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China

Challenges and prospects for dynamics development in the world's biggest car market

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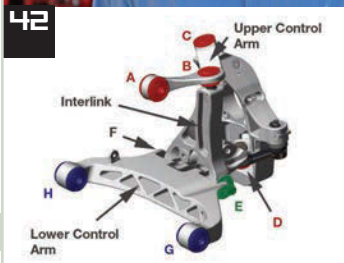

Vehicle dynamics in China

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at Automotive Testing Expo Europe 2013

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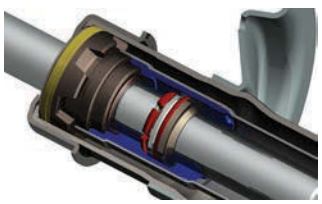

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A NOTE FROM THE EDITOR

Researching this issue's cover story was a rewarding experience thanks to the generosity of members of *VDI*'s LinkedIn group, a genuinely vibrant forum for discussion and debate among dynamicists around the world (and me!). I'm grateful to everyone who answered my request for information on working in China.

The responses I received surprised, informed and entertained me in almost equal measure. It was particularly heartening to hear from enthusiastic young Chinese dynamicists, keen to build their own skills and improve the dynamic quality of cars emanating from the domestic OEMs. Opinion was split on whether the next decade will see a shift away from the reliance on foreign engineers to lead dynamics programs; what's certain is that investment in new proving grounds and equipment will make it easier for those programs to deliver higher quality.

For those of you who prefer physical gatherings of people to online communities, may I take this opportunity to direct you to Messe Stuttgart, Germany, June 4-6. The three-day Open Technology Forum promises to be as informative as ever (see page 52 for the full program), while specialist suppliers in the adjacent Vehicle Dynamics Zone will complement the dozens of other companies with relevant products and services exhibiting in Hall 1 as part of Automotive Testing Expo Europe. Don't miss it!

Graham Heeps

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CONTRIBUTORS

BRIAN COWAN
New Zealander Brian has fond memories of the R32 Skyline GT-R from its racing days in Australia, where it earned the nickname Godzilla. You can read his first Dynamic Legends piece for *VDI* on page 44

RENÉ LE GRAND
Cotech dynamicist René was one of half-a-dozen engineers who've tuned in China to offer to share their experiences for this issue's cover story (page 36). His top tip? Don't book a return flight, because you can never predict how long the job is going to take!

TONY LEWIN
As an author, editor, technical translator and news writer in the automotive industry for more than 30 years, Tony has done it all. He makes his *VDI* writing debut in this issue interviewing the head of SKF's chassis unit, Aurelio Nervo (p12)

MARC NOORDELOOS
The eagle-eyed among you will have spotted Marc's first contribution to *VDI* in the previous issue (the Viper cover story). This time, the former *Automobile* road test editor has the latest on another legendary US nameplate: Corvette (p8)

JOHN O'BRIEN
John's been with us for a year now so it's high time we introduced him properly! For this issue the assistant editor and clubman MG ZR racer has recorded the dynamic likes and dislikes of AMG development chief Tobias Moers (p26)

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Height of sophistication

McLAREN'S NEW HYPERCAR BOASTS SOME RATHER SPECIAL SUSPENSION AND BRAKE TECHNOLOGIES. **GRAHAM HEEPS** WENT TO THE WOKING HQ TO FIND OUT MORE

McLAREN'S SIMULATION TOOLS WERE ESPECIALLY USEFUL DURING THE DEVELOPMENT OF THE P1'S ACTIVE AERODYNAMIC DEVICES. IN TERMS OF TEST TRACKS, IDIADA AND NARDÒ HAVE BEEN USED MORE FREQUENTLY THAN FOR 12C BECAUSE OF THE P1'S HIGHER PERFORMANCE

In a scenario reminiscent of the late 1980s, when vehicles such as the Ferrari F40, McLaren F1 and Porsche 959 all pushed the boundaries of supercar performance to new levels, 2013 is shaping up to be the year of the hypercar. Those three protagonists are back in the ring once more; Ferrari's LaFerrari and McLaren's P1 were unveiled in Geneva, with Porsche's 918 to follow in Frankfurt this autumn.

