelling, but it's typically to within 5cm."

According to Hubbard, the four most compelling reasons to buy

A DRIVERLESS CAR EQUIPPED WITH ABD HARDWARE AWAITS ANOTHER TEST RUN. THE FIRM'S EXISTING IN-VEHICLE ROBOT SYSTEMS HAVE RECENTLY BEEN DEVELOPED INTO AN AUTONOMOUS TEST SYSTEM

> "I see a big role for robot driver systems where you have vehicles with automatic avoidance systems traveling down the road and avoiding each other"
> Dr George Gillespie, CEO, MIRA

TWO ABD-EQUIPPED CARS MOVING IN CLOSE PROXIMITY. ROBOT DRIVING SYSTEMS ARE PREDICTED TO HAVE A BIG FUTURE IN SUCH SCENARIOS

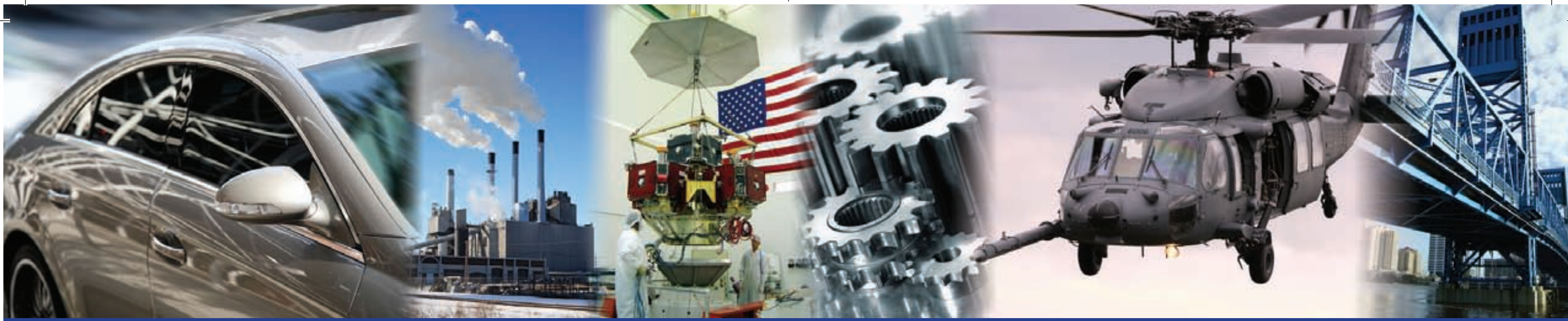
driverless robot testing systems are risks, repeatability, reduced proving ground space requirements and legislative tests where steering robots are already used.

"Number one is removing the risks to the test driver," he says. "Not just the risk of a crash, but of long-term back injuries and similar health problems. Second is the repeatability. Our system can beat most human drivers on accuracy and it's more flexible than wire-following systems. Third is the fact that it allows testing in a smaller proving ground area. One customer has justified buying robot systems rather than building a new proving ground. The fourth compelling reason is the legislative test that requires a steering robot and is potentially risky, such as the FMVSS 126 'spinout' or NHTSA 'fishhook' test. Our system removes the need to fit outriggers."

Hubbard sees demand for the systems likely to come from countries where vehicle manufacturers are interested in making safer models, developing new technology quickly and saving time and money through efficiency. He cites Germany, France, Japan, and Korea.

Costs are likely to be a key issue. However, if manufacturers already have steering and/or braking and throttle robot drivers from ABD, the additional investment to put together a full driverless robot test system is reduced. And where tests provoke potential health and safety concerns, the investment in driverless systems is likely to be less than compensation awards to injured drivers.

Not all suppliers are convinced that driverless vehicle testing yet has a role in their development programs. Holger Simon, chief engineer of vehicle development and brake system application at TRW's Koblenz technical center in Germany, says simulation still provides virtually all that is required without risking expensive prototypes or drivers. For physical vehicle-to-vehicle tests, which could be dangerous for drivers



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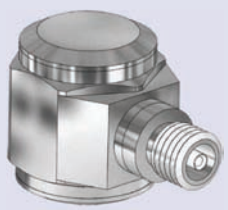

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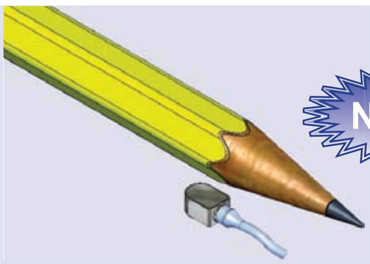

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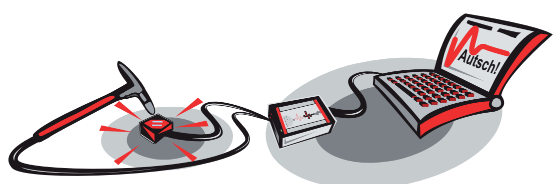

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"Operators have to be able to stop the car remotely and have no doubt they're never going to have a run-away"

Mat Hubbard, technical director, ABD

LEFT: **ABD INSTALLATION IN A HONDA CIVIC.** BELOW LEFT: **DRIVERLESS SYSTEMS CAN REMOVE THE DANGER TO HUMANS FROM RISKY MANEUVERS**

or potentially wreck the vehicles, TRW uses one real and one soft rubber facsimile vehicle. The latter can be static or tethered to a second real vehicle. "Having a driver in the car gives us the important subjective assessment," he adds.

Simon believes that for some supplier companies, such as TRW, the additional costs of a full driverless system could be difficult to justify even though it already has ABD steering robots.

ON THE WEB

Watch video footage of ABD's driverless systems in action at vehicledynamicsinternational.com

However, Dr George Gillespie, the new CEO at MIRA, is very keen on driverless testing: "I see an important role [for robot driver systems] when we're developing intelligent vehicles and telematics, where you have automated vehicles with automatic avoidance systems traveling down the road and avoiding each other. A lot of development work on such systems is beginning, and taking the driver out of the vehicle during the development could be very useful."

Under construction at MIRA is Europe's new InnovITS – Advance R&D center, where customers from the telecommunications, automotive and electronics industries as well as highways authorities and operators will develop, test and validate future transport technologies. "This is exactly where I would see us using robot driver systems," says Gillespie. "There are many things to be learned about autonomous vehicle systems, and there will be occasions when some of the things we have to do will be relatively dangerous. These are the occasions when we'd want to have robot drivers in the vehicle."

He also acknowledges their value in avoiding driver injuries. "There could possibly be applications for robot drivers in vehicle-to-vehicle impact tests because they're certainly not tests where we are going to use human drivers!

"Health and safety is of paramount importance, and we need to look after our employees and those of customers using our facilities," he adds. "So, as we get into highly aggressive testing, I can see opportunities where a robot driver could be an alternative."

Gillespie's views are shared by Brian Bucallo of Michigan-based Test

DRIVERLESS TECHNOLOGY FROM STAHLE AND GRAYMATTER HOOKED UP IN A FORD F-150 PICKUP TRUCK

Cells Service, a company servicing and installing Stahle equipment including robot drivers. "A lot of manufacturers are looking to do more aggressive testing that they can't do with a human being as unions are getting a bit upset about these test guys getting beaten up as badly as they are. It is an issue.

"Our latest technology is all completely enclosed," continues Bucallo. "Behind the robot is the complete operating system with battery and battery backup. We're also demonstrating vehicle avoidance – a radar system that can avoid obstacles in the road."

"They have identified that driver fatigue is a factor that seriously limits their ability to conduct the test"

Matt Hardey, operations manager, GrayMatter

Mind over matter

A key focus for driverless vehicles is the US Defense Advanced Research Projects Agency (DARPA) annual challenge. One entrant in the 2005 Grand Challenge event, GrayMatter Inc, was formed by the owners of a New Orleans-based insurance company simply to compete. But when its Ford Escape Hybrid (below) came fourth – and was one of only five vehicles to complete the 132-mile course – things got serious.

Today, GrayMatter is ramping up research on driverless and autonomous vehicles and is poised to launch projects that should bring in its first revenue, according to operations manager, Matt Hardey.

"We've done a series of tests with one of the major US light-duty truck manufacturers," he reveals. "They have a track that stresses every conceivable part of the vehicle. They have identified that driver fatigue is a factor that seriously limits their ability to conduct that test, and that they were experiencing a higher-than-acceptable level of medical issues relating to the pounding that the driver took in the cab of the vehicle.

"We put one of our vehicles out there, equipped with our complete system, and ran repeatedly over the course with complete precision and a high degree of accuracy. With no driver in the vehicle, any issues with respect to driver safety are mitigated."

Despite the high cost of driverless systems, Hardey sees potential market opportunities in the tire industry. "A lot of the work that goes into tire testing is mileage accumulation in a real-world environment. A small staff of technicians could supervise a large number of vehicles without having to have a driver on board, thus reducing the primary issue they face of driver boredom and inattention, and resulting safety problems."

GrayMatter is currently prototyping a low-cost driving robot without the 'intelligence' of an autonomous vehicle. Hardey says it should fall in the US$25,000-US$40,000 range. However, if GrayMatter's autonomous vehicle system (AVS) is added, the total cost will rise to US$150,000-US$175,000. "That, of course, is before you add the GPS and whatever sensors you want to use," he continues.

Vehicles for military missile and aircraft gunnery targets are the sort of application Hardey has in mind for the low-cost system. "You wouldn't want to put US$500,000 worth of equipment into a vehicle just to have it blown up by a missile," he says. Testing of the system is imminent and a decision on production will be taken immediately afterward.

Crash-testing is also on Hardey's radar. "Much of the side-impact testing takes place with the target vehicle static and a sled running into the side of it. Using our system you could, in fact, conduct a completely dynamic test with the target vehicle in motion – just as it would be in the real world.

"There are a lot of opportunities out there for driverless systems, and we'll be attacking them as we see them – not only in automotive testing, but also in the military, agricultural and mining markets."

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GRAHAM HEEPS GETS AN EXCLUSIVE INSIGHT INTO THE METHODS AND FACILITIES OF FORD OF EUROPE'S VEHICLE DYNAMICS TEAM AT THE LOMMEL PROVING GROUND


NORBERT KESSING IS MANAGER OF VEHICLE DYNAMICS, FORD OF EUROPE

Since Richard Parry-Jones initiated the creation of a dedicated vehicle dynamics development team back in 1994, Ford of Europe has established itself as a benchmark OEM for steering, ride, and handling.

According to the man who oversees the 55-strong department working on everything from Ka to Transit, little things can make a big difference.

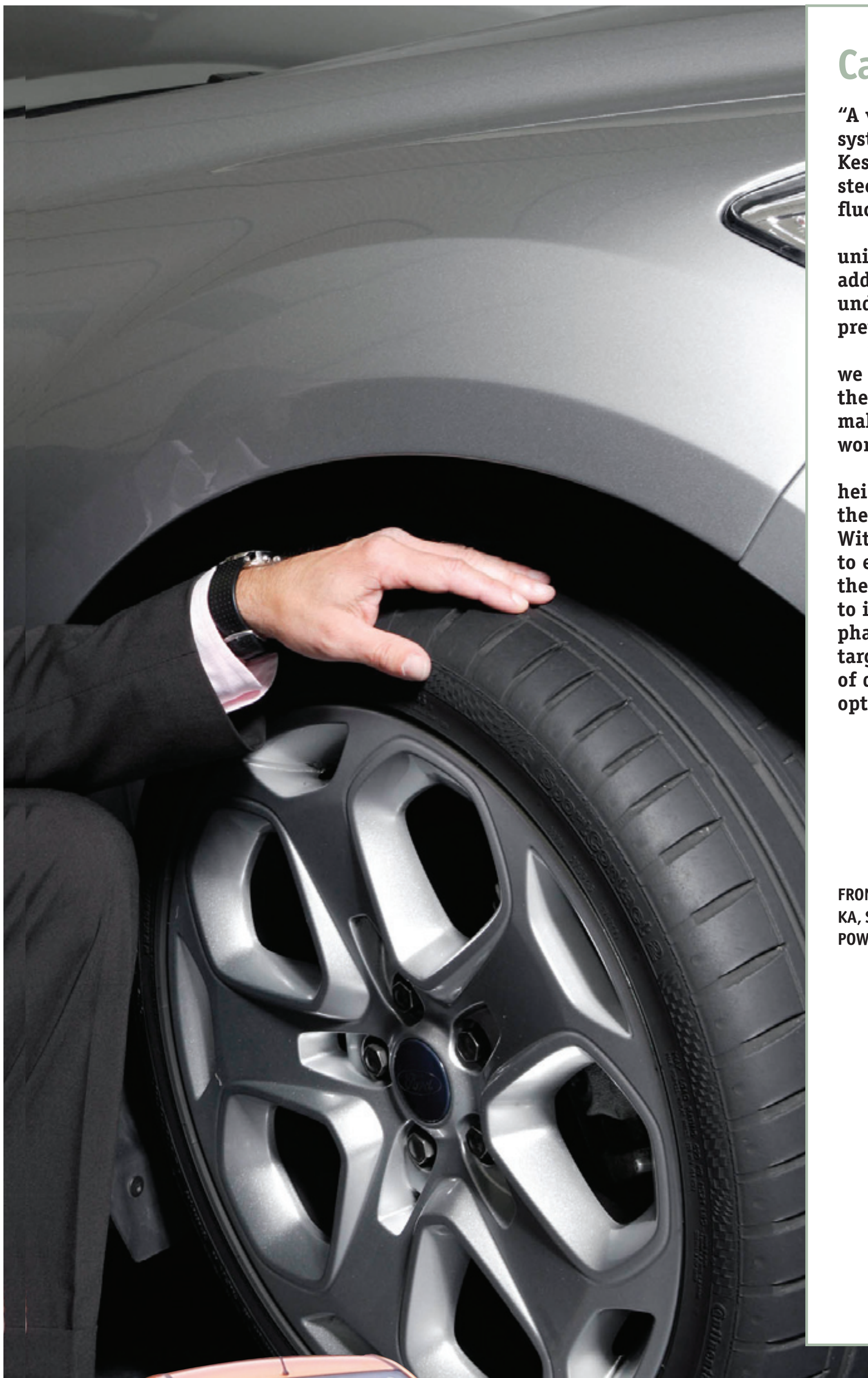
"The key thing we're always working toward is attention to detail," explains Norbert Kessing, Ford of Europe's manager of vehicle dynamics. "There are premium OEMs who can afford to put more technologies into their vehicles than we can. Our way is to fine-tune each and every component to its limit."

"We are still convinced that customers don't want to just drive a vehicle, they want to have some fun doing it"
Norbert Kessing, manager, vehicle dynamics, Ford of Europe

To understand why the department has had so much success, it's worth looking first at what it's trying to achieve. "We're looking for functional harmony," says Kessing. "It's no good having a very agile vehicle in terms of steering response but a very lazy reaction on the throttle pedal.

"Beyond that, we remain convinced that customers don't want to just drive a vehicle, they want to have some fun doing it. But that should not mean that the customer always has to be involved in keeping the car on the road – fun-to-drive must be combined with a relaxed, refined and comfortable driving experience."

To achieve its goals, Ford's team relies on two major assets. The first is a stable team of experienced testing, tuning, and CAE engineers who work closely together on developing steering, handling, ride, and, increasingly, ESC. "It's very important to us that all the areas of work are combined," Kessing stresses. "The development engineers who do the tuning, the testing engineers, and the CAE engineers are all part of the same team, which accelerates learning. For example, CAE engineers and the tuning guys sit together in



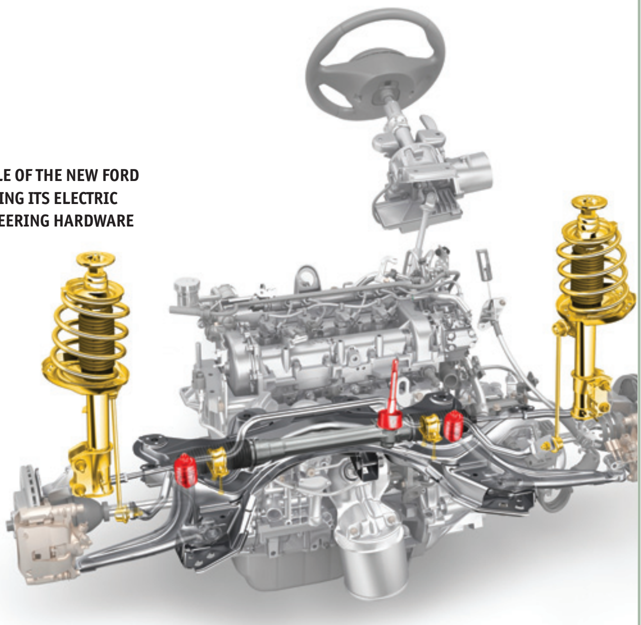
Case study: Steering development

"A very interesting, complicated, and important part of the steering system is the area with the two universal joints," explains Norbert Kessing. "These joints give a non-uniformity effect – if you turn the steering wheel at a constant speed, the road wheels will turn with a fluctuating speed.

"One can either design the steering column to reduce the non-uniformity as much as possible, or make use of the non-uniformity to address issues like compliance feel or progressive yaw gain. Once we understood this, we used CAE models to tune these elements, which are pretty complicated to tune, to achieve this characteristic.

"But the complex models meant that it took quite a bit of time, so we aimed for a faster approach. We translated the basic formula from the complex model into an Excel-based model, which enables us to make changes very quickly. With the CAE and development engineers working together, a change can be made in an hour or so.

"What makes the thing more complicated is that we usually have height and reach adjustment in the steering wheel, which affects the geometry, so we have to tune the system for all these positions. With this [Excel] tool we can do the calculations pretty quickly, but to evaluate the output is pretty complicated. It's difficult to see what the optimum design is by comparing all the numbers so the next step to improve our way of working was to translate the numbers into a phase space, which tells us how these positions perform. We have a target area where we want to be, and we can easily check the position of different designs on the diagram. Now it is quicker to find the optimum design."



FRONT AXLE OF THE NEW FORD KA, SHOWING ITS ELECTRIC POWER STEERING HARDWARE

"Certainly there is very high internal visibility of vehicle dynamics, it's a key attribute for Ford. Senior managers such as Joe Bakaj spend a lot of time evaluating the cars and putting pressure on us. It's demanding, but it's also helpful" the vehicle to look at an issue, or look at the simulation together. The same is true of testing, with strong communication between testing and tuning, and testing and CAE."

An exchange of ideas between people working on different cars is equally important: "It's only by enabling people to have a chat over a coffee that you get the sparking of ideas," he argues.

For Ford, the second secret of success lies in its methods. "The results of our work are no coincidence; we work in a pretty structured way," says Kessing. "Vehicle dynamics is still a very subjective thing and there is still a lot we cannot measure. But we're always trying to increase the objective approach, and make use of the elements we can measure to better describe the vehicle up front and shorten our development time. That frees up time for the engineers who have to do the fine-tuning later.

"Objective metrics are important in trying to describe what makes a good subjective vehicle," he continues.

VEHICLE DYNAMICS IS SPLIT FROM CHASSIS ENGINEERING WITHIN FORD AND FIGHTS ITS CORNER TO ENSURE THE HARDWARE CAN DELIVER THE REQUISITE DYNAMIC PERFORMANCE

"We apply a lot of full-vehicle and system measurements, a lot of CAE, we use a lot of 'health charts', and we have ever more detailed component specs. Everything we learn, the build-up of experience, is translated into more detailed component specs so that we can make sure the first bush that we order for a new vehicle, for example, is close to the limit."

Kessing's team does its CAE work in Merkenich, Germany. The main tool is ADAMS, but veDYNA from Tesis is also used. "It's not as complex in terms of kinematics, for example, but it's much more capable in including controls stuff, it's much quicker, and it allows hardware-in-the-loop applications," says the man who himself has a CAE background. "We use veDYNA a lot to do pre-work for the ESC tuning."