McLaren's challenger, the P1, is the second product from its new Automotive business. The car is based around the MonoCage, a 90kg, carbon-fiber composite monocoque that incorporates the distinctive 'snorkel' roof-mounted air intake, to which (as on the MP4-12C) aluminum subframes are attached front and rear. Some of the 12C's suspension pick-up points are retained, while others are moved to tweak the geometry, for reasons that will become clear.

The P1's calling card is its active aerodynamics, principally an active rear wing with an F1-style drag reduction system (DRS), and front underbody flaps. The car has been designed to go as fast as possible around a racetrack, a feat for which Race mode (one of four selectable vehicle modes) has been designed. In Race mode, the vehicle is lowered by 50mm and the aerodynamic package generates 600kg of downforce at 161mph (257km/h), said by McLaren to be more in line with a GT3 racer than a supercar. To handle the downforce, or more particularly the disparity between the desired ride performance on road and track, McLaren invented a new system for controlling the car's vertical stiffness, called RaceActive Chassis Control.

"Getting significant aero downforce is difficult to do with the standard ride height, so we came up with a concept of having two ride heights," explains McLaren's vehicle dynamics manager, Paul Burnham, whose group also handles aerodynamic development. "But we extended it further, and asked how we could make a system that would allow for control of ride height but also control of vertical stiffness. And from our experience of hydraulic suspension on the 12C, we could see there was a lot of potential around hydraulic control of those systems.

"So what we've done is take the 12C system and add hydraulic

SPECIFICATIONS

McLaren P1

Dimensions: 4,588mm (L) x 1,946mm (W, without mirrors) x 1,188mm (H, 1,138mm in Race mode). Wheelbase: 2,670mm. Track width: 1,658mm (F), 1,604mm (R)

Dry weight: 1,395kg

Powertrain: 3,799cc twin-turbo V8. 737ps @ 7,500rpm, 720Nm @ 4,000rpm. Lightweight electric motor. 179ps, 260Nm

Steering: Modified version of 12C system to suit P1's tires, geometry etc. Ratio changed to 2.2 turns lock-to-lock (12C: 2.6)

Brakes: Akebono layered carbon ceramic discs with forged and hardened steel bells. 390mm (F), 380mm (R)

Wheels: 19 x 9J (F), 20 x 11.5J (R)

Tires: Pirelli P Zero Corsa. 245/35 ZR19 (F), 315/30 ZR20 (R)

Performance: 217mph (350km/h) electronically limited top speed. Acceleration 0-62mph (0-100km/h) <3 seconds; 0-124mph <7 seconds, 0-186mph <17 seconds

EXPO-IN-BRIEF

On show at Automotive Testing Expo Europe will be Caemax's new telemetry steering effort sensor, CLS-E, which fits into the airbag compartment of nearly every serial steering wheel on the market. In addition to torque, steering angle and steering angle velocity acquisition, accelerations in x, y and z direction can be measured in the center of the steering column. The new receiver unit offers online monitoring in physical units, CAN and Ethernet interfaces, as well as the BNC output of the analog signals. Booth 1902

Race Technology will be showcasing the latest INS option for its SPEEDBOX product, which extends the possible applications from straight-line performance and brake testing, to all types of dynamic testing. The INS option uses the same PurePhase GPS technology, but in addition uses an advanced inertial sensor consisting of three accelerometers and three gyroscopes. All the data is automatically combined to calculate position, speed, distance, heading, gradient, acceleration, roll, pitch and yaw – all in real time. Booth 1574

• For more news on Automotive Testing Expo Europe and the Vehicle Dynamics Zone, see p50

AN XP P1 ON TRACK. THE VP PHASE IS NOW UNDERWAY: BURNHAM'S SMALL TEAM HAS TWO CARS, ONE OF WHICH WILL HANDLE ESC DEVELOPMENT

control of heave – vertical stiffness – effectively adding an extra system at the front and at the rear, which gives us independent control of ride height and vertical stiffness.

"That means we can have a normal road car stiffness at the higher ride height so that the car is not too uncomfortable and quite usable, say, when you are driving to the track. When you get there you can select Race mode. The car lowers itself by 50mm and also stiffens vertically by around a factor of three, so you have something much more akin to a race car in terms of ride height and vertical stiffness."

By controlling the pressure in two additional hydraulic circuits (one front, one rear – see drawing, below), the vertical stiffness – spring rate – can be altered. Note that this system – which was developed specifically for the P1, and for which the IP rests with McLaren – only controls ride height and vertical stiffness; roll stiffness is controlled as on the 12C by the Tenneco Kinetic system, moving hydraulic fluid from one side of the car to the other.

In terms of hardware however, the actuators are incorporated into modified versions of the Kinetic damper units, which now contain multiple chambers to accommodate the vertical system as well.

A "quite insignificant" conventional steel spring at each corner maintains the static height of the car, but "the large majority" of the springing is now done hydraulically, according to Burnham, who says of this semi-active system: "It's quite tricky in terms of packaging, but in terms of performance, it works very well."

Another key innovation in the P1 lies in the braking system, which, as with the 12C, was developed with Akebono. So important was this program that one of the dynamics team's three experimental prototype (XP) cars was devoted solely to brake development.

"You have to size everything to accommodate the peak temperatures," explains Burnham. "With a car with this level of performance, there was a risk that the brakes were getting too large because there is so much energy going through them. So we were looking for a way to keep the weight of the brake system down."

The solution is a material hitherto found in F1 and on the Ariane rocket. Stronger than conventional carbon ceramic, it dissipates heat more effectively. McLaren says it can absorb 50% more energy through the contact patch between disc and pad than the 12C's carbon ceramic brakes.

McLAREN'S RACEACTIVE CHASSIS CONTROL SYSTEM

RACY RUBBER

"Quite challenging" is Paul Burnham's modest description of the tire development program for the P1. "Pirelli has done a great job for us, as they've pushed the limits of what they can normally achieve and we've got very good results," he says, giving nothing away on the compound and construction of the bespoke P Zero Corsas. Two years were required to develop the rubber, which was treated as an integrated component from the very start of the program, due to the P1's unusual levels of power and downforce.

The carbon ceramic discs are infused with a highly durable surface layer rich in silicon carbide, giving improved stopping power and an appealing mirrored finish. Burnham says the pedal feel should be good too. "You need to resize the hydraulic system and the footprint of the pad appropriately," he says. "In fact, the feel is rather better than a standard carbon ceramic system as one of the things we obtained from this new material is a much more linear friction characteristic. Standard carbon ceramic has very good friction characteristics, but tends to be non-linear with temperature. Part of the reason why we have this new mirrored surface is that the material is very hard and very consistent. So from when it is cold, right up to very high temperatures, you get very linear behavior, and the pedal feel will be much more consistent."

McLaren has also opted not to employ regenerative braking on the P1 (unlike the LaFerrari), in a bid to retain a 'pure' friction-braking pedal feel. Instead, the hybrid system's 96kg lithium-ion polymer battery pack is recharged on throttle over-run, or via a plug-in lead.

VDI SAYS

It goes without saying that the P1 will be special to drive. We're just excited that McLaren is prepared to back true innovation, rather than rely on proven technology. Bravo!

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THE TRADITIONAL LEAF – SORRY, 'TRANSVERSE COMPOSITE' – SPRINGS REMAIN, BUT CHEVROLET'S LATEST C7 CORVETTE HAS HAD A THOROUGH DYNAMIC MAKEOVER, AS **MARC NOORDELOOS** REPORTS

"The Corvette has always been such great value," notes Josh Holder, its program engineering manager. "We want this new car to be aspirational. We want people to want to own the car, to wish to own the car."