As well as these two packages, many tailored tools are employed, mostly based on either Matlab or Excel, to accelerate certain steps of the work in a targeted way (see box on steering development, *p35*).

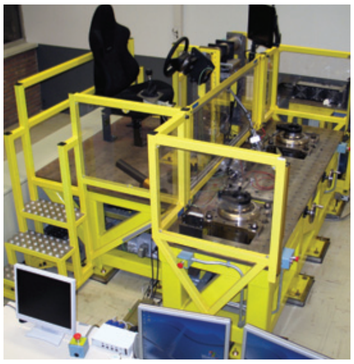
"When I started at Ford 13 years ago, we had in some cases even more complex CAE models than we're operating today," Kessing expands. "But the models were so complex that the results were available only once the development was over! Since then we've tried to concentrate on value-added CAE work that meets the vehicle-development timing. Communication within the team is important here – by talking to the development engineers, the CAE

Stands that deliver

In the workshops at Lommel are two key pieces of test equipment for the vehicle dynamics engineers: a K&C rig and a steering test rig.

The former (pictured, right) has performed more tests than any other SPMM supplied by Anthony Best Dynamics (ABD). "We do the same work in CAE, but this rig is still very important for us to validate our models and make sure the calculations are right," says Norbert Kessing. "There are often complicated cases when our CAE models are not accurate enough and we have to rebuild them. We also have to check that our prototypes were built to the specification defined by CAE, without, for example, differences from side to side." Other uses of the rig are for benchmarking competitors, measuring moments of inertia, and determining a center of gravity height.

A number of improvements have been made to the rig during the course of its life. The latest major upgrade took place in April 2009 to bring it to a specification similar to ABD's most recently supplied rigs, although the dynamic testing option was not incorporated. On the day of *VDI*'s visit, the Lommel test team had a Ford Escape SUV on the rig to take measurements for their counterparts in Dearborn.



"Our colleagues in the USA have their own, similar K&C rig. But our methods are aligned so that we can directly compare the results of both rigs," says Kessing.

Next door to the K&C workshop is another piece of ABD equipment, a three-year-old Steering System Test Machine (SSTM). "Tuning an EPS is pretty cumbersome because there are so many parameters in the controller that you can change," he explains. "When

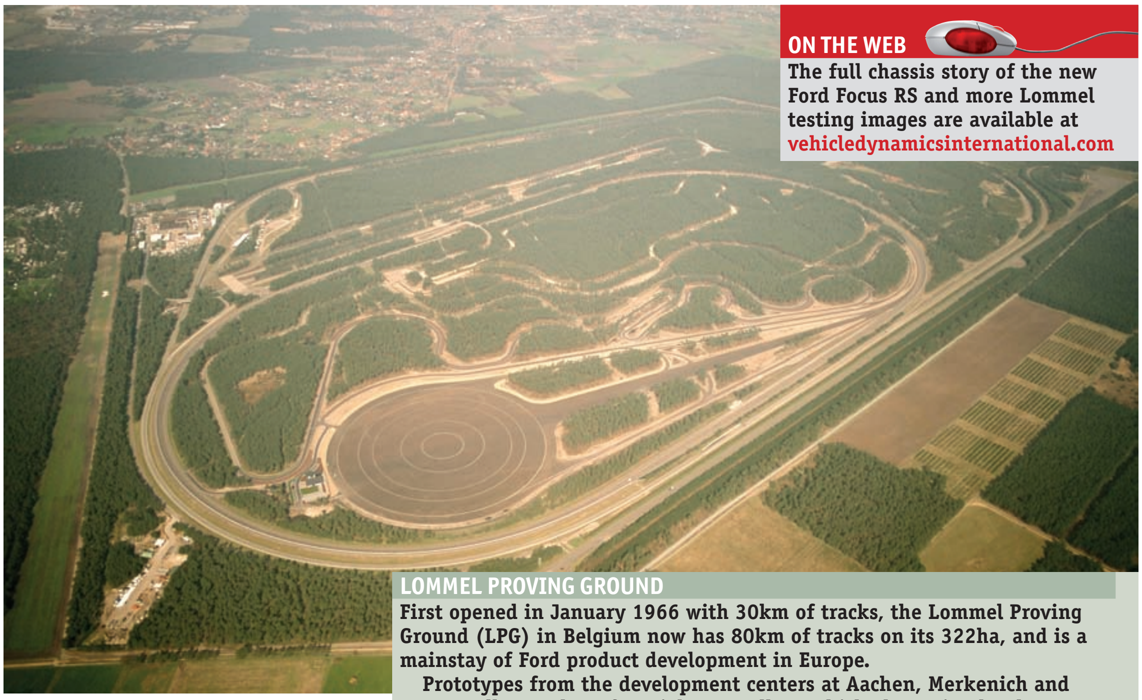
we developed the new Fiesta, we ran a project to determine which of those parameters impact on nibble suppression. It's something you cannot do on the road, at least not within realistic timescales. So we measured the road inputs, and here in the cell fed them into the tie rods and did an experimental investigation, measuring the outputs at the steering wheel.

"From there we could generate some maps that told us which parameter areas to concentrate on when doing the tuning on the road. It makes the development much faster once you have the vehicle available, which means you can concentrate on tuning the system toward good steering feel – not that easy with an EPS."

The steering rig at Lommel was originally intended for algorithm development, but is now being used for the whole steering system, meaning that stand-up tests to measure characteristics such as friction, stiffness or damping can also be done. Ford has also developed a HIL system for the rig.

"Rigs like this are becoming increasingly important because of the extra features going into steering systems," Kessing adds. "You can also investigate [the effect of] faults in the controller, for example. That's difficult and dangerous to do on the road."

ON THE WEB
The full chassis story of the new Ford Focus RS and more Lommel testing images are available at **vehicledynamicsinternational.com**



guys get ideas about where some simulation could be really helpful."

During development programs, the team makes extensive use of 'health charts', which include lines plotted through a series of target performance windows, to provide a quick overview of how an aspect of the vehicle is shaping up compared to its targets.

"It gives the development community a very good, quick overview of the state of the vehicle," Kessing enthuses. "For example, in steering development we derive some metrics from the complex curve that describes our vehicle. By comparing the lines it's easy to see which attributes are better at different stages of development. It's the same for handling and ride."

Come the end of a program, the results are meticulously logged and fed back into the processes.

"We've translated the learning from vehicles we've developed in recent years into CAE metrics," he says. "From that we can derive some rules for spring and damper settings. We then apply these via CAE so that they're available before the first physical vehicle. We also use this to order the first prototype parts – we'll already have a good feel for the kind of spring settings we'll need for different types of vehicle. Cumulative learning like this enables us to perform the next development task faster and more robustly."

LOMMEL PROVING GROUND

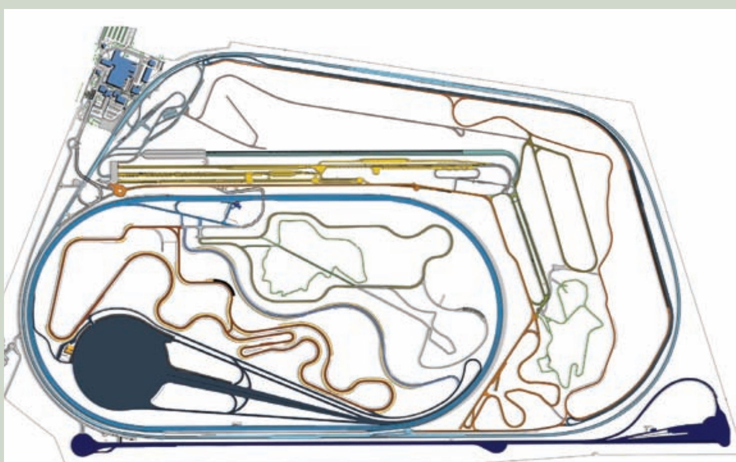
First opened in January 1966 with 30km of tracks, the Lommel Proving Ground (LPG) in Belgium now has 80km of tracks on its 322ha, and is a mainstay of Ford product development in Europe.

Prototypes from the development centers at Aachen, Merkenich and Dunton all come here for trials. As well as vehicle dynamics development, all aspects of performance testing, NVH, driving quality assessment, corrosion resistance, and durability validation are conducted on the site.

In the latter case, work is carried out non-stop, with 90 test drivers working in three shifts, Monday morning to Saturday morning, and two further 15-driver shifts working 12 hours a day at weekends. Eighty technicians look after the test fleets.

Various tracks and surfaces are available to the testers, including special brake surfaces, handling tracks, hills up to 30%, and a high-speed oval. Of particular interest to Kessing's team is the vast vehicle dynamics area. Added in 2001, this consists of a 330m-diameter circular platform with multiple access roads at different approach angles. "Space is by far the most important parameter for doing maneuvers in safe conditions," observes facility manager, Valère Swinnen, himself a very experienced former Transit development engineer. The VDA required the careful moving and reconstructing of two other test tracks, including the Route 7 handling track, the corners of which were exactly replicated but reordered to fit the available space.

LPG is rented to third parties for development purposes whenever capacity is available, and the facility maintains strong links with the former Ford PAG companies. Formula 1 teams Red Bull (ex-Jaguar) and Toyota have also used it for tasks such as aerodynamic coast-down testing, although the recently implemented testing restrictions have meant such bookings have dried up for the time being.



"Space is by far the most important parameter for doing maneuvers in safety"
Valère Swinnen, manager, Lommel Proving Ground

Split decision

JONATHAN LAWSON CATCHES UP WITH SOME KEY PLAYERS IN ELECTRONIC LIMITED SLIP DIFFERENTIALS TO EXAMINE CURRENT TRENDS AND FUTURE TECHNOLOGIES

"We are now working on a fully electronic LSD for front-wheel-drive cars. Many of the OEMs are interested in this architecture due to its inherently better fuel economy"
John Grogg, chief engineer for vehicle dynamics in Eaton's Torque Controls Product Division

THIS EATON DIFFERENTIAL HAS BEEN FITTED TO THE FIAT PALIO ADVENTURE IN BRAZIL FOR ITS 'LOCKER' SYSTEM

In the current climate it's sometimes easy to forget that there is still some innovative technological development work going on in highly complex areas to deliver better dynamics, traction, and driver enjoyment.

One area in which there are numerous advances is electronic limited slip differentials, or eLSDs, and one company investing research dollars is USA-based Eaton.

It's an exciting time for the men from Michigan as the company is working on a new design for front-wheel-drive cars. John Grogg, chief engineer for vehicle dynamics in Eaton's Torque Controls Product Division, explains, "We have been working with Fiat in Brazil on the Adventure electronic locker, and we have had a great deal of success, building on what we have learned from our torque management and vehicle dynamics research. We are now taking this forward and working on a fully electronic LSD for front-wheel-drive cars, where things like packaging, cost, and weight are important. Many of the OEMs are interested in this architecture due to its inherently better fuel economy."

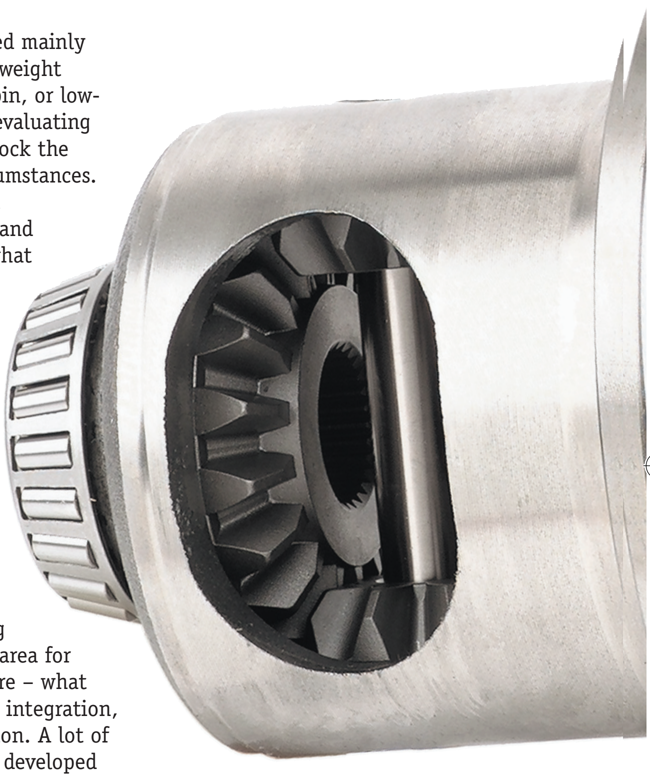
The new eLSD is packaged inside a transaxle, all of which is made by Eaton. Grogg elaborates, "We are using a hydraulic power supply to energize and de-energize the eLSD. It is governed by a series of control valves so we can modulate the limited-slip capability all the way from completely open to fully locked. We are using the same sensor information as for the brake system, the wheel-speed sensors, lateral accelerometers, yaw, steering wheel angle sensor, and throttle position."

The new eLSD is scheduled for a 2011 or 2012 launch. The testing process has begun: "We have learned a lot from our experience with off-road testing, but the new design will be tested very differently," Grogg reveals. "We are interested mainly in two scenarios: lateral weight transfer, causing wheelspin, or low-µ situations. We will be evaluating the benefits of when to lock the differential in these circumstances. We are very interested in emergency lane changes and slalom maneuvers, and what they can teach us about yaw damping, and we are very interested in integrating the ESC systems to prevent the vehicle losing traction and spinning off the road. We feel we can provide great benefit here."

This is a subject that seems to have fired the collective Eaton imagination. Grogg continues, "This is a big area for improvement in the future – what you could call subsystem integration, including active suspension. A lot of these systems have been developed in isolation, so maybe the challenge for some of the suppliers – including ourselves – is to get together and integrate all of this stuff then take it to the OEMs as a total solution. The problem is cost, especially when developing the software algorithms."

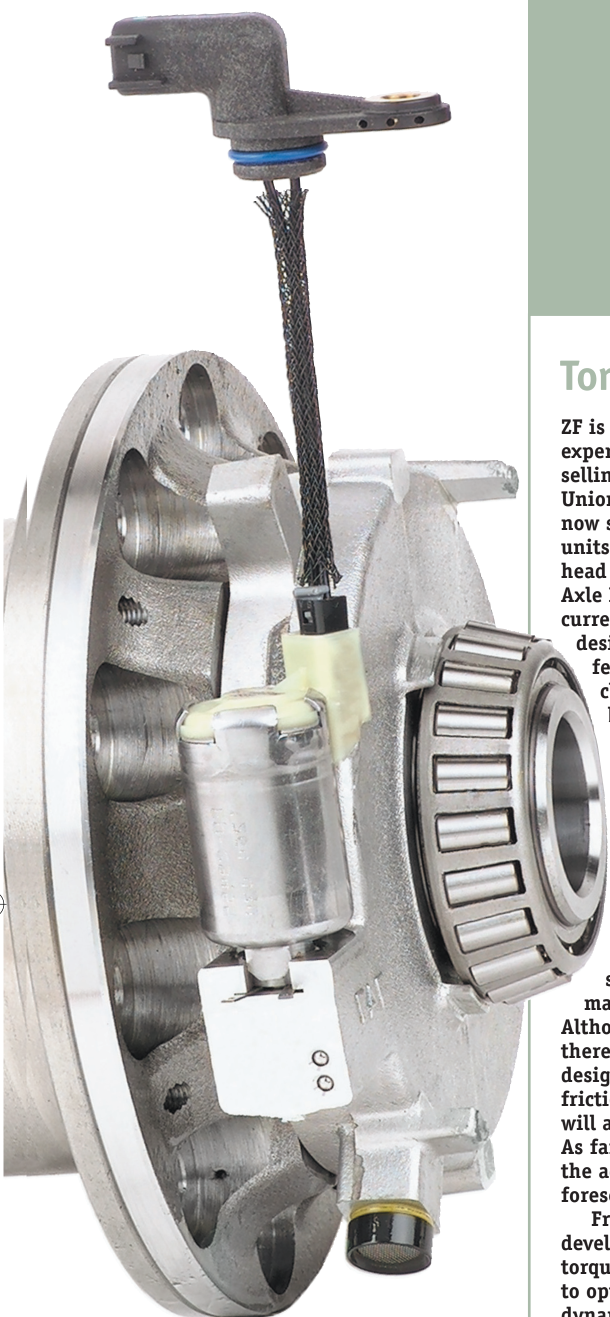
The next iteration for the technology is torque management. Grogg listens to auto manufacturers, and says, "The efforts here are likely to be focused on reducing the weight and having better packaging, primarily due to fuel economy requirements. Also, again, cost is an important deciding factor."

This said, there is a firm belief at Eaton that the high-end models will soon all come with some form of torque vectoring, even though there is a bit of a chicken and egg situation. To get lower costs, higher production volumes are required; when those volumes are reached, the costs will come down.

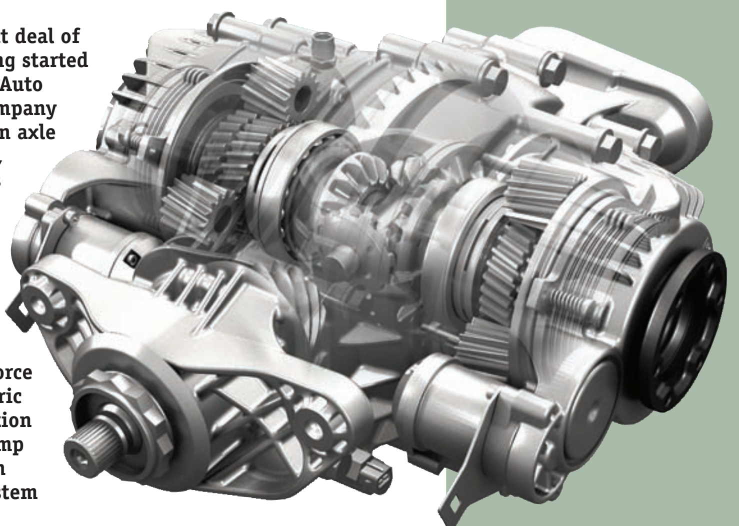


ABOVE: **EATON'S REAR-AXLE ELECTRONIC LSD, AS FITTED TO THE JEEP GRAND CHEROKEE. THE CORRESPONDING UNIT FOR FRONT-AXLE INSTALLATION IS ALSO PICTURED** (BELOW RIGHT)

"Legislation can help here," Grogg believes, "but it's not the safety legislation, which is pretty strict anyway, especially where brakes are concerned. It is the economy drive that will force cars to get lighter, increasing the use of the FWD platform, which will give us the opportunity to fit more eLSDs. We are able to use the technology as a performance enhancement, with increased stability leading to increases of 10% in things like corner-entry speeds. Although the differential won't add on-center yaw authority to counteract understeer, we can definitely dampen oversteer, improve traction in launch, improve



Torque about the future



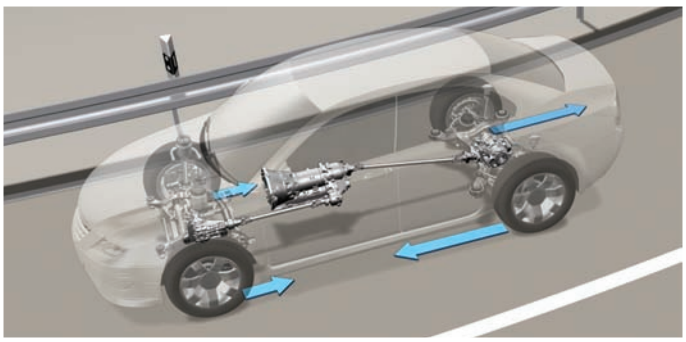
ZF'S VECTOR-DRIVE REAR AXLE DRIVE UNIT. THE ADDITIONAL YAW MOMENT LENDS SUPPORT TO THE VEHICLE'S STEERING AND CAN STABILIZE THE CAR DURING SUDDEN SWERVES WITHOUT RESORTING TO THE BRAKES

ZF is a company with a great deal of experience with LSDs, having started selling mechanical units to Auto Union in the 1930s. The company now sells around one million axle units per year. Robert Peter, head of development at ZF's Axle Drive Unit, says, "The current state-of-the-art design for our eLSDs features a multiplate clutch pack arranged between the differential case and one side-gear. Axial force generated by an electric motor through reduction gearing and a ball-ramp mechanism creates an electromechanical system with no hydraulics."