In the USA, the average Corvette buyer is getting older. Nearly 50% of owners are over 55 (20% are 65 or older) – compared with around 20% for the Audi R8 and 30% for the Porsche 911. Clearly, Chevrolet needs to attract younger people to the US icon and this new, seventh-generation (C7) model is looking to do just that. Still, we'd forgive you if scanning the data panel made you think there isn't much technical progress hidden behind the new design. Don't let the pushrod V8 and seemingly familiar architecture fool you; this is a very advanced Corvette.

The outgoing C6 Corvette featured a steel frame and later introduced an aluminum frame for the higher-performance Z06 and ZR1 models. An all-new aluminum structure graces the C7 from the start and is 45kg and 57% stiffer than the outgoing steel frame. It's stiff enough that the convertible version of the C7 needs no additional structure. The laser-welded chassis is built at the Corvette assembly plant in Bowling Green, Kentucky, and uses aluminum extrusions and high-pressure die-castings. Additionally, the front and rear cradles are hollow cast, compared with solid on the C6.

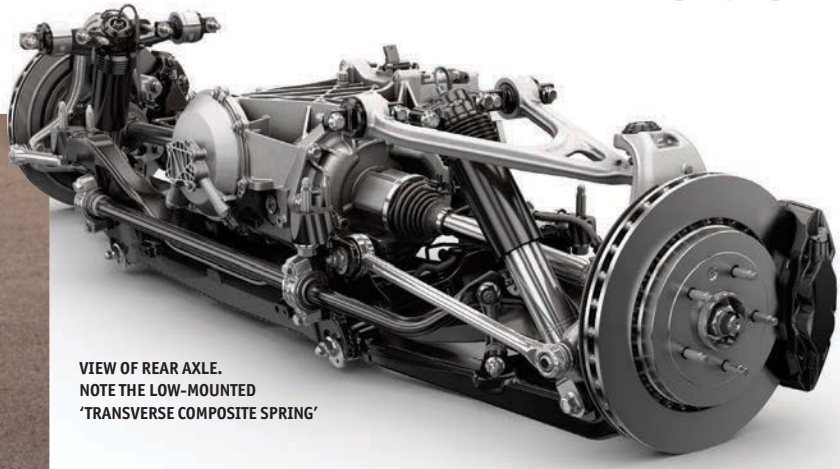
This new chassis gains structural reinforcements in the pedal box, making a right-hand-drive Corvette difficult. Holder adds, "Right now, it's a business decision, but we are also trying to expand our market globally, and we'd like to do that with this car. So, who's to say that there wouldn't be one (a RHD version) down the road?" Final testing and tuning for export models will be done around Europe and at the Nürburgring. Also, all Corvettes bound for Europe and the Middle East use the cooling setup from the higher-performance Z51.

The 6.2-liter LT1 V8 powering the C7 is all-new. It continues with a pushrod valvetrain, but the engine uses new fuel-saving technology, including cylinder-deactivation. The packaging constraints of these systems forced engineers to extend the wheelbase by 25mm. An added bonus of this stretch is rear-biased weight distribution – likely to be 51% for final production cars.