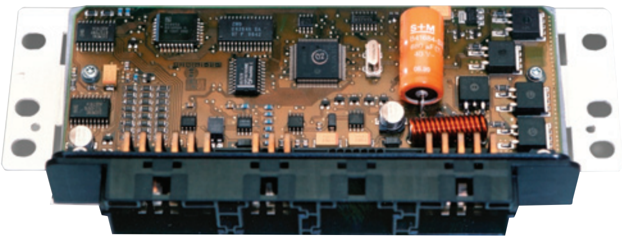
This is the basis of ZF's current eLSD offering. The design has been around since 2003, and is unlikely to undergo major structural changes in the near future. But Peter predicts, "There may be investigations to reduce cost, which is a major issue. Although performance of the current design suits customer needs, there are trends we can identify for the next few iterations of the design. Transmission losses can be reduced by new types of low-friction bearings, and there is a general trend for downsizing. There will also be small improvements in the synthetic oils available." As far as prototype work is concerned, Peter believes that despite the advances in simulation, physical testing will still be used for the foreseeable future.

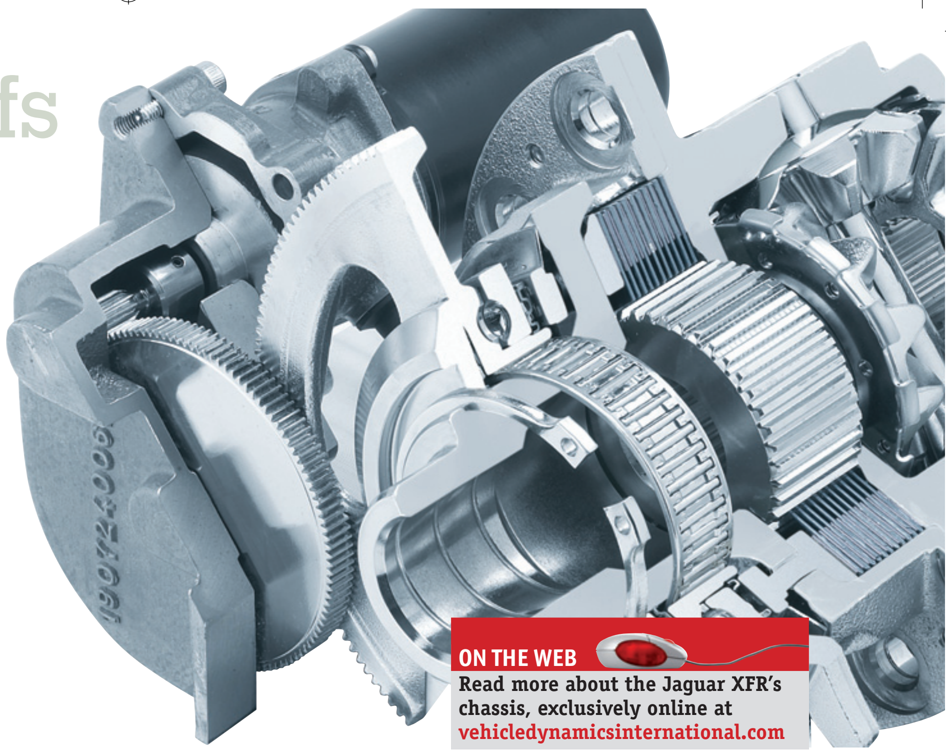
From a dynamics perspective, perhaps the most exciting development from ZF's point of view will be the growth of special torque sensors in the drivetrain that could open the possibility to optimize the control strategy, improving traction and driving dynamics.

"Initial studies have shown the advantages, but currently there are several obstacles to overcome, such as cost, robustness, and safety criteria. In the meantime, the eLSD does improve traction considerably, and also driving dynamics can be improved moderately, depending on the control strategy. And with our ZF Vector-Drive torque-vectoring system, the driving dynamics will be further enhanced," says Peter.



electronic diffs





THE GKN ELECTRONIC TORQUE MANAGER (ETM) IS SHOWN (RIGHT) **AND ITS ELECTRONIC CONTROL UNIT** (ABOVE)**. AFTER SEVERAL SUV APPLICATIONS, IT'S NOW IN JAGUARS TOO**

ON THE WEB
Read more about the Jaguar XFR's chassis, exclusively online at vehicledynamicsinternational.com

THE ETM-EQUIPPED JAGUAR XFR PUTS 510BHP THROUGH THE REAR WHEELS

traction in cornering, and by getting the algorithms right we can temper the torque steer."

That may not be an issue for rear-drive cars, but there are still some major dynamic benefits to be had. Jaguar's new flagship 510bhp XKR and XFR models feature a clever Active Differential Control (ADC) system, which uses GKN Driveline's Electronic Torque Manager (ETM).

The Jaguar diff is an evolution of the design that has seen service in the Land Rover Discovery, Volkswagen Touareg and Mercedes-Benz M-Class among other vehicles. GKN product technology director Jörg Trommer says, "This is the first application on a high-performance car. It has a different electric motor, and there are small design detail changes. However, the biggest difference is in the control software. The SUV's focus is mainly on traction, but the Jaguar is also very much focused on vehicle dynamics and stability."

Working closely with Jaguar, GKN improved the intelligent power module that governs the differential hardware. Trommer continues, "We have tested it on rigs to check the hardware over a two-year period, and Jaguar has also conducted numerous dynamic tests on various proving grounds.

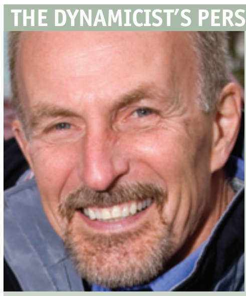
"As far as transferring drive from a wheel with lower adhesion to the wheel with higher adhesion, it is about as good as it can get, so to improve the dynamics further we need to move to next-level torque vectoring, where we can transfer torque independent of µ conditions."

Looking forward, Trommer feels there is a risk that the current economic climate may stifle active-differential-control and torque-vectoring-system development. The high levels of technology involved mean that such systems aren't cheap, and although GKN Driveline's own torque vectoring system (developed in partnership with ZF) was launched last year on the BMW X6, he feels that the system will remain a premium option.

Setting cost issues aside for a moment, Trommer sees a career path for eLSDs. "We have seen the emergence of the passive systems, both helical-worm gear or multiplate, they have been around for decades with minor evolutions in materials and lubricants, without changes in the basic mechanical concept. The same is true of the eLSD. It will be a story of small movements with better packaging, but there will be further integration of software with a reduced number of ECUs – and this will present the biggest challenge."

Away from conventional drivetrains, GKN observes the growth in competing areas with great interest. Trommer notes, "The biggest threat to LSDs, whether active or passive, comes from brake systems. Although the functionality is limited, there is strong activity within the brake-supplier world to mimic LSDs. Also we are carefully watching the hybrid drive world. We know wheel motors are being investigated and this would be a serious threat, even if it will be many years before these products come to market."

THE DYNAMICIST'S PERSPECTIVE

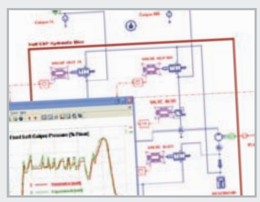


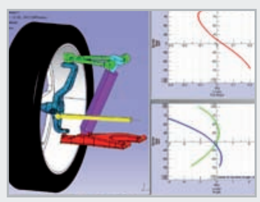
Initially matching a differential perfectly to a vehicle requires thought. John Heinricy, formerly of GM and *VDI*'s Dynamicist of the Year 2008 observes, "The decision to incorporate an LSD is based on what kind of performance you plan for the car. Controlling inside-wheel spin is difficult with small, powerful front-wheel-drive cars unless very grippy tires are specified, and this may not be an appropriate solution for a road car. The trend recently has been for stiffer spring setups, with more roll control, which reduces overall suspension articulation. This can cause reduction in inside tire normal force and then potentially more wheelspin. An LSD means the roll can be controlled more without the accompanying wheelspin."

Heinricy likes mechanical LSDs, but is aware of the limitations in front-wheel-drive applications. "Like most things, the good ones are expensive, which is an issue when it comes to wider adoption in the market. Having had some experience now with an electronic, controllable LSD I was very impressed with the flexibility offered and the way in which the power can be put down and understeer controlled. There is much more latitude where calibration is concerned."

While he acknowledges high-end torque-vectoring technology can be used to great effect, the cost and complexity raise issues. "I view this stuff in a slightly different category to electronic LSDs, being more akin to four-wheel active steering and active suspension as technologies I don't see going mainstream. The cost of the additional electronics is prohibitive and it offers much more than most consumers want. If you look at something like the Mitsubishi Evo, as brilliant as it is, it will never be a huge seller and the electronics are almost like a Band-Aid – the effects of the unfavorable weight distribution are being smoothed out by the technology."


Electrical Power Steering System





Prize guys

THE WINNERS OF THE 2008 VEHICLE DYNAMICS INTERNATIONAL AWARDS HAVE BEEN PRESENTED WITH THEIR TROPHIES, AND PREPARATIONS ARE IN HAND FOR 2009

Dynamics Team of the Year

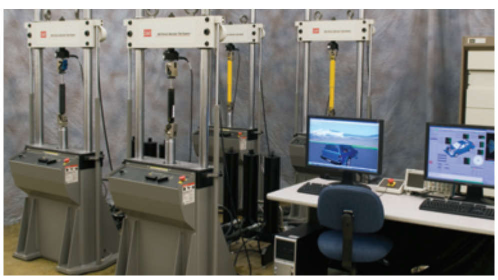
In a special event at the Lommel Proving Ground, Ford of Europe's Vehicle Dynamics team gathered to witness Pim van der Jagt (executive technical leader, vehicle dynamics) and Norbert Kessing (manager of vehicle dynamics, Ford of Europe) receive the trophy on behalf of Ford dynamicists worldwide.

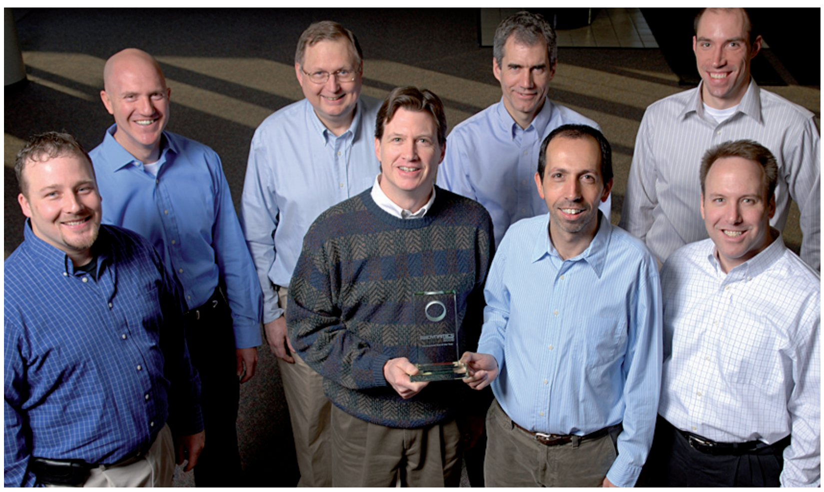
CAR OF THE YEAR

The prize-winning Nissan GT-R will be launched into the European market this year. Accepting the Car of the Year trophy was Melanie Jupp, who is Nissan's sports car manager in the UK.

Development Tool of the Year

This award went to the partnership of Nissan and MTS Systems Corp for the jointly developed Four-Corner Damper System with mHIL. Pictured right are some of the MTS team members responsible for the winning test rig.





SUPPLIER OF THE YEAR

Bosch's UK managing director of original equipment, Hermann Kaess, was delighted to receive the trophy on behalf of the German-based Tier 1. "Gaining recognition for our work in the area of chassis systems, particularly related to safety, is much appreciated by our engineers and further encourages us to continue and extend our development work," he commented.

DYNAMICIST OF THE YEAR

Winning the Dynamicist of the Year award was just about the last thing John Heinricy did before retiring from General Motors in November 2008. *VDI* caught up with him in Detroit in January, where he talked about his new career working with a number of supplier companies, and coaching race drivers.

Innovation of the Year

Bishop Steering Technology's product manager, David James (on the right) is pictured at the Autosport International show with *VDI* editor Graham Heeps. One application for Bishop's winning ActivRak technology is on the IndyCar Dallaras.

VDI AWARDS 2009

Nominations are already open for the 2009 *Vehicle Dynamics International* Awards (closing date: August 7), so if you have an innovative product coming to market this year, or think your people are worthy of nomination, be sure to tell us about it! Email vehicledynamics@ukintpress.com for more information. Good luck!

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Bishop´s ActivRak™ Variable Ratio Rack

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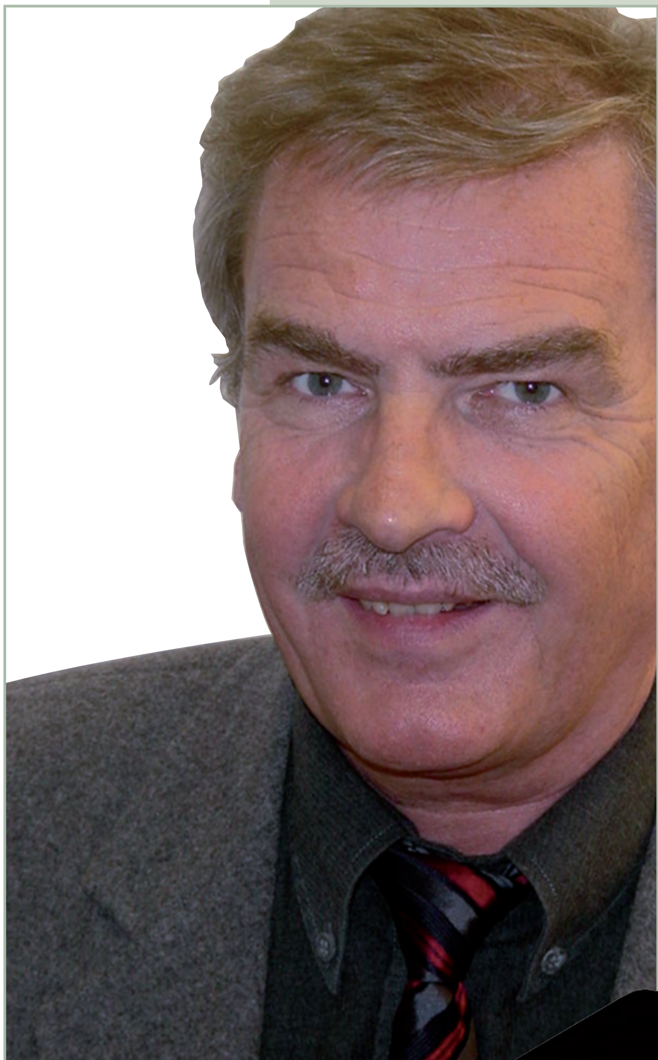
New generation

TRW'S ESC-R REGENERATIVE BRAKING SYSTEM IS CURRENTLY UNDER DEVELOPMENT. **JONATHAN LAWSON** TALKS TO THE COMPANY'S LEO GILLES ABOUT THE TECHNOLOGY



Not only has the market for full hybrid cars such as the Honda Insight and Ford Fusion developed far beyond early expectations, but many regular cars are now being fitted with fuel-saving mild hybrid architectures comprising stop/start functionality and regenerative braking.

Developed especially to take advantage of this changing landscape is TRW's new ESC-R braking system. And with legislation set to underpin the drive for greater fuel efficiency, Leo Gilles, TRW regenerative braking specialist, sees further opportunities ahead. "Legislation will certainly have an impact on the market for hybrid vehicles, and thus for regenerative braking systems," he says. "For example, in the USA, the Corporate Average Fuel Economy standards (CAFE) will increase. By 2020, the combined standard will be raised to 35mpg from the current 27.5mpg for cars and 20.7mpg for light trucks. In Europe and Japan, emissions reduction targets will also play a role in driving the uptake of such fuel-efficient technologies and the growth of hybrid vehicles."

ESC-R is based on TRW's standard ESC system, but with the addition of a pedal travel sensor and an integrated brake volume displacement simulator. This provides a consistent pedal feel, identical to the pedal feel during conventional hydraulic braking, regardless of what combination of hydraulic or regenerative braking is taking place. The related vehicle deceleration then results from the sum of regenerative and friction deceleration, which are arbitrated by the ESC-R brake ECU or the vehicle generator's ECU by information exchange.

Should the electronics fail, a fully adequate braking function is still assured. In such a case, TRW says the ESC-R system will switch off, and the braking will revert back to the conventional, fully boosted hydraulic system without pedal degradation.

"As with any safety-critical system, ESC-R is intensely performance tested to ensure it meets all industry and customer specifications, and performs in all weather and road conditions and in challenging road maneuvers," assures Gilles. "This is done in computer simulations and on vehicles fitted with the technology. Component-level testing is also carried out, as with all standard slip control systems, across a range of environmental conditions including extreme temperatures, salt spray for corrosion, etc."

He goes on to highlight that basing the regenerative system around a regular ESC system brings its own advantages. "This solution is one of the lightest hybrid-braking-compatible solutions we are aware of due to its modular design and the limited increase in size of the ESC unit by the integrated pedal simulator," he explains. "Because the ESC system itself helps to build brake pressures when needed, there is no additional actuation unit necessary to increase system weight."

More generally, regenerative braking systems could also extend the service life of discs and pads because friction braking may be used less often or less aggressively as the hybrid energy assists in stopping the vehicle. Such a benefit comes on top of the fuel savings that are driving regenerative braking adoption – up to approximately 18% in a mild hybrid application, or 25% or more for a full hybrid, according to TRW.

TRW'S LEO GILLES (ABOVE)
AND ESC-R CONTROLLER (RIGHT)

Silent runnings

A FAMILY FAVORITE, THE PEUGEOT 504 WAS RENOWNED FOR ITS COMFORTABLE RIDE, LOW ROAD NOISE AND VAST LOAD-CARRYING ABILITY. BY **MICHAEL SCARLETT**

The Peugeot 504 was launched in September 1968 as the eventual replacement of the preceding 404, both cars being five-seater sedans around 1.6 liters aimed at the family buyer. As such, the 504 owed quite a lot of its engineering design to the 404, while being an advance in several respects, most notably in replacing the 404's independent front end and live-axle rear with an all-independent setup.

At the front the 504 used coil-sprung MacPherson struts, and at the rear were similarly sprung trailing arms, the pivots of which were aligned almost parallel with the line between the wheels, keeping the usual camber change of other semi-trailing arms during suspension movement to a minimum, which was helpful for secure grip. Both suspension systems were controlled by Peugeot-made telescopic dampers, and anti-roll bars with a larger diameter in front. Steering was unassisted rack and pinion, relatively low geared to provide 4.5 turns lock to lock for a 10.3m turning circle.

The 504 was only 69mm longer than the 404 at 4,488mm overall, and 32mm wider at 1,689mm. But its 2,741mm wheelbase was 94mm longer than the 404's, with a 1,420mm front track, and a 1,359mm rear track. Its genuinely roomy body was styled by Pininfarina, which gave it a gently distinctive look.

The car benefited from exceptionally low road noise, an attribute that Peugeot was famous for back then. This was always mainly put down to the attachment of the front suspension. The track control arms pivoted from a relatively large front cross member made from cast iron, which also carried the rack and pinion steering box. The front trailing links of the suspension pivoted from a fabricated sheet steel cross member (which carried the anti-roll bar and also the radiator), acting as the second front subframe to the cast iron member's part as first subframe.