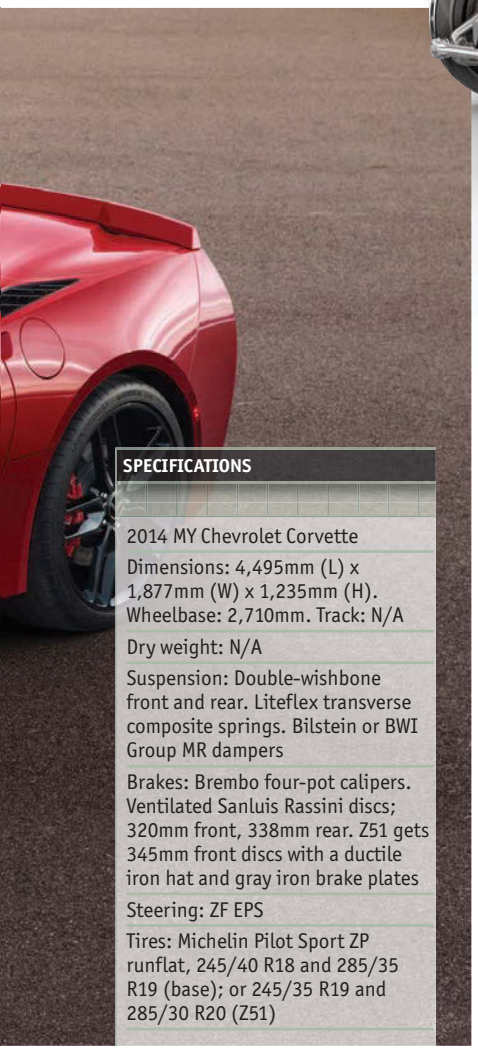
The basic suspension design is the same as the C6, including double-wishbones and transverse leaf springs. "We prefer to call it a transverse composite spring!" clarifies Holder. "The technology involved to manufacture the spring enables a low mass, low center-of-gravity spring choice versus a conventional coil-over. It packages very well in the car. There is a lot of science in it. It helps reduce roll without giant anti-sway bars." Holder also notes the excellent durability of this setup and the fact that many popular, aftermarket coil-over setups work well, but don't pass GM's strict durability tests. The C7 is further enhanced and lightened through the use of hollow lower control arms and new aluminum rear toe links.

The Corvette will be offered in both base form and the more

FRONT CORNER SHOWS DOUBLE-WISHBONE SUSPENSION SETUP



VIEW OF REAR AXLE. NOTE THE LOW-MOUNTED 'TRANSVERSE COMPOSITE SPRING'



SPECIFICATIONS

2014 MY Chevrolet Corvette
Dimensions: 4,495mm (L) x 1,877mm (W) x 1,235mm (H). Wheelbase: 2,710mm. Track: N/A
Dry weight: N/A
Suspension: Double-wishbone front and rear. Liteflex transverse composite springs. Bilstein or BWI Group MR dampers
Brakes: Brembo four-pot calipers. Ventilated Sanluis Rassini discs; 320mm front, 338mm rear. Z51 gets 345mm front discs with a ductile iron hat and gray iron brake plates
Steering: ZF EPS
Tires: Michelin Pilot Sport ZP runflat, 245/40 R18 and 285/35 R19 (base); or 245/35 R19 and 285/30 R20 (Z51)

focused Z51 at launch. "The biggest difference is roll stiffness," says Holder. "The base car has no rear anti-sway bar and a smaller front bar. This improves the ride. The base car also comes with a taller (aspect-ratio) tire." Both cars feature standard Bilstein dampers. The 45mm piston setup on the Z51 – versus 35mm – is very track-oriented; therefore it sacrifices some on-road comfort.

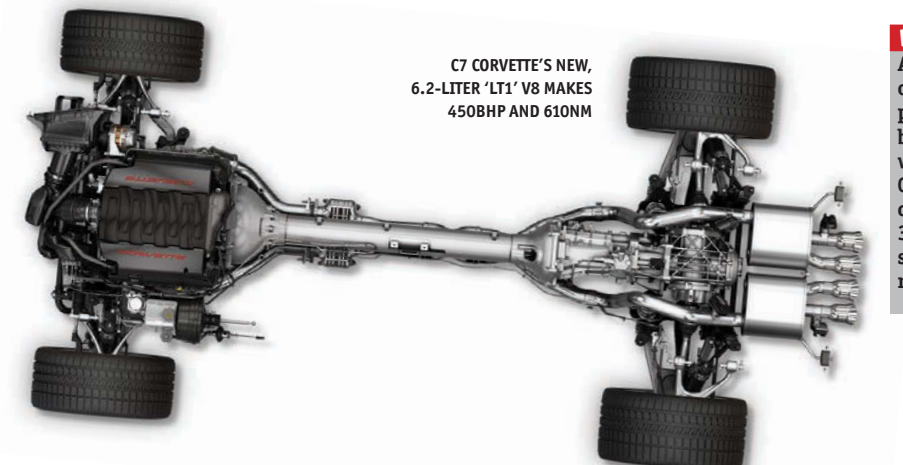
Buyers can also specify magnetorheological (MR) dampers on the Z51. Supplied by BWI Group, they now use a twin-wire/dual-coil setup, reacting 40% faster. Holder elaborates, "When you go to the MR damper, the extreme setting is just a touch stiffer than the passive Z51 damper. Where you really notice is on the softest setting. It is much, much softer so the ride frequencies are going to be lower. We look at the Z51 with MR as the no-compromises car."

Further technical advancement is shown in the steering system. Supplied by ZF, it is now electrically assisted – a first for Corvette. Chevy claims increased steering feel, helped by a 150% stiffer steering column and 600% increase in intermediate shaft torsional stiffness. The end result is five-times stiffer overall compared with the C6. Holder notes, "We've toyed with it (EPS) for some time. Our biggest concern, as with everyone, is that EPS compromises on-road sensitivity or road feel. Our experience in integrating it into the C7 has shown us no compromises."

Steering is just one of the systems integrated into the new Driver Mode Selector. This new feature uses a rotary knob near the shifter. It offers five settings – Weather, Eco, Tour, Sport and Track. Within each mode, up to 12 performance parameters are adjusted. This includes the steering and the active exhaust system, as well as the stability/traction control and available six-speed automatic transmission. An added benefit of cars equipped with the MR dampers is the utilization of ride-height sensors. Holder adds, "The data from these sensors allows the chassis systems to act progressively and work more quickly in a track environment. This is for things like weight transfer and how much power we can apply."

Another system integrated into the Driver Mode Selector is the new hydraulically actuated, electronic limited slip differential (eLSD). "The eLSD can basically go from nearly an open differential to a fully locked differential," says Holder. "When you're in a yaw rate change, it can lock and unlock accordingly to maintain control. Where you'll really see it is in slalom runs. In a conventional differential, you get some body-roll upon transitions – head toss. With the eLSD, the car feels planted." The eLSD is included in the Z51 package and has three calibrations, depending on the Drive Selector Mode. The system improves stability on the highway, enhances steering turn-in as well as responsiveness, and improves traction out of corners. Holder adds, "With the traction-control features active, you can mat the throttle with the wheel at full-lock, and power out of a corner. It's a pretty amazing setup [the eLSD]."

The Corvette's wheel, tire, and brake package rounds out the dynamic advancements. Both models come equipped with Michelin Pilot Super Sport ZP runflat tires. The Z51 adds larger, 19in front and 20in rear forged alloys. We talked to Holder about the decision to continue with runflat tires on the Corvette: "We're at a point where the structure of the sidewall that used to be required for runflat technology has evolved so that you can now get a quiet, compliant tire. The Corvette is a grand touring car. We felt the little bit of mass savings [of going with a non runflat] was not worth the package space and mass of a fill (fix-a-flat) system."



C7 CORVETTE'S NEW, 6.2-LITER 'LT1' V8 MAKES 450BHP AND 610NM

VDI SAYS

As with the C6, the new C7 Corvette offers a tremendous amount of pace for the price – anticipated to be around US$55,000. Combined with an estimated sub-4.0-second 0-60mph time, more sophisticated chassis dynamics and more than 30mpg touring economy, this should surely be enough to attract new and younger buyers.

NEWS-IN-BRIEF

Multimatic's high-performance DSSV (Dynamic Suspensions Spool Valve) damper technology will make its volume production car debut on the 2014 Camaro Z/28. DSSV damper technology has a strong record in motorsport, highlighted by Red Bull Racing's three consecutive F1 World Championships 2010-12. It's also on the Aston Martin One-77.