That unusual cast-iron member, a presumably somewhat heavy


elegant line,
balanced design
504
PEUGEOT

feature, was already familiar from the 404. Rear suspension pivoted from one of the two resilient mounted fabricated sheet steel box-section cross members. Separately these were like the front ones but together they formed a subframe for the final drive and back suspension. The rear one also carried the hypoid final drive (another minor difference from the 404, which had a worm and wheel drive).

Drive was provided by a four-cylinder pushrod OHV engine with the same 84mm bore as on the 404. However, the stroke increased from 73mm to 81mm to lift the swept volume from 1,618cc to 1,796cc, with an 8.35:1 compression ratio. To contribute to a lower bonnet line, and as on the 404, the engine was inclined at 45° on its mounts, with the exhaust side on the lower side.

Two variations of this power unit were made. The standard engine was fitted with a Solex 34 PBICA 5 carburetor; the more powerful one boasted Kugelfischer fuel injection. The carburetor engine produced 82bhp at 5,500rpm and maximum torque of 146Nm at 3,000rpm, and the injection unit produced 97bhp at 5,600rpm and 154Nm at the same 3,000rpm.

The four-speed all-synchromesh gearbox with its column gear change was fixed at the end of a propeller-shaft-containing tube running to the final drive unit. Rear driveshafts each had constant-speed universal joints at each end, using sliding pot couplings each with three rollers on needle-roller bearings. Rear wheel geometry provided a modicum of negative camber, ranging between 0°40min to 1°40min.

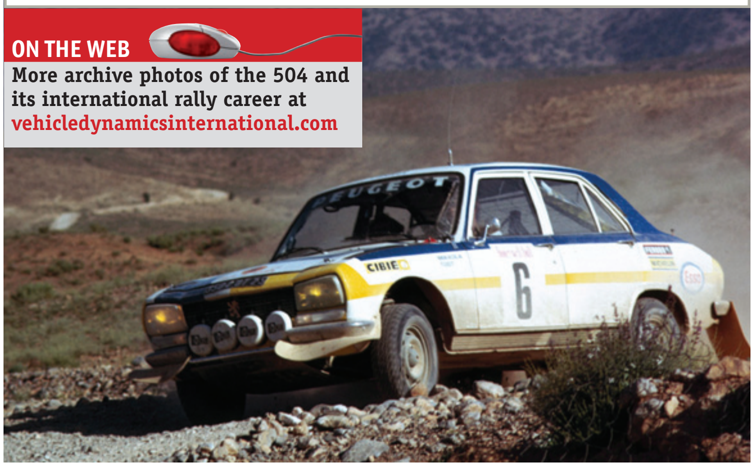
The 504 ran on pressed steel 14in wheels with 5in rims shod with 175-section low-profile tires: Kleber V10GT, Dunlop SP Sport or Michelin XAS. The hydraulic brakes were Bendix MasterVac vacuum servo-assisted with same-diameter (272mm) discs front and back. The usual difference between them due to

"In modified form, the car enjoyed sporting success. It was driven to victory by Ove Andersson on the East African Safari Rally"

Versatile variants

As a testament to its excellence, the 504 flourished for 15 years until 1983, when it was replaced by the 505, a slightly larger sedan. On the way there, the 504 range was expanded, first with the coupé – really a two-door variant of the sedan – followed by the cabriolet in 1969, then an estate model plus a 2.1-liter diesel in 1971.

The car, suitably modified of course, enjoyed several remarkable sporting successes. In 1975 it was driven to victory by Ove Andersson and Arne Hertz in the East African Safari Rally, and also in the Bandama Rally in the Ivory Coast by the same famous pair. Plus, in the Moroccan Rally the same year – the longest such event ever – Hannu Mikkola and Jean Todt won in a 504 Ti (below).



ON THE WEB

More archive photos of the 504 and its international rally career at vehicledynamicsinternational.com

ON THE ROAD

As the December 1968 *Autocar* Road Test of the fuel injection 504 says, 'Off the *autoroutes*, high averages can be maintained due to the car's outstanding ride and handling abilities. Not once in over 1,360 miles were the occupants unseated or seriously disturbed, and the stability on (typical French) steeply cambered roads with collapsed foundations merits very strong praise.' Earlier in the Test, the reviewer wrote that 'one might sum up the suspension's behavior by suggesting that any British visitor lucky enough to have his first experience of the notorious French secondary roads in this car (particularly those in the North) might well wonder what all the fuss was about."

the higher loading on the front was formed by fitting larger (by 16.8%) area pads on the front. To adjust fore and aft braking balance according to load, a pressure-regulating valve in the hydraulic circuit sensed load via a link to the rear anti-roll bar. At launch, the 504 weighed 1,200kg.

In those still early days of passive safety engineering, the 504 body was truly up to date, with the front and rear end of the deliberately stiff occupant-carrying zone forming progressively crash-deceleration absorbent spaces. The steering column was double-jointed, the steering wheel fitted with a comparatively large rectangular center pad. All inside parts were designed with good padding and the minimum of serious projection, and the doors used burst-resistant locks.

Inside the car, the cabin provided excellent space, with good rear knee room even behind tall occupants of the front seats. The seats in the front were fully reclinable, able to form a tolerably good approximation to a couple of rudimentary beds, and were built with height-adjustable head restraints.

PININFARINA-STYLED CONVERTIBLE AND COUPÉ WERE THE MOST STYLISH 504 VARIANTS (RIGHT). BIG-SELLING SEDAN (BELOW) WAS VOTED THE EUROPEAN CAR OF THE YEAR IN 1969

León kings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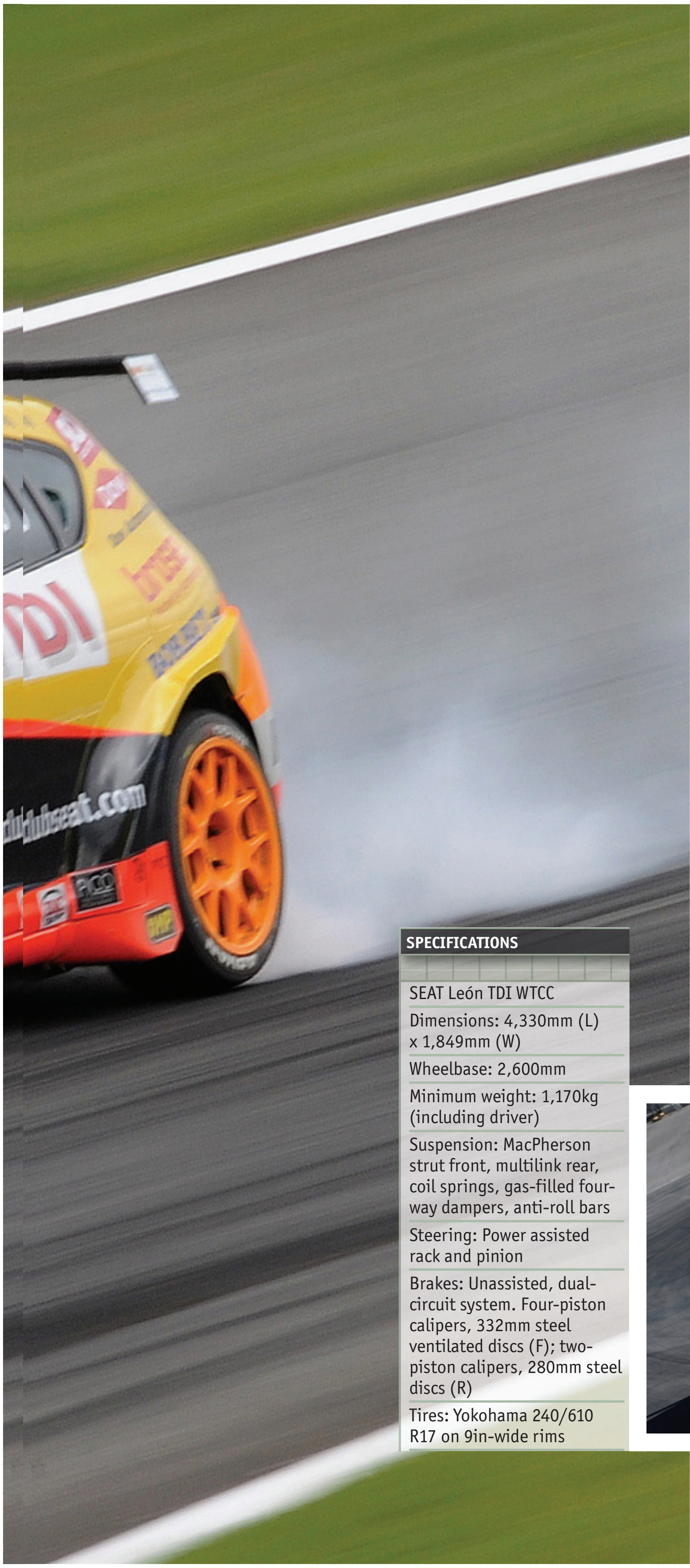
ENGINEERS FROM SEAT SPORT GIVE AN INSIGHT INTO THE WORLD TOURING CAR CHAMPIONSHIP-WINNING LEÓN TDI. BY **JONAS JARLMARK** AND **JORDI RIBA**



SPECIFICATIONS
SEAT León TDI WTCC
Dimensions: 4,330mm (L) x 1,849mm (W)
Wheelbase: 2,600mm
Minimum weight: 1,170kg (including driver)
Suspension: MacPherson strut front, multilink rear, coil springs, gas-filled four-way dampers, anti-roll bars
Steering: Power assisted rack and pinion
Brakes: Unassisted, dual-circuit system. Four-piston calipers, 332mm steel ventilated discs (F); two-piston calipers, 280mm steel discs (R)
Tires: Yokohama 240/610 R17 on 9in-wide rims

Last year's World Touring Car Championship (WTCC) marked the end of the former BMW and Andy Priaulx domination. Yvan Muller in a SEAT was crowned drivers' champion. Muller, together with Rickard Rydell, Jordi Gené, and Tiago Monteiro also secured the WTCC manufacturers' title for SEAT.

The machinery used – the controversial SEAT León TDI – sports a diesel engine, whereas the opposition runs petrol. The León race car is based on the FR road model and is modified according to the FIA regulations.

The León is essentially the same FWD chassis as in the VW Golf and Scirocco, Škoda Octavia, and Audi A3. The weight distribution is relatively front-heavy due to the heavy diesel power unit, and as a result, front axle performance is the limiting factor in terms of absolute grip.

The gearbox is an uprated Hewland S2000 unit specially designed for the high-input torque and low revolutions of the TDI engine. "Making the gearbox last was a challenge," admits Benoît Bagur, technical director at SEAT Sport.

The geometry of the suspension, which is precisely defined in the regulations, also posed problems. Not only does the race car have to retain the same type of suspension as the road car, but the pickup points cannot be moved more than 20mm from their original positions. This effectively limits the possibilities to enhance vehicle behavior using geometry changes. As a race engineer one often ends up at very unpleasant end positions on geometry.

On the front of the León TDI, castor and kingpin inclination can be altered via the strut top bracket, and is a relatively easy job. Camber and toe are set by shims in the wishbone and steering rod, with a maximum change of 2° of camber. On the rear, a similar shim system is applied but the possible camber range is greater, giving a variety of settings to suit most types of tracks and tires.

"Camber and toe are adjusted quite a lot, and the system on the León provides an easy and reliable way to do a quick and precise setup change," says Xavier Serra, chief race engineer.

The inner position of the suspension links can be vertically adjusted, front and rear, to change the roll center height and anti-dive. The change of position takes some time, so normally the roll centers are set at a specific height for each track and are then changed only between sessions.

Dampers and springs are free under the regulations and there are some solutions for the León that work well. Both ZF Sachs TRD

MAIN IMAGE: **FORMER FORMULA 1 DRIVER, TIAGO MONTEIRO CATCHES A REAR BRAKE DURING THE FIRST MEETING OF THE WTCC SEASON AT CURITIBA, BRAZIL.** ABOVE: **YVAN MULLER, WHO TOOK THE 2008 WTCC DRIVERS' TITLE IN A LEÓN WTCC, ON HIS WAY TO A RACE VICTORY IN PUEBLA, MEXICO, IN MARCH 2009**

TOP: **CO-AUTHOR JARLMARK (LEFT) TALKS SETUP WITH RICKARD RYDELL.** ABOVE: **THE SEAT SQUAD PICTURED IN FEBRUARY 2009 DURING A PRE-SEASON TEST AT THE CATALUNYA TRACK**

PETROL TO DIESEL

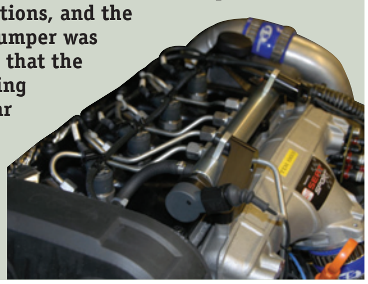
The petrol-powered León was known as one of the best chassis in the WTCC field, but the drag of the hatchback bodywork resulted in a lower top speed than cars with more streamlined bodywork. Clearly, some more top-end power was on the wishlist, and TDI technology was the answer.

The diesel engine with its special gearbox generated a heavier driveline than its petrol predecessor. The result was a shift in weight distribution – toward the front – with a predictable impact on handling.

After the first few tests, the drivers reported more engine power, but they also said the car was much less forgiving than the petrol-powered version and therefore more difficult to drive. Driving styles had to be altered to give an even higher level of maneuvering precision. Directional response was reduced due to the heavier front axle, and the extra load on the front tires led to an increased tendency to understeer. Over race distances it was prone to a massive drop in front-tire performance despite conservative setups.

SEAT Sport has since done extensive work to improve the handling of the diesel car. Moveable objects such as the fire extinguisher and ballast trays were redistributed, and a change in springs and dampers with corresponding shake rig sessions was made at an early stage. The front axle geometry required a gentler setup to extend tire life, and a thorough re-scan on the rear axle geometry was done to improve the turn-in attitude and handling. All these changes had a clear purpose: to transfer tire loads in a smoother and gentler way from front to rear and back in braking and turn-in, as the first cornering phase was key to curing the inherent understeer.

In the final development stages, the flat floor used on the petrol car was removed to comply with FIA regulations, and the aerodynamic efficiency with the new bumper was checked in a wind tunnel. It was found that the center of pressure had changed, requiring slightly different setups to make the car neutral again in fast corners.



Evolution and setup work continued right through 2008, enabling the car to survive high track temperatures and abrasive surfaces, despite the ballast added throughout the season.

Rule changes

Being successful in racing usually results in a change of regulations, especially if a technical difference can be singled out by the rule-makers. In the case of the SEAT León, the 2008 season started with a 35mm air inlet restrictor as the only diesel-specific point with which to comply. During the season, regulation changes involved engine speed (max 4,100rpm), turbo pressure, and fuel pressure limits as well as an air:fuel ratio limit. By the end of the season the diesel engine was not allowed to produce any visible smoke at all. Also during the 2008 campaign, the regulation base weights for the petrol competitors were reduced to make up for the ongoing development of the diesel SEAT. For the 2009 season, all limits remain except for the restrictor, which has been reduced to 34mm – an effective 6% decrease of available airflow, corresponding to a loss of 15-20bhp.

through-rod dampers and Öhlins TTX are used by different teams and drivers depending on what handling issues need to be addressed.

There is a great range of anti-roll bars available for the León, with three different tubes at the front and two at the rear that use rotating blades to provide the adjustment range. "The blade is a quick and easy adjustment to do, but changing the tube takes some time. It's not a job for the pit lane," says Jordi Marti, lead mechanic on Rydell's car.

Probably the greatest drawback of the front-heavy León diesel running the Yokohama control slick is turn-in oversteer gradually changing to exit understeer due to heat build-up of the front tires. The setup becomes a compromise to achieve a stable enough turn-in without spoiling the rest of the vehicle dynamics.

Engineering a touring car is very different to working on a formula car or prototype. The roll and diagonal motions are the behaviors to keep under strict control, rather than heave and pitch as on the lighter and lower cars running at large aerodynamic loads. Regulations permit a small wing on the trunk lid; the effect is not dominant but it can act as a tuning tool to change behavior slightly when accelerating from low to high speed.

One thing that makes a difference on the León racer is the setting of the limited slip differential (LSD). "The LSD has such a strong influence that it is easy to camouflage the effects of other changes just by tuning it," notes Rydell.

The data acquisition on the factory cars is done by a Pi Research Omega dash and Sigma Elite logger. A great range of sensors from a number of suppliers covers all aspects of the car and supplies data for advanced vehicle and driver analysis. The Pi Toolbox provides the analysis environment with a number of possibilities to personalize the analysis methods. When the Pi Toolbox itself is not enough, SEAT Sport turns to the Pi-DO Wrapper, which enables the team's engineers to write their own mathematical functions in external code, such as MatLab.

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European Patent #0891494 US Patent #5,857,800

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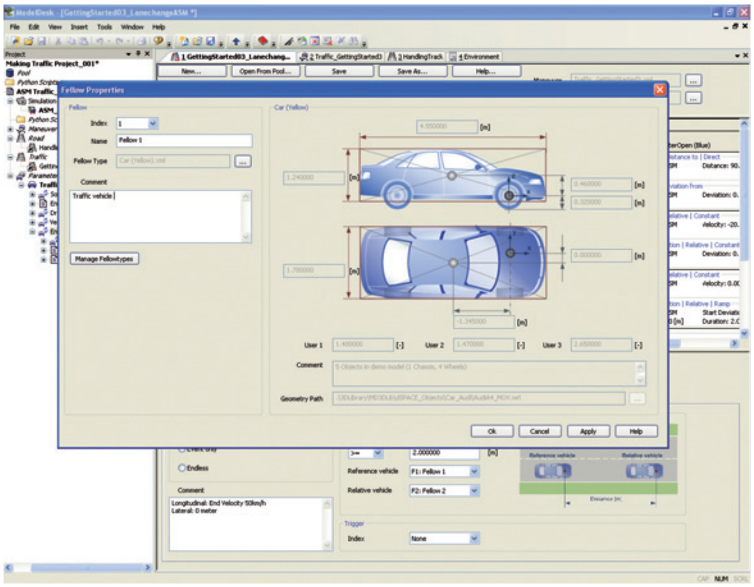
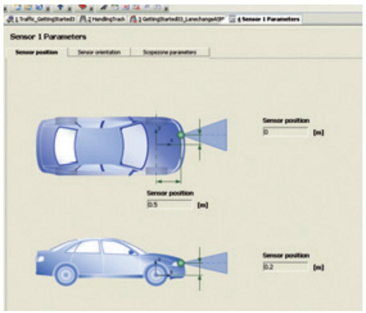
Traffic simulation

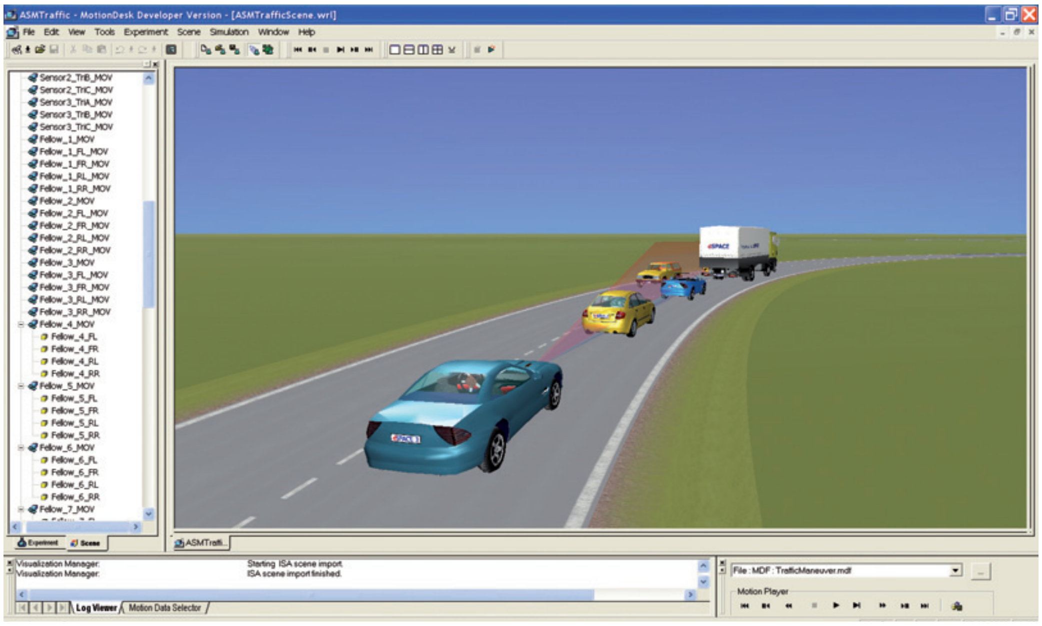
RIGHT: **DEFINING THE PROPERTIES OF A FELLOW SIMULATED VEHICLE**

BELOW RIGHT: **SENSOR POSITION AND ORIENTATION FOR ACC SIMULATION ARE ALSO DEFINED**

BOTTOM OF PAGE: **THE END RESULT – VISUALIZATION OF SIMULATED ROAD TRAFFIC IN MOTIONDESK**







ASM Traffic is a simulation system consisting of a Simulink model for road traffic and a brand new comfortable graphical user interface for the creation of traffic. It is a member of dSPACE's Automotive Simulation Models (ASM).

ASM Traffic supports users in developing and testing driver assistance systems that react to other vehicles, such as adaptive cruise control (ACC) and precrash systems. The model simulates one test vehicle and up to 15 independent traffic vehicles. The test vehicle can be equipped with multiple sensors for object detection.

ASM Traffic is used either on a dSPACE Simulator for hardware-in-the-loop (HIL) testing of electronic control units (ECUs), or for early validation by offline simulation during the design phase of controller algorithms.

ASM Traffic is so flexible that any kind of traffic scenario can be created to ensure thorough testing of controllers such as ACC systems. To test precrash functionalities, users can define traffic scenarios that could result in an accident in real life, and observe system behavior under challenging conditions.

ASM Traffic consists of the traffic scheduler, the sensor model, and the traffic editor for scenario definition.

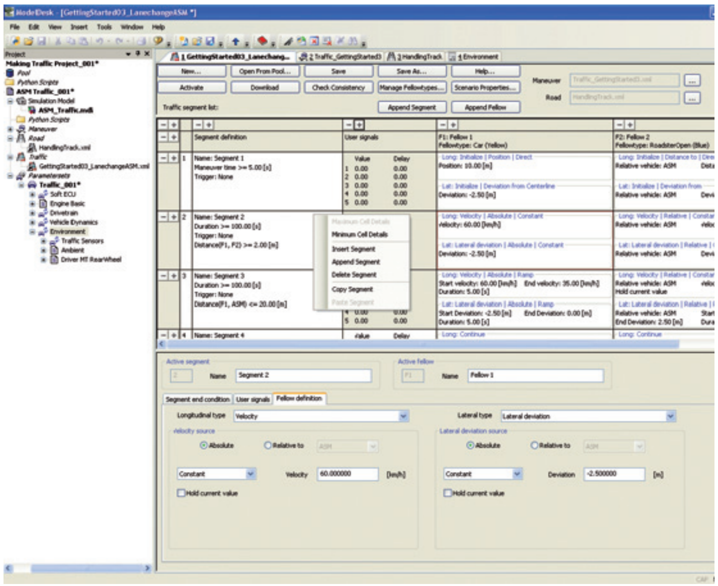
The traffic scheduler is a model that calculates the positions of the traffic vehicles according to a specific traffic scenario. It supports specific scenarios such as oncoming traffic, stop and go, and pedestrians.

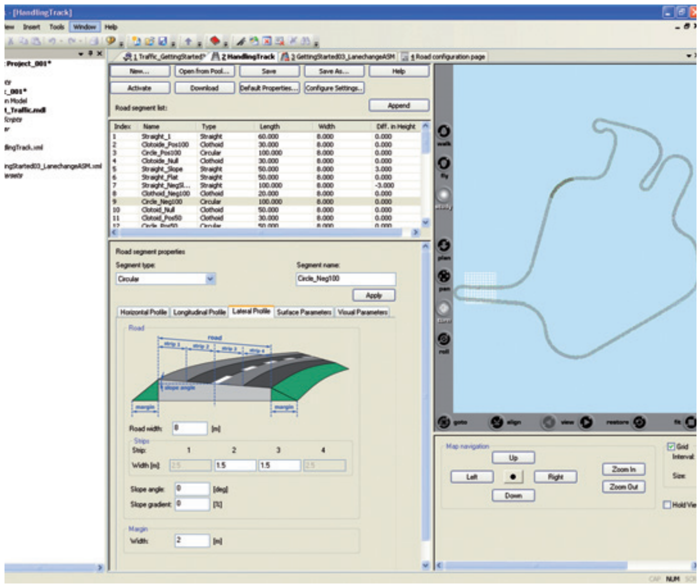
The sensor model checks whether traffic vehicles are in range of the sensor; it calculates the distance, relative velocity, relative acceleration, and angle between the test vehicle and each detected object.

As a part of ModelDesk, the traffic editor is the user interface for very flexible and easy traffic scenario definition.

Beside traffic definition, ModelDesk provides parameterization support and parameter-set management for an entire virtual vehicle and the vehicle dynamics. Its Road Generator and Maneuver Editor let users define individual roads and driving maneuvers. With ModelDesk, one can handle various parameter sets for several models and download them to offline (Simulink) and online (HIL) simulations.

The definition of roads is usually the starting point for a new traffic scenario. With the road generator, users graphically define road segments and plan entire roads. Road segments are assembled and





rearranged in a segment list. Each segment can have individual lateral and longitudinal profiles, and there are various options for configuring the road surfaces. Parameters are entered in graphical dialogs that display the road segment being configured. The results of the settings are immediately visible in a 3D preview window.

The next step for traffic scenario creation is to define how and where the test vehicle moves. The maneuver editor supports maneuvers that consist of several segments, each with its own individual properties such as speed changes, position on the road, and external trigger signals. These segments are assembled in the maneuver list. A maneuver is created in a similar manner as a road, with a graphical display of the road to which the maneuver relates. Road and maneuver files can be linked.

After the movement of the test vehicle is set, the surrounding traffic can be defined. Traffic scenarios are based on segments, which define the lateral and longitudinal movements of a fellow vehicle for a certain time or distance range. A list of segments defines the movements of a fellow vehicle for the whole scenario. Based on the definitions, the trajectories of the fellow vehicles are calculated from distances or speeds, defined either as absolute values or in relation to other vehicles or the road.

Basic movement profiles such as constants and ramps are available for segment definition, and the transition from one movement segment to the next can be defined freely. The transition criteria can be events such as approaching a certain speed limit, reaching a predefined distance to other vehicles, or any external trigger signal such as CAN-signals or user inputs.

It's obvious that these enormous simulation flexibilities require a user interface for handling complex projects. A combination of graphical and numeric displays lays the foundation for this – all integrated in ModelDesk. The traffic editor provides copy and paste functionality for a vehicle's movement and also for segments with multiple vehicles. Thus, the trajectories for new vehicles are easy to implement. The vehicle type can be selected from a drop-down menu. It is even possible to exchange vehicles without generating code again.

To simulate complete ACC scenarios, the test vehicle has to be equipped with object-detection sensors. The sensor model in ASM Traffic simulates a 3D detection range consisting of layered triangles, and the fellow vehicles are modeled as cuboids. The sensor model uses a purely geometric approach, so it can also be used for sensor types other than just radar sensors, such as lidar and camera. The sensor model calculates the nearest point of each of the fellow vehicles detected in the sensor's range and returns the distance, the relative speed, the relative acceleration, and the relative horizontal angle for each one. Sensor position, orientation and the parameters of the scopezone are defined on graphical parameterization pages. Multiple sensors per vehicle are supported, allowing applications such as parking systems.

Visualization of the simulated traffic scenarios is performed by MotionDesk, the 3D animation software from dSPACE. For getting started, ASM Traffic provides seven traffic scenario examples, including special ones such as for oncoming traffic and pedestrians. Once equipped, the new model can be put into operation quickly.

MORE INFORMATION

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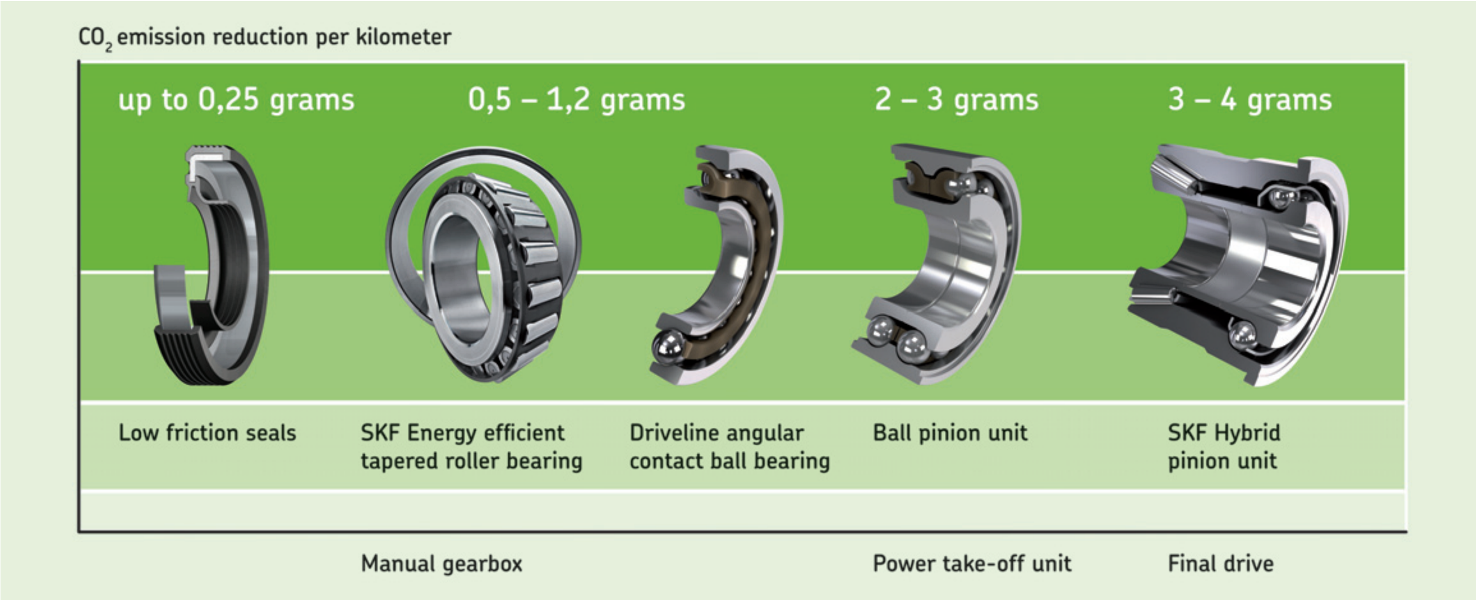
Quote ref VDI 001

ABOVE LEFT: **THE TRAFFIC EDITOR HANDLES SCENARIOS WITH UP TO 15 FELLOW VEHICLES**

ABOVE: **ROADS WITH INDIVIDUAL PROFILES AND SURFACE CONDITIONS CAN BE CREATED**

Friction reduction



ABOVE: **SKF PROVIDES A WIDE RANGE OF ENERGY-EFFICIENT SOLUTIONS TO OPTIMIZE EVERY AREA OF THE POWERTRAIN**

Reduced friction can help to increase the efficiency of the vehicle drivetrain and therefore reduce CO_2 emissions. Roller bearings may well play a decisive role in this effort.

Alternative drives are the focus for automotive development. But the potential of the internal combustion engine has not been fully explored yet. So what is SKF's contribution to increasing the efficiency of Otto and diesel engines?

Based on its comprehensive knowledge of motion engineering, SKF can make a difference. It has, for example, developed a product enabling it to achieve belt-drive maintenance intervals of up to 200,000km and to optimize the fuel-injection and combustion timing. In addition, SKF's focus is on units comprising pulley, bushing, and shaft, which enable injection pressures of up to 3,500 bar in a diesel engine while ensuring minimum wear and low friction. Roller bearings are today used instead of dry-sliding bearings to support balance shafts in order to improve fuel economy and increase energy efficiency.

So which measures are most efficient in reducing friction?

In the drivetrain there are a great number of bearing positions fitted with tapered roller bearings which, due to their design, do not help to reduce friction. Therefore SKF optimizes the internal geometry of the bearings, replacing tapered roller bearings with angular-contact ball bearings wherever the application permits. Knowing which loads act on the different bearings, it is necessary to decide in each individual case how the internal bearing geometry can be improved. Today SKF has software programs that determine not only bearing life and loads, but also the bearing frictional moment as a function of the bearing internal geometry. Previously, such determination could only be made through physical tests.

Is it possible to quantify by what percentage friction can be reduced?

Several studies have shown that using SKF solutions can enable a friction reduction of 20%, and in some cases, even more. As the number of bearing positions indicates the improvement potential available, quantification of such a value depends on the vehicle layout. The savings potential of a front-driven lightweight vehicle is not as large as that of an all-wheel-drive car with a transfer gear, rear-axle reducer, and manual transmission. In terms of emission reductions for the all-wheel-drive car, an average CO_2 reduction of 6-8g/km can be expected.

Motorsport relies on metal-ceramic bearings; even metal-plastic bearings are considered a possibility. Will the bearing industry be moving in this direction?

There are developments to combine ceramic rolling bearings with steel inner and outer rings to be used as gearbox bearings. Either all rolling elements can be replaced by ceramic ones, or just one in order to counteract the aging process caused by contamination in the bearing brought from the outside. This design is called a self-healing bearing, a ball bearing having, for example, seven steel balls and one ceramic ball. The effect? Usually a gearbox bearing suffers from wear due to dirt particles, but the ceramic ball's hardness gives it a planishing effect. This increases bearing-service life. In F1 cars, ceramic rolling elements are used for reasons of weight, but series manufacture in large quantities is not economically feasible yet.

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Quote ref VDI 002

Race-car simulation

MSC.Software, a leading global provider of simulation solutions has announced that Triple Eight Race Engineering, the motorsport company responsible for the design, build and racing of the British Touring Car Championship (BTCC) cars of the Vauxhall VX Racing team has extended its relationship to include the company's multidiscipline (MD) solutions.

With the addition of MSC.Software's MD solutions, Triple Eight Race Engineering aims to progressively increase the scale, complexity, and ultimately the reliability of its race-car simulations. Since becoming MSC. Software partners in 2004, Triple Eight and VX Racing have won nine BTCC championships, including the triple crown in the 2008 season.

ABOVE: **TRIPLE EIGHT RACE ENGINEERING HAS ADOPTED MD SOLUTIONS FROM MSC.SOFTWARE**

Triple Eight will migrate its existing simulation environment to a new standard platform based on the multidiscipline (MD) solutions including MD Nastran. Using the new MD solutions, the design team at Triple Eight focus on overall structural optimization of the race-car chassis and detailed simulation, both at component- and system-level, of critical performance items such as the suspension assemblies.

In addition to a more accurate representation of complex non-linear race applications, the new MD capabilities will provide substantial productivity gains in the areas such as multi-body free and glued contact, and topology optimization.

MD Nastran is the core technology behind MSC.Software's SimEnterprise portfolio. By combining all of the most common analysis types into a single integrated solution, MD Nastran enables a wide range of multidiscipline applications to be addressed with greater accuracy and speed than was traditionally possible. The coupled nature of the simulation allows significant improvements both in the physical representation of the simulation model, and in the computational efficiency of the solution. It also eliminates the inefficiencies and potential for error in the re-modeling and data translation associated with a traditional chained-analysis approach of multiple-point technologies

"We are enthusiastic about adding MSC.Software's MD solutions to our existing simulation capability," says Kevin Berry, technical director at Triple Eight Race Engineering. "Our designers and engineers heavily rely on having not only the best software technology, but also support at hand, whenever it is required to avoid any downtime. In these ways, MSC.Software has played a key part in helping us to achieve success and we look forward to having many more championships to celebrate."

"Through its collaboration with customers like Triple Eight Race Engineering, MSC.Software has developed a special understanding of the unique demands of the motorsport industry", adds Amir Mobayen, executive vice president for worldwide sales and services, MSC.Software.

"The migration to multidiscipline simulation at Triple Eight Race Engineering is another example of one of the major MD-standardization projects around the globe, as customers seek to maintain competitive advantage and maximize their return on investment by using the latest simulation technology."

TRACK DOWN MORE INFO

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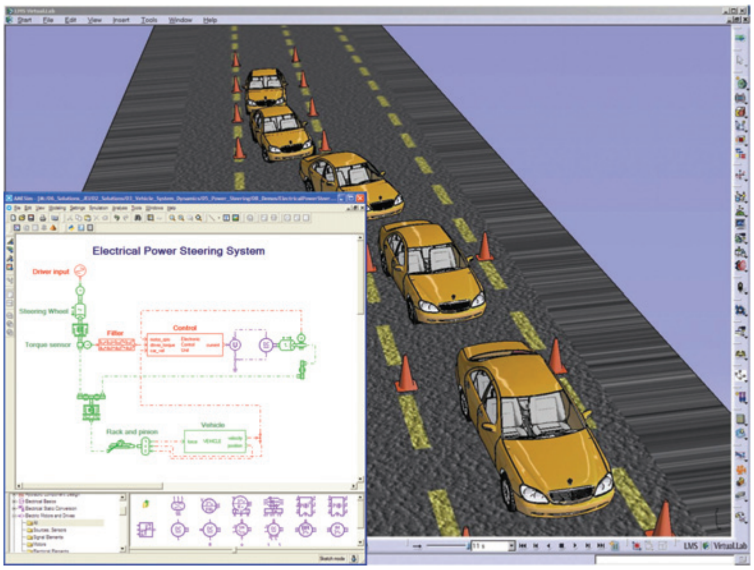
Quote ref VDI 003

1D and 3D simulation

RIGHT: **EVALUATION OF STEERING SYSTEM PERFORMANCES ON THE ENTIRE VIRTUAL VEHICLE MODEL BY CO-SIMULATION BETWEEN LMS'S IMAGINE.LAB AMESIM AND VIRTUAL.LAB MOTION TOOLS**



Vehicle dynamics engineers are challenged by a number of questions. For example, how does one guarantee that the designed vehicle handles like its given target vehicle without compromising its ride comfort or noise performance? And how does one standardize, on a corporate level, the ride and handling simulation process, capturing invaluable engineering insight and experience in a knowledge-based environment?

A dedicated analysis solution, including 1D and 3D simulation methodology, provides invaluable help in the design process for chassis systems and the full vehicle.

LMS Virtual.Lab Vehicle Motion simulates all types of vehicle ride and handling behavior from passenger cars and motorsport vehicles to multi-axle vehicles such as trucks and buses. Front- and rear-axle suspension models created with the LMS Virtual.Lab Suspension Interface can easily be integrated in a modular fashion into a full-vehicle model. The time-domain analysis covers from the conceptual rigid-body model evaluation to high-fidelity model performance with flexible body details and various kinds of non-linear effects.

Vehicle simulations include multiple runs with standardized events. The available library of predefined vehicle events, including ISO maneuvers, can be extended by any user-defined event. The car can be driven through a kinematic driver or through a path following the control algorithm implemented in LMS Virtual.Lab Motion or the IPG Driver model, which includes complex driver-vehicle interaction such as human reactions.

The ability to automate any repeated process through VBA journaling and scripting saves time by eliminating highly repetitive tasks, and puts the process emphasis on the performance optimization of the design.

Accurate tire and road modeling is vital if motion simulations are to be used as input for downstream durability and comfort analysis with LMS Virtual.Lab Durability and LMS Virtual.Lab Noise and Vibration. LMS Virtual.Lab Motion offers a set of tire models dedicated to specific applications – from basic ride and handling analysis at low frequencies up to more complex comfort and durability analysis at higher frequencies with TNO, FTire, and LMS-LBF CDT tire formats supported.

LMS Imagine.Lab Vehicle System Dynamics offers dedicated capabilities to design individual chassis system components (brakes, suspension, steering, anti-roll system, and the vehicle itself) and integrate them in a single system model to simulate and validate global chassis-control strategies.

With Imagine.Lab Braking System, Imagine.Lab Power Steering and Imagine.Lab Suspension and Anti-Roll, LMS provides reliable and accurate models to design robust chassis systems and components (such as booster, valves, and active dampers) early in the process, as well as ways to validate and test control strategies, using model-in-the-loop, software-in-the-loop, and hardware-in-the-loop. It further gives an understanding of issues specific to each subsystem, such as the noise and vibration behavior of the braking system and the shimmy phenomenon of the power steering, and it can also improve damper design versus cavitation.

In addition, LMS Imagine.Lab Vehicle Dynamics offers a comprehensive vehicle dynamics library for real-time simulation, and real-time hardware, including parametric functions to modify the shape of kinematics tables to optimize the vehicle behavior.

Efficiency in simulation can be achieved from the proper application of 1D physics-based and 3D-geometry simulation. The combination of LMS Virtual.Lab and Imagine.Lab AMESim enables an efficient scalable simulation process. In Imagine.Lab AMESim, models can be built for chassis-concept analysis, based on an elasto-kinematic representation of suspension components. As design details become available for the actual suspension, and the body concept is available, one can further transit to a 3D model in Virtual.Lab, expanding the realism of simulation to ride comfort. In addition, direct co-simulation allows complex chassis interactions to be tackled, such as between mechanical and hydraulic systems, such as when analyzing the shimmy phenomenon.

MORE DETAILS AVAILABLE
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Quote ref VDI 004

Vehicle separation video

Anyone involved with vehicle-separation testing may well have experienced problems when trying to interpret the large amounts of data generated. It's all very well having a mass of information on various distances, angles, and speeds, but interpreting this information usefully is often difficult. As development of advanced driver assistance systems (ADAS) becomes more commonplace, the methods used to develop vehicle-separation systems become more advanced, leading to a need for methods that can manipulate data intuitively and in a way that it can be easily used.

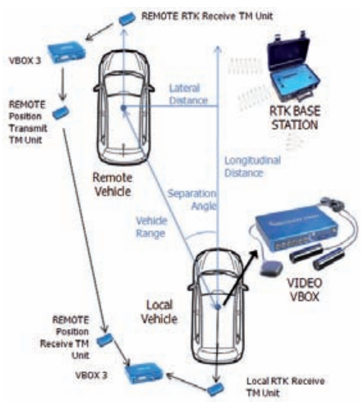
In response, Racelogic has developed simple-to-use, dedicated vehicle-separation functionality for its industry-proven VBOX 3, which affords ADAS developers the capability to verify the accuracy of their systems effectively. Real-time vehicle-separation data can be viewed in the local vehicle while being logged for analysis, and can also be transmitted via CAN for use by third-party systems.

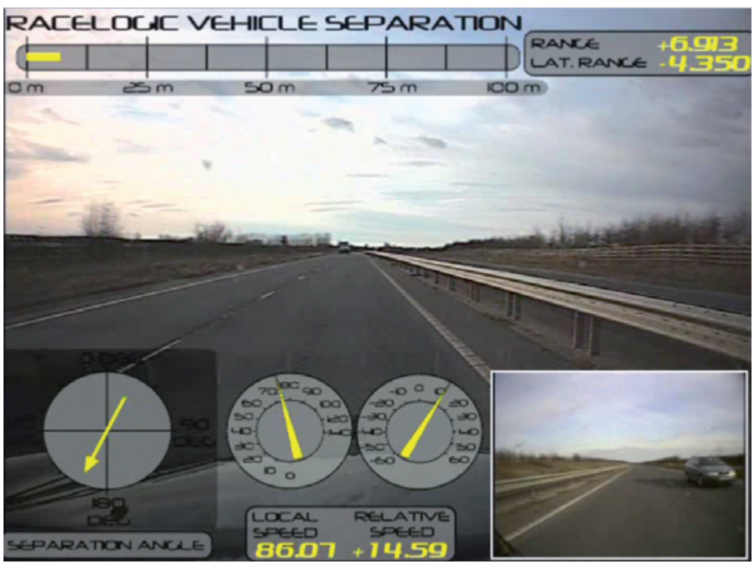
This feature means the information can be seen in a more meaningful way, and by connecting a Video VBOX to the system it is even possible to observe vehicle and driver behavior integrated with the data in a real environment. Using the CAN output, the vehicle-separation data can be graphically overlaid over video, in real time. The driver, vehicles, and external environment can be monitored, alongside the GPS information that is invaluable in test analysis.

Racelogic is often asked how the GPS data can be accurate enough to reliably report the (usually small) distance between two cars. The answer is, by using local position corrections transmitted over radio from a locally placed BaseStation, VBOX 3 modules are accurate to just ±2cm. This is possible because in addition to receiving frequencies from US GPS, the Racelogic system picks up Russian GLONASS satellites, which are numerous and very reliable. It is the amalgamation of these two groups of satellites that helps to increase positional accuracy.

With all the data stored on a CompactFlash card, it can then be analyzed using the included software, or alternatively with a laptop in the vehicle. The software calculates vehicle separation data by taking two serial streams, one from a VBOX in the local vehicle, and the other from a VBOX connected via telemetry in the remote vehicle. The channels, such as range, separation angle, and relative speed, can then be displayed in live windows.

The beauty of using VIDEO VBOX in vehicle-separation testing, and indeed any vehicle testing, is in its ability to integrate seamlessly with this CAN data. Using a .dbc file enables the selected channels to be displayed graphically in real time, overlaid on the video. This intuitive way of viewing complex data means the relationship between different variables can be recognized immediately, resulting in more effective testing. Racelogic can supply the graphic overlay as seen in the screenshots, although every scene is fully customizable using the included software, so any desired parameter can be included.





ABOVE AND BOTTOM OF PAGE: **OVERTAKING WITH RACELOGIC'S VEHICLE SEPARATION SYSTEM AND VIDEO VBOX.** LEFT: **DIAGRAM TO ILLUSTRATE THE EQUIPMENT USED AND VEHICLE POSITIONING**

FURTHER INFO

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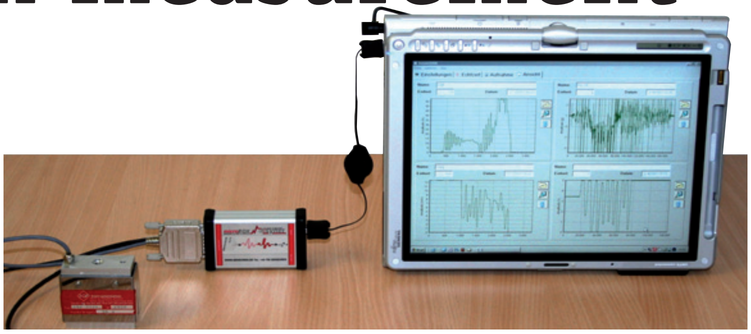
Quote ref VDI 005

Vibration measurement

TOP RIGHT: **DISYNET'S MINIATURE FOUR-CHANNEL DATA ACQUISITION TOOL.** BELOW RIGHT: **CI COCO 80/90**



After entering a very successful partnership with Dytran (one of the leading manufacturers of piezoelectric accelerometers and impulse hammers), disynet, a German company specializing in miniature sensors and instrumentation, has now signed up with Crystal Instruments (CI) and IOtech to supplement its portfolio with portable high-end vibration-analysis devices.

This new team supplies turnkey vibration solutions covering the entire spectrum of IEPE and charge-mode sensors, from the smallest and lightest in the world to those that can be used in the highest and lowest temperatures. There are also standalone hand-held devices and front-ends with dynamic ranges of up to 130dB. These cost-effective but high-quality solutions are of particular interest to the automotive industry, in the wake of the current economic crisis.

With almost 30 years' experience in manufacturing world-class DC- and piezoelectric accelerometers, force and pressure sensors, and a high degree of popularity in the USA, Dytran Inc has now established its high profile in the European market as well.

Its in-house machining capability guarantees a high degree of flexibility and allows the manufacturing of specials in low quantities. Very competitive pricing and superior quality, combined with very quick deliveries and excellent support, have already led to leading manufacturers and suppliers of aerospace, automotive, and vibration-monitoring equipment, as well as research and development institutions, switching to Dytran.

The product line includes miniature mono- and tri-axial accelerometers with IEPE amplifiers, high-temperature sensors, impulse hammers, and high-quality cable assemblies and support electronics. Dytran sensors serve in modal analysis, structural dynamics, NVH, ESS, crash applications, aerospace flight and ground testing, and many other applications.

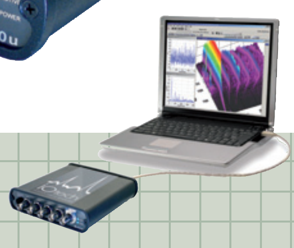
Crystal Instruments (CI) is focused on data acquisition and dynamic signal analysis. Recently, CI introduced CoCo-80/90, the first handheld data recorder, vibration data collector and real-time dynamic signal analyzer that matches the performance of high-end, lab-quality instrumentation.

With its low-power and rugged design, the CoCo-80/90 is ideal for field use. It is equipped with four to 16 input channels and can accurately measure and record signals simultaneously up to 102.4kHz with a dynamic range of 130dB. Software includes long-time recording, real-time spectral analysis, transient capture, octave analysis, order tracking, swept sine, digital filters, route-based data collection, and many more.

Since 1984 IOtech's PC-based data acquisition has been used in a variety of test applications, ranging from research and product development, to production monitoring and quality control, and serves a diverse set of industries including aerospace, automotive, biomedical, chemical, communications, and energy. IOtech is a leader in out-of-the-box data acquisition, providing complete hardware and software vibration-based measurement solutions.

The 600 Series of dynamic signal analyzers sets a new standard for real-time vibration and acoustic monitoring and analysis, especially with respect to ease of use. A DASYLab driver and application-specific eZ-Series software packages are available for rotating-machinery monitoring, machine balancing, and non-destructive testing.

RIGHT: **THE IOTECH 600 SERIES OF DYNAMIC SIGNAL ANALYZERS IS SUITABLE FOR REAL-TIME VIBRATION AND ACOUSTIC MONITORING, AND ANALYSIS**



MORE INFORMATION
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Quote ref VDI 006

Simulation developments

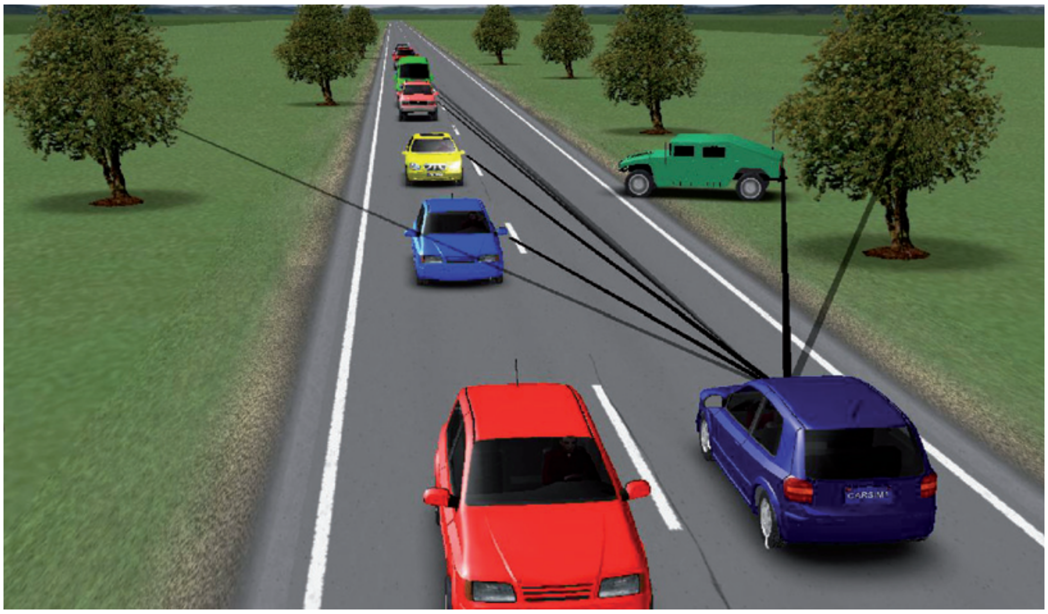

FIGURE 1 (ABOVE): **CARSIM VEHICLE WITH SENSORS OPERATING IN A COMPLEX TRAFFIC ENVIRONMENT**

Mechanical Simulation has just released the most recent version of its software for simulating dynamics of cars, light trucks, and trailers. CarSim 8 contains innovations tailored to meet the needs of engineers developing vehicles, chassis systems, electronic controls, and advanced driver assistance systems (ADAS).

Many ADAS systems rely upon radar, lidar or visual sensors detecting target objects, evaluating potential traffic conflict situations, and then warning the driver or intervening in control. CarSim 8 helps developers by simulating nine sensors in traffic environments with 99 targets on 3D roads. Object motions are completely programmable, ranging from simple placement and speed, to complicated motions governed by differential equations.

The example animation shows one sensor operating in a complex traffic environment. The sensor detects multiple objects denoted by the ray extending from the forward-facing sensor to each object. The darkness of each ray is indicative of signal strength. Graphical analysis of each sensor is automatically plotted for engineering evaluation.

Automotive product development often involves collaboration between OEMs and Tier 1 suppliers. To reduce time and cost, CarSim now enables exchange of encrypted vehicle or component data sets that can easily be emailed to co-developers while keeping confidential details hidden. The partners import these encrypted 'parsfiles' to their copy of CarSim and can run any test with a fully functional simulation model, but are unable to view encrypted data.

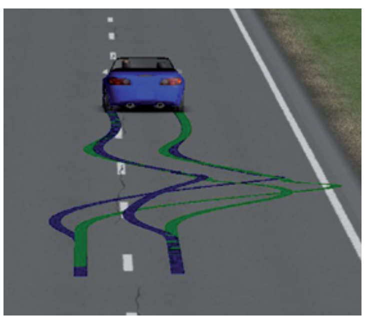

FIGURE 2 (BELOW LEFT): **EXAMPLE OF A COMPLEX BOOTLEG TURN MANEUVER SHOWING TIRE TRACKS**

VS Commands is an internal scripting language that enables the user to modify the model at runtime. These, combined with the Events feature, enable users to build complex testing maneuvers such as the NHTSA Fishhook Rollover Test or the FMVSS 126 ESC performance test. Procedures for these are included in the example data sets that come with CarSim.

The power of these tools for constructing complex driving maneuvers is illustrated in a bootleg turn. In this maneuver, the vehicle accelerates in reverse to about 45km/h, then the steering is turned to begin a yaw rotation. When sufficient yaw rate has built up, the brakes are locked so the vehicle can spin around to face the opposite direction and drive away. In the picture shown, the vehicle started in the foreground facing the camera. The tire tracks generated in CarSim show the path of travel as it accelerates backward, spins around and accelerates away from the camera. Animations of these simulations are available on the CarSim website (see below right).

CarSim has always accommodated multiple tire models because vehicle dynamics experts favor different models for particular applications. CarSim has its own internal model based on classical combined slip theory, and options for Pacejka 5.2 or MF-Tyre. FTire and TNO Swift tire model options provide a higher frequency response when needed. CarSim also includes a tire-test simulator to generate curves of force and moment behavior in familiar forms as means to check proper function of the model.

A common problem for many vehicle dynamics simulations is finding the extensive set of data values needed to describe a car. Mechanical Simulation's staff has dealt with this problem for 30 years, and has extensive experience and access to vehicle information needed to characterize a vehicle. CarSim includes a family of vehicles covering A- to F-class cars, sports cars, SUVs, vans, pickup trucks, and trailers. The data sets represent typical vehicles in each class. Most users start with the CarSim example closest to the vehicle of interest, and refine the data as more information becomes available.

NEED MORE?

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Quote ref VDI 007

Lifelong performance

FAR RIGHT: **CORRELATION OF PERFORMANCE BETWEEN UNUSED PART AND A USED PART TAKEN FROM A PRODUCTION ROVER 75**

Suspension components are designed to deliver reliable performance under tough conditions. A manufacturer's quality testing is used to predict lifetime performance, but how accurate is this when compared with the actual wear and tear that components experience in use?

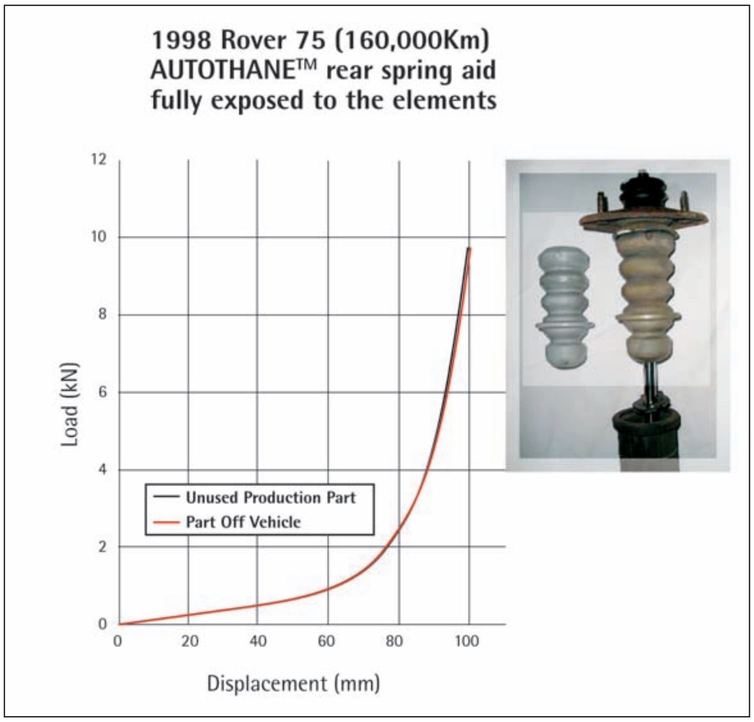
To answer this question, Dow Hyperlast, part of Dow Polyurethane (PU) Systems (a business group of The Dow Chemical Company), procured a selection of front and rear struts from used Rover cars fitted with spring aids manufactured from its Autothane microcellular polyurethane elastomers. Dow Hyperlast analyzed the struts' performance and determined what wear and deterioration, if any, had occurred.

Autothane is a high-performance microcellular polyurethane elastomer system based on hybrid polyols and methylene diphenyl diisocyanate (MDI) technology, specifically developed for impact, shock, and vibration management in automotive applications. Rover was the first motor manufacturer to install Autothane spring aids. Before Rover closed, Dow Hyperlast had achieved 100% supply status, through its proven quality and track record with the company.

Upon examination, the Autothane spring aids had experienced little or no damage and still met Rover specifications for load-deflection characteristics. In fact, the parts remained fit for purpose and as functional as they were on the day they were fitted.

The component pictured was exposed to the elements and would have taken up most of the space along the damper rod, being active for most of its life, while other parts were either inside a cup or covered entirely by the dust shield. It was taken from a 10-year-old Rover 75 rear-suspension strut where 80% of the part was uncovered, and only the top section was protected from the elements by the dust shield.

While opening the strut to remove this component, inspection revealed that rust had covered the spring-aid seat and that the plastic striker, which formed the top of the damper unit and impacted with the part, was completely broken.



Dirt aside, there was no external degradation of the skin or internal foam section, which would be expected if any microbial of hydrolytic decay had occurred, and no sign of wear from 10 years of use in absorbing shock. As indicated in the graph, retesting showed no change in deflection characteristics compared with a new, off-the-shelf component.

The longevity of these components in such an aggressive working environment is a direct consequence of the closed-cell structure of the microcellular polyurethane system developed from the Autothane technology.

Autothane is an ideal material for suspension component manufacture because, when compressed, the component suppresses and absorbs shock and vibration to improve the vehicle's ride profile. Its resilience enables it to maintain this high performance for more than a million compression cycles.

As well as excellent hydrolytic stability and dampening properties, Autothane provides exceptional resistance to chemicals, grease, ozone and microbial attacks, as well as to water, salt, oils and fuels, and continues to perform in extremes of temperature or climate.

Autothane is well suited for high-quality, high-volume automated molding production, and offers cost effectiveness through easy processing and a short in-mold time. It meets current automotive specifications for high-stress components and has a proven 12-year performance history.

As well as offering high-performance specifications backed up by laboratory and field testing, Dow Hyperlast can now confirm, from its analysis of used-production parts, that Autothane components really can maintain lifelong performance in motor vehicles.

FURTHER DETAILS

Contact Dow Hyperlast
Tel: +44 1663 746518;
Email: help@dowhyperlast.com;
Web: www.dowhyperlast.com
Quote ref VDI 008

Indirect TPMS solution

THE 2009MY AUDI A6/S6 IS THE FIRST MODEL ON THE US MARKET WHICH HAS AN INDIRECT TPMS CONFORMING TO FMVSS 138

The 2009MY Audi A6/S6 features TPI, an advanced indirect TPMS from Sweden-based NIRA Dynamics AB. It is the first vehicle to be sold in the USA with an indirect TPMS that meets the FMVSS 138 requirements.

NIRA Dynamics is currently working with Audi to develop TPI solutions for all Audi models for use worldwide. The company also has comprehensive development programs with VW and other manufacturers targeting both the European and North American markets. This marks a breakthrough for this technology and proves that TPI is ready for the mass market.

Being an indirect TPMS, TPI has an optimum simple but robust system design. Its software-based function uses only existing sensors in the vehicle. This ensures minimum complexity and maximum robustness and cost-effectiveness. TPI also offers good value for end users in that it can detect pressure drops in one, two, three, or four tires, while being resistant to nuisance warnings.

A further positive feature of TPI is that the function is integrated into the vehicle and does not use any tire- or rim-mounted components that can be damaged when the tires are replaced or are changed between summer and winter in certain climate zones.

TPI is delivered as a standardized software component that can be integrated into different ECUs in the vehicle. So far TPI has been integrated in standalone ECUs and in different ESC systems from several leading ESC suppliers that combined have a market share of more than 80% of the global ESC market.

This makes NIRA Dynamics and TPI well positioned for further market expansion, especially because future integration of TPI in the ESC is likely to be the preferred solution for most vehicle manufacturers in terms of complexity and cost. The key reason for this is that all the required input signals are available in the ESC, and modern ESC controllers have the processor power and memory available to be able to host the TPI function without changes or upgrades.

The ESC alternative can be expected to win over other possible integration solutions because in Europe and the USA there will soon be legal requirements for mandatory fitment of both ESC systems and TPMS in all passenger vehicles. The industry will increasingly focus on finding and developing the most robust, cost-effective solution, and NIRA believes this is exactly what TPI integrated in the ESC system offers.

NIRA Dynamics continues to invest heavily in its product development. It will expand its scope and offer TPI solutions for vans and light trucks as well as for motorcycles to complement its successful automotive business.

FIND OUT MORE

NIRA Dynamics AB
Tel: +46 13 329800;
Email: info@niradynamics.se;
Web: www.niradynamics.com
Quote ref VDI 009

Induction heating

Induction heating is widely used in the automotive industry. But as two case studies from EFD Induction show, a little creativity is all it takes to extract even more value from this amazing technology.

The first example involves EFD Induction France. The challenge was to integrate induction drying and curing into the anti-corrosion coating process for brake discs. Complicating matters was the fact that each drying and curing station had to deal with widely different discs. How could such varying workpieces be individually treated, while only equipping each station with a single induction coil?

EFD Induction worked together with DACRAL, the protection coating specialist, and came up with a solution for drying and curing spray-applied Geomet 360 brake disc protection. After leaving the machining line, the discs are loaded into the Geomet spray booth. Once sprayed, they are transferred to the induction heating booth for drying and curing. Each drying station features EFD Induction Sinac converters (50kW each). The number of drying stations needed depends on the production rate, the coil's efficiency, and the discs' shape and weight. The actual drying process involves heating each disc to 80-100°C. With induction this takes only seven seconds per heating station for discs up to 7.5kg.

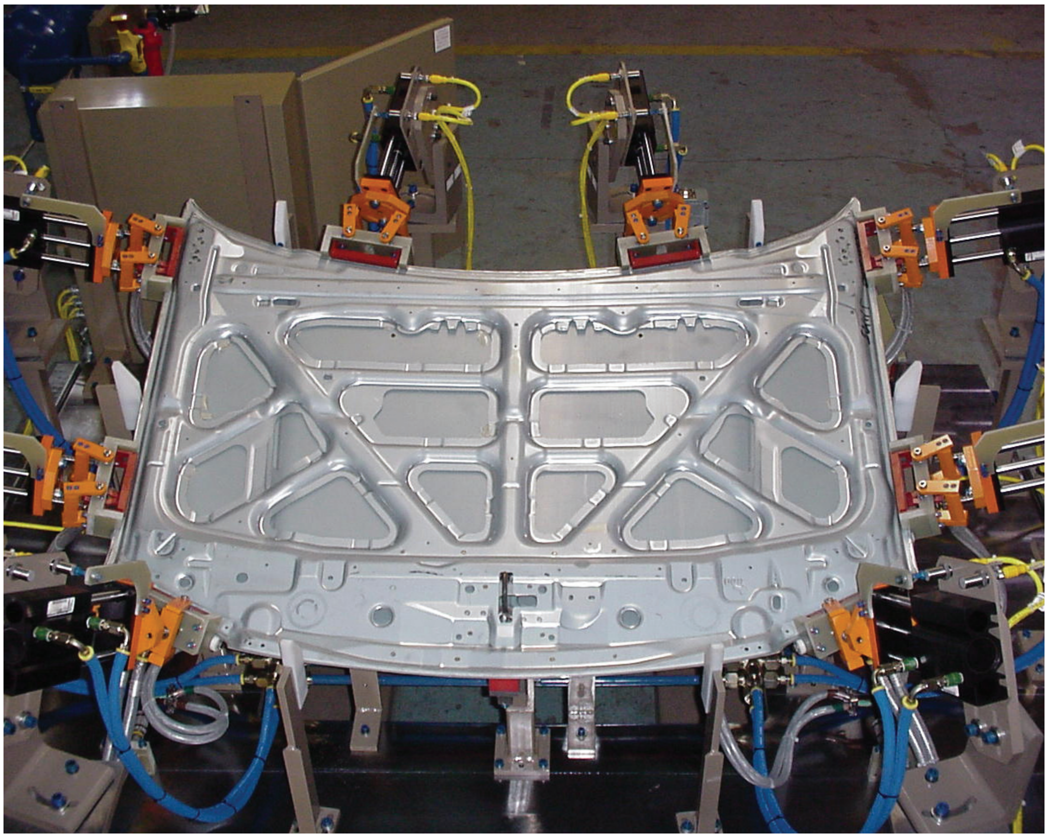
Induction curing is the next step in the process. The curing stations are equipped with EFD Induction Sinac converters (100kW each), and curing temperatures range from 100-340°C, with an allowable deviation of only ±15°C. As each drying and curing station must heat discs of different sizes with a single one-size-fits-all coil, a number of 'free stations' are installed to ensure optimum temperature homogenization for each disc.

The second example involves Jaguar, with which EFD Induction UK has enjoyed a long working relationship. In fact, after providing an award-winning bonding solution for the XJ saloon in the 1990s, EFD Induction's patented L-Coil and U-Coil bonding systems were chosen by Jaguar for several subsequent models.

A key reason for Jaguar choosing U-Coil was the system's elimination of drawbacks associated with spot-bonding. These drawbacks were due to temperature variations caused by panel condition changes and deformation during heating (particularly with aluminum). The launch of the U-Coil in 1999 removed these limitations by ensuring simultaneous heating of inner and outer panels. Also, the self-aligning coil 'head' maintains the coil/panel relationship, even in the event of panel differences or movement while heating. Costs are reduced because there is no longer any need for clamps to maintain panel shape/position. Tooling costs are also lowered. Savings in the form of less downtime and reworking far outweigh the initial capital investment.

The Jaguar X400 (X-Type) body shop in Halewood, UK, has U-Coil spot-bonding systems for curing closure panels. The systems have delivered a reliable, high-strength, zero distortion process since commissioning and setup of pre-production panels in 2000. But it was the move of Jaguar's Castle Bromwich facility toward aluminum body and closure construction that really highlighted the benefits of U-Coil. Aluminum hoods and trunk lids are now heated on table type tools, and the aluminum doors of the X350 (XJ) are heated while on the cell output conveyors, leading to considerably lower tooling costs and floor space requirements.

BELOW: **JAGUAR HAS BEEN USING EFD TECHNOLOGY FOR OVER A DECADE, ESPECIALLY FOR LARGER ITEMS LIKE ALUMINUM HOODS**



MORE INFO FROM

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Tel: +33 476 69 03 73;
Email: rca@efdgroup.net
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Quote ref VDI 010

Repeatable ACC testing

Oxford Technical Solutions (OxTS) has developed an interface from its RT-Range measurement systems to steering robots supplied by Anthony Best Dynamics (ABD). This enables the synchronization of tests between robot-driven vehicles.

Designed to enable in-vehicle robots to perform tests based on range measurements, the interface also enables the robot to capture measurements from the RT-Range. This powerful combination enhances the testing capability of driving robots and provides the customer with all the data in one file.

The award-winning RT-Range not only measures the distance between vehicles (range) with high precision, but also the lane position. This sophisticated measurement system has been specially designed to test and verify the accuracy of radar, LiDAR, and other sensors used for ADAS, such as brake assistance, lane departure warning, ACC, and other collision mitigation features. ABD's robots are often used for highly repeatable tests that are difficult for multiple human drivers to carry out. Using the RT-Range, in-vehicle robots can perform maneuvers based on the position of a second vehicle with high accuracy and maximum repeatability. One example is precisely cutting in front of a vehicle that is using adaptive cruise control (ACC). This can only be achieved if the range between the vehicles is known.

The RT-Range provides real-time measurements of range, normally output over the CANbus, and this also enables direct connection to existing data-acquisition systems. The Ethernet interface to the ABD robots can be shared with an RT3000 Inertial and GPS navigation system, which is used as part of the guidance system for the driving robot. Using the RT3002 Inertial and GPS technology, the position of a vehicle is accurate to 2cm, velocity to 0.05km/h, and polar angle typically <0.2°, all under dynamic conditions.

The RT-Range can be used for a great variety of tests. A 'hunter' vehicle can communicate with up to four 'target' vehicles, enabling tests including cutting in and overtaking maneuvers with multiple cars to be performed easily. The new outputs from the RT-Range to ABD robots ensure maximum repeatability, and make it the ideal tool for testing ACC scenarios. New RT-Range features also include fixed point locations and remote measurement points for testing with balloon cars suspended from trucks. The innovative RT-Backpack system, an additional component for the RT-Range, even enables car-to-pedestrian tracking.

The RT-Range represents a turnkey solution that enables car manufacturers to reproduce all possible traffic scenarios to test ADAS features with ease, high accuracy, and impressive repeatability.

LEFT: RT3002 INERTIAL AND GPS NAVIGATION SYSTEM TO MEASURE VEHICLE'S MOTION, POSITION AND ORIENTATION

BOTTOM LEFT: THE RT-RANGE MEASUREMENT SYSTEM FROM OxTS

TO GET FURTHER DETAILS
Contact OxTS Ltd
Tel: +44 1869 238015;
Email: info@oxts.co.uk;
Web: www.oxts.com
Quote ref VDI 011

Annular shaft flange

WAUKESHA'S STA-COLLAR IS NOW BEING SHIPPED TO VEHICLE OEMS IN FOUR DIFFERENT COUNTRIES

As product continues to ship worldwide, across a variety of automotive, light-truck, and SUV platforms, Waukesha Tool and Stamping's patented Sta-Collar annular shaft flange remains an innovative, cost-beneficial solution to limit the lateral movement of a stabilizer bar within its isolator blocks.

Since its inception and profile in the launch issue of *Vehicle Dynamics International* in March 2003, prototype and production orders for the Sta-Collar have steadily risen as suspension engineers recognize the advantages of this unique one-piece stamping. The Sta-Collar is currently shipped to the USA, Japan, Thailand, and South Africa for application to various vehicle stabilizer bars.

The Sta-Collar is made from mild steel manufactured in a progressive stamping die. One advantage of this product is that it easily slips over the stabilizer bar in any location, regardless of the bar's shape, thereby simplifying the process, reducing assembly time, and lowering total costs. The Sta-Collar is then clamped onto the stabilizer bar and spot welded to itself to provide an interference fit, which results in high push-off performance.

Another advantage is the compact design, which allows for placement in tighter suspension packages and the repeatability of placement provided by precision assembly equipment. When automated, the precision equipment can assemble Sta-Collars to the stabilizer bars complete, at a rate of up to five assemblies per minute. The option to fully automate (for high production) or assemble manually, along with ease of tooling changeovers, has enabled customers to realize substantial savings by using one common assembly machine across multiple platforms and sizes.

Continuing research and development provides customers with new options to meet their needs. One such application under consideration includes using the Sta-Collar to withstand pre-load forces of components during a suspension assembly process. Ongoing development has also produced options for surface textures imbedded in the Sta-Collar, permitting higher push-off forces to be achieved when clamped to a previously painted stabilizer bar.

Along with options for material and finish (bare or zinc-plated), and the ability to assemble before or after powder coat/paint, the Sta-Collar annular shaft flange has proved to be a viable, innovative, lower total cost solution to prevent lateral movement of a stabilizer bar.

As well as the Sta-Collar product line, Waukesha Tool and Stamping's engineering and production team and total manufacturing capabilities (including up to 600-ton presses), make it a consistent and reliable source for all small- and medium-sized metal-forming requirements. This includes complete fabrication and prototype services, which have been made possible through recent acquisitions.

LEARN MORE

Visit Waukesha at www.sta-collar.com or www.waukeshastamping.com
Quote ref VDI 012


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Steering-rack technology

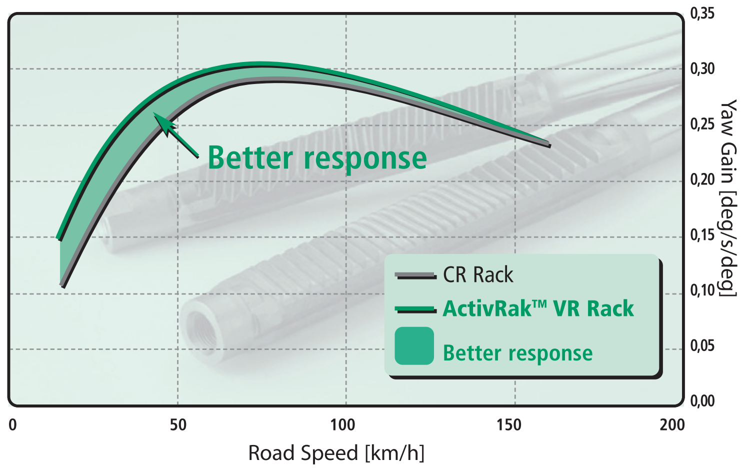
RIGHT: **COMPARISON OF YAW GAIN FOR THE ACTIVRAK VR RACK AND ORIGINAL CONSTANT-RATIO RACK**

BELOW: **ACTIVRAK VR RACKS IN Y- AND D-FORM APPLICATIONS**

Bishop introduced the first variable-ratio (VR) rack and pinion steering system to the market in 1981 and continues to develop this technology. Fifty years after Bishop's first variable-ratio rack and pinion patent, Bishop has introduced another first into the automotive steering market – ActivRak VR racks.

Conventional variable-ratio rack applications give the opportunity to have a steering rack that provides relaxed on-center driving as well as reduced turns lock-to-lock for ease of parking and low-speed maneuvering compared to constant-ratio rack applications. Bishop's ActivRak VR steering racks offer all this as well as a fast response to steering inputs from the driver, which is beneficial to the vehicle's dynamic behavior.

An ActivRak VR rack has a unique form of Bishop variable ratio, where the rack-gain characteristic is tuned to achieve a particular yaw-gain target. This yaw-gain target is consistent with what might be achieved using an angle-overlay active steering system. Here, typically there will be a considerable increase in rack gain, greater than 25%. This increase will occur within a small absolute pinion rotation from on-center – typically the maximum rack gain will have been achieved in less than 170° pinion rotation from the on-center position, and often in 90° or less.



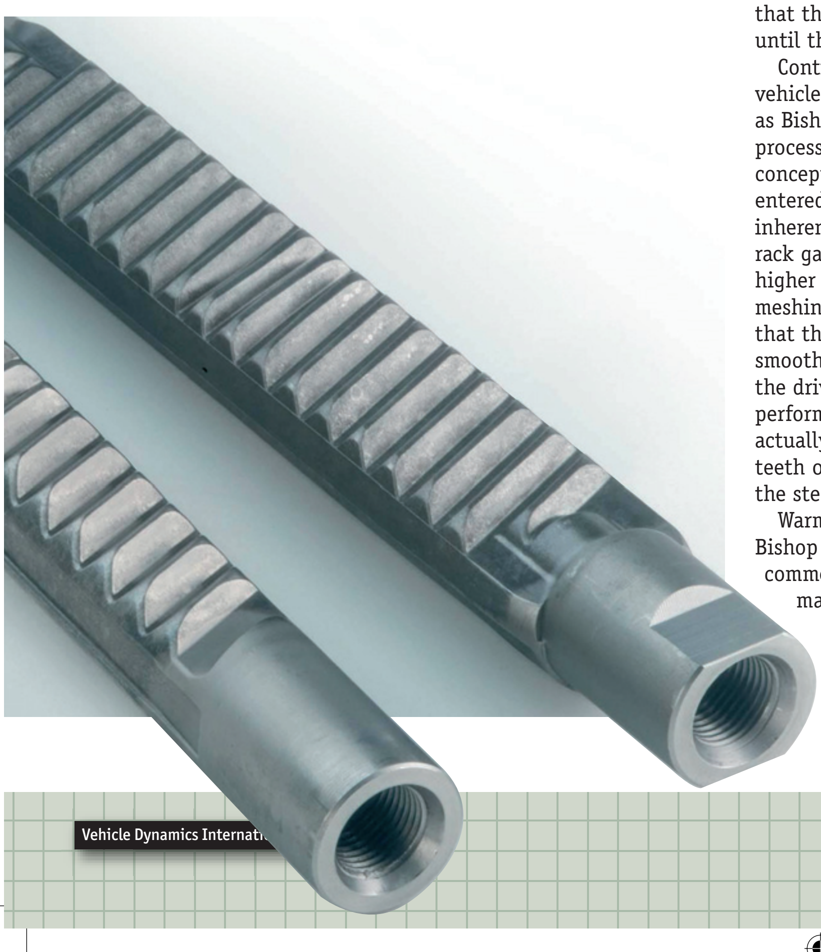
Arthur Bishop first proposed such a steering ratio in 1953. However, excessive compliance in the steering and suspension systems of the day and the lack of a suitably accurate manufacturing technology meant that this remained just a concept until the 21st century.

Continuous improvement in vehicle-suspension systems, as well as Bishop's own warm-rack forging process, mean that the ActivRak concept is now fully feasible. It entered production in 2008. The inherently high rates of change in rack gain call for a combination of higher levels of tooth accuracy and meshing-contact ratio to ensure that the variable-ratio transition is smooth and stable – ensuring that the driver can feel the steering performance of the vehicle without actually feeling the rack and pinion teeth of the steering gear through the steering wheel.

Warm-forged steering racks from Bishop offer the highest accuracy commercially available in the market. Bishop offers two basic types of rack shape – the Y rack and D rack. Several sub-types are available to ensure a cross-section of availability for every application. Bishop's Y-form racks offer the widest teeth available – up to 115% of the rack-shaft diameter, independent of the position of the pinion relative to the rack.

Today the automotive engineer can choose from manual steering, hydraulic and electrohydraulic power steering, column- and pinion-driven electric power steering, through to rack-driven electric power steering, where the rack is driven by either a second pinion drive or a ball-screw drive. Bishop is unique in the market in that it is not confined to only one rack type, but can offer an ActivRak suitable for each of these applications. It also has the capacity to assist in the development of the variable-ratio gain curve to meet the vehicle-dynamics requirement.

Modern electric steering systems offer the opportunity to include the active features of torque-overlay technology. When combined with an ActivRak VR rack, they offer the yaw-response tuning effect similar to that achieved by expensive angle-overlay systems, but without the need for a complex and expensive servomotor-actuation system that might filter out vital road-feel feedback to the driver.



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Vehicle development toolsets

Pratt & Miller's vehicle engineering system (PM-VES) is a comprehensive data-management application designed to manage, process and analyze large amounts of information generated during vehicle development and testing programs. PM-VES integrates with corporate enterprise Product Data Management (PDM) systems to store product benchmark, design, computer-aided engineering (CAE) and development information throughout the product lifecycle. The unique features of PM-VES are in its ability to transform this data into true knowledge-base engineering features specifically integrating functional design, CAE and development activities.

Joe Kiefer, the principal software architect of PM-VES and previously a race engineer of Pratt & Miller's successful Corvette GT1 race program, explains, "Historically, data management tools have not been integrated into, or made available to, vehicle development teams, the people in the trenches who need to make final product decisions quickly. The vehicle-development engineer has generally relied on his or her vast subjective experience to tune a vehicle."

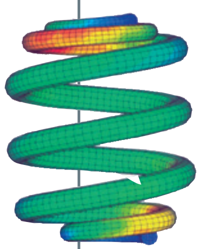
PM-VES accurately and efficiently records the configurations of multiple vehicles while also storing the results of vehicle testing, development, and benchmarking activities. The design of the data structure is extremely flexible to handle a wide array of vehicles and development activities. All aspects of the application, from the vehicle and parts architecture to the application security model, can be customized to meet the specific needs of each development program.

For more information

go to www.prattmiller.com or visit
www.ukipme.com/recard/vdmcard.html quoting reference VDI 014

Ahle Springs

New side-load springs



Miniblock springs (pictured left) were developed many years ago by Ahle Springs for series production in the automotive sector. The main applications are on the rear axle of passenger cars and light commercial vehicles and in spring brake actuators on commercial vehicles. The taper wire, in combination with the 'principle of inconstancy', offers compact installation, light weight, and an absence of coil-clash throughout the spring's working range.

The advantages of taper wire are not limited to Miniblock springs. Taper wire allows the creation of new, 'super-progressive-rate' springs that have applications in rebound- and simulator springs. More recently, a new generation of side-load springs with non-constant wire diameters has been designed, which reduces frictional forces in MacPherson spring-damper systems. This is achieved by minimizing the side force or by modifying the direction of the line of action of the side force. Another benefit is that the free length of the springs can be reduced to afford more protection to pedestrians. Further advantages are lightweight design and optimization of the installation of the spring-damper system. A major advantage of the Ahle taper-wire side-load spring is that it can be more easily assembled than a curved spring.

The design, development and manufacture of this new, steel spring concept will be discussed by Ahle Springs at Vehicle Dynamics Expo 2009 in Stuttgart, June 16-18 2009.

VEHICLE DYNAMICS EXHIBITOR EXPO 2009

For more information

go to www.ahle-federn.com or visit
www.ukipme.com/recard/vdmcard.html quoting reference VDI 016

Cruden

Simulators with feel

With fewer prototype development vehicles available, engineers and program managers needing data to sign off tooling or a chassis calibration are increasingly relying on dynamic simulators. Trusted by F1 and proven in the OEM market, Cruden's latest 'driver-in-the-loop' simulator provides six degrees of freedom to accurately reproduce vehicle behavior. "Cruden simulators provide real feel to the driver," says Cruden's commercial director Frank Kalff. "The accuracy, derived from extensive industry expertise and in-house software capability, allows engineers to objectively and repeatedly assess vehicle or component performance."

Cost reductions are pushing simulators to be a primary tool in other areas; driver assessment, benchmarking competitor vehicles and confirming ECU functionality when interfacing with humans are just some of the uses to which Cruden's simulators are being put.

In motorsport, testing restrictions are pushing engineers and younger drivers to use simulators to optimize setup, experience new circuits or even assess the feel of carbon brakes. "Cruden's simulator is a safer and lower-cost way for drivers to learn or understand new technologies," adds Kalff. "Teams and drivers can actually do much more work than they expected with an appropriate simulator package."

VEHICLE DYNAMICS EXHIBITOR EXPO 2009

For more information

go to www.cruden.com or visit
www.ukipme.com/recard/vdmcard.html quoting reference VDI 015

Kistler Instrumente

Tram testing

The roll-out of the world's first measuring tram took place in Dresden, Germany, in March 2009, with the handover of the tram for regular operation on the tramway network of the Dresden Transport Company (DVB).

The aim of the project is to acquire scientific knowledge and practical experience in the field of rail-vehicle and track-measurement technology in tramway systems. The data obtained in the course of the operation of the tram will serve to optimize simulation models for the development of new vehicles and vehicle components.

Performance measurements over the next five years during routine tram operation will permit conclusions to be drawn on power transmission in the drivetrain and the knowledge gained will aid the development of more energy-efficient driving methods.

Kistler's contribution to this project consists essentially in the supply of sensors to measure strain in the vehicle structure in the region of the carriage body and to investigate acceleration- and vibration-effects on the axle bearings and in the bogie frame. To this end, several piezoelectric triaxial accelerometers Type 8793A500 have been fitted to measure bogie vibration and the effects of the primary spring level between the two structures.

Capacitive triaxial accelerometers Type 8393B10 are used in the area of the articulations, doors, portal region and roof to measure the oscillation of the carriage structure mounted on the bogie. One is positioned directly above the bogie to determine the effect of the secondary spring between the bogie frame and the carriage body.

automotive EXHIBITOR testing expo 2009 europe

For more information

go to www.kistler.com or visit www.ukipme.com/recard/vdmcard.html quoting reference VDI 017

GeneSys

ACC evaluation

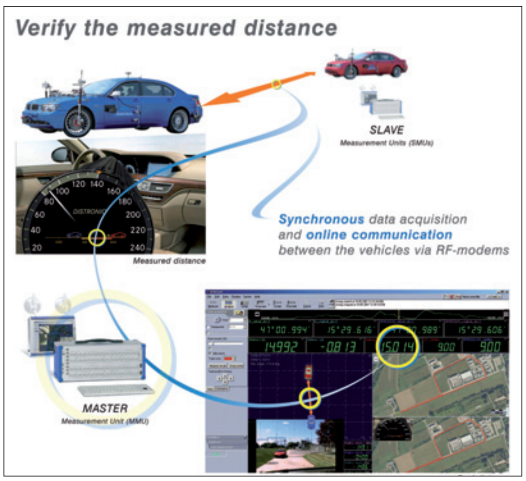
The ADMA GPS/inertial system is widely used for vehicle-dynamics testing applications to precisely measure acceleration, velocity, position, pitch/roll/yaw rate and pitch/roll/yaw angle as well as the side slip angle of a vehicle.

Based on the ADMA GPS/inertial system GeneSys Elektronik GmbH, in cooperation with Dewetron Ges mbH and TÜV SÜD Automotive GmbH, has developed a turnkey solution called CAPS-ACC to validate driver assistance systems such as ACC and LDW/LKS. It allows recording of relative data, especially position, velocity and angle of several vehicles dynamically and simultaneously. The position can be determined down to the last centimeter with the help of DGPS correction data from the base station.

Synchronism is ensured by using GPS synchronization: in each vehicle, data such as ADMA position and velocity data, video data, data from the vehicle CANbus and other data such as brake pedal trigger or steering angle, is recorded. As this data is generated at exactly the same time in each vehicle, it is possible to deduce the relative movement of all vehicles participating in the test.

CAPS-ACC provides online data transfer via W-LAN from one vehicle to another, online calculation and visualization of the relative variables, online driver guidance, in situ quality control of the data measured, as well as automatic generation of parameters and a test report.

The system will be presented at the Automotive Testing Expo in Stuttgart, on booth 1360.



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For more information

go to www.genesys-offenburg.de or visit www.ukipme.com/recard/vdmcard.html quoting reference VDI 018

BorgWarner TorqTransfer Systems

Electric-drive gearboxes

BorgWarner is applying its years of expertise to deliver robust and highly efficient electric-drive gearbox solutions as the trend toward vehicle electrification gains momentum.

The company's eGearDrive systems provide primary drive for front-wheel-drive and rear-wheel-drive electric vehicles as well as series-type hybrid electric vehicles. In addition, the systems can provide launch assist, energy recovery, and AWD performance for the secondary driven axle on any type of vehicle.

BorgWarner's eGearDrive systems deliver high torque capacity, outstanding efficiency, and low noise, vibration and harshness (NVH) in a compact package. They offer optional electronic disconnect and park systems, and electronic limited-slip differential control or full torque-vectoring capability.

BorgWarner's eGearDrive system is currently featured on a high-performance all-electric vehicle and is among the most advanced next-generation technologies available as part of the company's torque-management portfolio.

BorgWarner TorqTransfer Systems is a leading global designer and producer of torque distribution and management systems.

For more information

go to www.bwauto.com/products/tts or visit www.ukipme.com/recard/vdmcard.html quoting reference VDI 019

JOHN HEIDER TURNS HIS ATTENTION TO SUSPENSION TRAVEL

Travel agent

HEAVY-DUTY 4x4s SUCH AS THE LAND ROVER DEFENDER HAVE EXTENSIVE WHEEL ARTICULATION, BUT NEARLY ALL VEHICLES BENEFIT FROM MORE TRAVEL

ON THE WEB
Further comment from John Heider can be found on *VDI*'s website, vehicledynamicsinternational.com

In any passenger vehicle segment, the vehicle with the most suspension travel generally offers the best vehicle dynamics performance.

Establishing targets for front and rear jounce/rebound travel is a difficult task with many conflicting requirements, the key ones being vehicle dynamics (more travel is better), package (less is better), durability (more is better), cost (less is better), and NVH (more is better). The usual process involves benchmarking key competitive vehicles for vehicle dynamics performance, chassis hardware, wheel/tire size, turning circle, and other attributes that strongly influence suspension travel; selecting targets and vehicle assumptions via CAE and engineering judgment; then starting detailed design to implement those assumptions.

The detailed design phase is where the best-laid plans go awry and travels start to be compromised. As is the case in many vehicle engineering decisions, there is no single culprit – it is death by a thousand cuts.

"The detailed design phase is where the best-laid plans go awry and travels start to be compromised"

Many areas can create issues once highly capable CAE design tools are employed, suppliers are brought on board, and designs are finalized. One common problem area is joint included angles and travels. Full travel and full wheel turn package analyses (including suspension compliances) can reveal over-travel conditions on ball joints, bushings, or CV joints. If design limits are exceeded, reducing jounce or rebound travel is the usual suggested course of action.

Another is jounce bumper compressed heights. Whether the jounce bumper is a short, end-of-travel stop, or a longer, spring-aid-type bumper used as an integral tuning component, the compressed height at the predetermined loading (typically 2*g*) defines the usable jounce travel. Any durability issues with the jounce bumper are usually not identified until late on, with the fix typically a harder and/or longer bumper that reduces usable travel. Similar problems occur when compliant damper mounts are not included in the original assumptions.

The increased desire for large wheel/tire diameters also drives reduced suspension travels. Ironically, these low-profile, stiff-sidewall fitments are the ones that could benefit the most from increased travel. It is not uncommon for current vehicle platforms to accommodate a 4in+ wheel diameter spread from the smallest base wheel to the high-performance optional fitment. More often than not, these large sizes are late additions not included in the original travel assumptions.

There are many other potential culprits, each of which nibble away 1-2mm of jounce or rebound travel. By the time the final designs are complete for the chassis and body, the targeted levels of suspension travel can be reduced by 15mm or more.

There are a few things to keep in mind when suspension travel is debated. First, it is rare for travel to ever increase through the development cycle of a program. If detailed component and geometry assumptions are unavailable, erring on the side of slightly more travel at the beginning of a program is preferable.

Compliance of the tunable mounts, bushings and jounce/rebound stops is difficult to predict early in a program, so your travel predictions should include conservative assumptions for these components.

Within reason, reductions in rebound travel are easier to overcome than jounce reductions. Fully compressed suspensions at or near maximum jounce travel create very high durability-loads and cause handling issues.

Engineering standards must be carefully considered for full jounce and full wheel turn clearances on the front suspension. Experimental evidence suggests that standards of considerable and minimal clearance as well as interference with friendly surfaces are currently in use by major manufacturers. And, most importantly, remember that every millimeter counts!

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Volkswagen **Golf**

1.4 TSI Turbo

IN THE FIRST OF A NEW SERIES, JOHN MILES GETS BEHIND THE WHEEL OF THE SIXTH-GENERATION VW HATCHBACK

> **"The overall ride and handling compromise is a hard one to beat; much better than the 1 Series BMW and, for me, preferable to a Ford Focus"**

Look at the Mk6 VW Golf and it is hard to pick up the styling differences from its predecessor. It may look unremarkable, but as the driver's door shuts with a muted thud, the lack of audible resonance inside generates a quality feel even before you move off. The minor controls and clutch work with a sort of oily precision that is not there in a Ford Focus, and is certainly absent in those maddening 'flick to work' stalks found in some GM Europe cars.

The 1.4 TSI test car came with standard specification 205/55-16 tires and passive dampers, and a normal six-speed shift rather than the optional and technically marvellous twin-shaft DSG gearbox. Idle and cruising refinement are truly excellent. The turbocharged (rather than SuperTurbo) 1.4-liter, 120bhp power unit generates a seamless mid-range thrust that follows through, unlike the temporary push forward of a typical diesel. Admittedly it gets a touch coarse working hard toward the 6,500rpm limit, but that is entirely academic unless you absolutely must get to 62mph (100km/h) in the claimed 9.5 seconds.

VW's claims for great improvements in quiet running are valid, although road noise suppression on the UK's challenging rough aggregate surfaces was judged similar to the Mk5 Golf, almost certainly due to the latter having the advantage of narrower, taller, and quieter running 195/65-15 tires. This meant that I found overall differences in cabin noise quite difficult to detect despite the new screen with noise damping film, thicker side glass in front, better sealing, and other refinement tweaks. The Mk6 Golf remains perhaps the most refined C-class car overall if only because powertrain refinement is so good, and wind noise so low.

MILES WAS IMPRESSED WITH THE MK6 GOLF'S REFINEMENT, EVEN OVER BROKEN SURFACES

Even if there is not quite the incisive steering response gain of a Focus, on-center connection is reassuring, and aligning torque properties appropriate according to the cornering force. In *VDI* March 2007 I wrote about VW's ESP + Steering Recommendation package. As well as the usual stability control functions, it uses feedback from yaw sensing and rack loads to help eradicate tracking deviations generated at the road surface and nudge the driver (with up to 3Nm torque) to steer in the correct way when loss of adhesion occurs. Its operation is undetectable in normal driving, and I can attest to the rock-solid security feel and high-speed stability, especially over bumpy roads. For small steering inputs the lateral response phasing between front and rear axles is excellent at all speeds. With three turns from lock to lock, the steering ratio is slightly lower than in most competitors, which makes for slightly more maneuvering work, but the payback is great confidence in a high-speed lane change. High-speed stability is often achieved at the expense of excessive understeer at medium to low speeds, but this is not the case here as the front axle has a pleasant tenacity, and a feel of slowly building understeer rather than sudden lateral slippage at the front axle. Heavy braking is very stable, but initial response comes in a bit sharply after rather long initial pedal travel – something that Focus braking has always avoided.

Look under the car and we see that the underpinnings are unchanged, namely struts and a Focus-like four-link axle at the rear, plus anti-roll bars at both ends. My biggest criticism of Mk5 1.6 FSI was its lack of roll stiffness. Body lean is now as well controlled as anything in the class. On the Mk6 GT platform, three-stage selectable damping is available (ACC), but for UK roads I think the passive settings do a better job. The stiffer roll rates have resulted in a slightly busier ride response over Norfolk's back roads, but primary body control in heave and roll is well judged. In fact, the overall ride and handling compromise is a hard one to beat; much better than the 1 Series BMW and, for me, preferable to a Focus. There is some attendant powertrain and/or unsprung mass shake (something that UK roads always excite so well), but this is moderate. There is a real quality feel over broken surfaces: thud and rumble, rather than the crashy and tinny response found in some cars.

Overall, it is hard to pick holes in Mk6 Golf 1.4 TSI Turbo: a refined, comfortable, stable, brisk performer with an overall quality feel to which others should aspire. Mid-range performance is all the more remarkable considering the engine capacity, the only penalty being my brim to brim fuel consumption of 35.3mpg against the 46mpg I typically get from my own Focus 2.0 TDCi, a car of only slightly greater, but dramatically less refined, outright performance.

Is this a setup?

CARS WE DROVE RECENTLY THAT DIDN'T BEHAVE AS THEY SHOULD

CASE 20: HONDA INSIGHT, BY GRAHAM HEEPS

SPECIFICATIONS

- Honda Insight
- Suspension: Carried over from the Jazz: MacPherson struts up front and an H-shaped torsion beam at the rear. Mitsubishi springs; rates 22N/mm (F), 32N/mm (R). Showa dampers
- Brakes: 356mm discs; Nissin calipers; Conti ESC
- Steering: Showa EPS; ratio 16.73:1; 3.29 turns lock-to-lock; turning circle 10.34m
- Tires: Bridgestone Turanza ER370 185/55R16

"Is that the new hybrid?" asked a friend. "How is it?" I grimaced slightly, for I was about to pour cold water on his excitement at seeing the Mk2 Insight, Honda's much-vaunted 'affordable hybrid', for the first time. He won't want to trade his Mk1 Focus in for this, I thought...

On the one hand, the Insight is a proper family car. As one would expect from a vehicle that shares some of its platform with the roomy Jazz, the interior is very spacious, as is – unusually for a full hybrid – the 400-liter trunk, which swallowed the family's paraphernalia with ease.

But although Insight matches C-segment competitors for practicality, it comes up short on the driving experience. To begin with, the rear visibility is hopelessly compromised by the aero-friendly styling and the horizontal bar where the spoiler sits.

The stop/start element to the hybrid drivetrain works superbly, but the regenerative braking application is less successful. Honda says that its engineers "concentrated on delivering effective stopping power with a linear, natural feel to the pedal", but on our test car this simply wasn't the case.

The friction and regenerative elements of the braking were not seamlessly blended through the pedal, which we felt had an inconsistent and sometimes artificial feel. More than once in this CVT-equipped car we juddered to a stop in heavy traffic, as if the clutch hadn't been disengaged in time!

Worst of all, the low-speed ride comfort wasn't good enough for a machine that encourages gentle, eco-friendlier driving. The rear springs are stiffer than the fronts; if the intention is to handle the battery's mass, it doesn't work, for the seven NiMH modules make their presence felt over rough surfaces and potholes.

Worthy as the Insight is, there are cheaper, better-to-drive, and just-as-economical diesel hatchbacks (we got 51mpg in normal use) available to European consumers. The car makes more sense for Japanese or North American buyers who don't have those options, but even for them, better economy still has its price.

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