Honda has developed an accident avoidance support system called City-Brake Active System, which operates when the vehicle is travelling at speeds up to 18mph and also protects drivers from accidental acceleration at speeds of less than 6mph, or from standstill. The system will debut on the all-new Honda Fit, which will go on sale in Japan later this year.

SKF is supplying its Hub Knuckle Module to the new LaFerrari hypercar. The system features a light-alloy aluminum knuckle permanently fixed to the bearing outer ring, but with a dedicated single-nut design, as seen on F458 Italia 'Ferrari Challenge' race cars. The system is said to deliver improved bearing and wheel-end performance, reduced weight of the knuckle and bearing assembly, and easy wheel changes.

• SKF interview: page 12

Head to head

TWO OF THE MOSTLY HIGHLY RATED PERFORMANCE HATCHBACKS HAVE BEEN RENEWED. **GRAHAM HEEPS** EXAMINES THE FORD FIESTA ST AND RENAULT CLIO RS

NEWS-IN-BRIEF

Anthony Best Dynamics (ABD) plans to build a new US$9m factory, which it hopes will be operational by the end of 2015. The 2,743m² facility, in Bradford-on-Avon, UK, will nearly triple the firm's manufacturing capacity, and will be close to carbon neutral. To the fund the project – having decided against alternative sources of investment such as a trade sell or management buyout – ABD will be listed on AIM on the London Stock Exchange as of June 2013, with a view to attracting small private investors. The listing will also secure the future of the business, according to Tim Rogers, MD at ABD, who told us: "[Company founder] Tony Best is looking to eventually step away from the business. But for now he's still actively involved, as executive chairman."

Continental has launched a new generation of brake boosters. Compared with the traditional steel brake booster, the weight of the Gen III booster has been reduced by about 50%, or 1.7kg. It is also 12% (15mm) shorter. This weight reduction and the improved packaging has been achieved by using thinner metal and by optimizing the component's internal dimensions.

SPECIFICATIONS

Ford Fiesta ST

Dimensions: 3,975mm (L) x 1,709mm (W, no mirrors) x 1,456mm (H). Wheelbase 2,489mm. Track width 1,476mm (F), 1,452mm (R)

Dry weight: 1,163kg

Suspension: MacPherson strut front, twist beam rear

Geometry (regular Fiesta in brackets): Camber – Front -1.2° (-0.7°), toe in +0.2°, castor 4.5°; rear -0.6° (-1.6°)

Steering: TRW EPS with bigger motor than other Fiestas. 2.32 turns lock-to-lock, ratio 13.69:1, turning circle 11.2m

Brakes: Sourced from B-MAX. Tandem master cylinder for performance and pedal feel. Front – vented discs 278 x 23mm, calipers with 54mm pistons. Rear – solid discs 253 x 10mm, calipers with 34mm pistons. Switchable ESC with EBD and EBA

Wheels: 7.5J x 17in alloys

Tires: Bridgestone Potenza RE050 or Goodyear; 205/40

Performance derivatives of mainstream family hatchbacks have traditionally sought to be fast, fine-handling and stylish, but these days that's not enough to get the go-ahead from OEM product planners, let alone the thumbs-up from paying consumers.

Instead, they must also emit less CO_2 than predecessor models, so the new Ford Fiesta ST and Clio Renaultsport 200 EDC (to give its full title) both come with emissions-friendly 1.6-turbo powerplants.

In these straitened times they must offer improved profitability, too. So it is that the Fiesta's development costs will be spread across higher volumes thanks to sales in North America for the first time. The new Clio, meanwhile, does without the pricey bespoke panels that the Gen III car's wider-than-standard track width required.

"The base Clio IV has a track width of 1,505mm – 89mm wider than the Clio III – and it's a little bit lower, so the ratio of center-of-gravity height to track is about the same," says Patrice Ratti, CEO of Renault Sport Technologies.

There are similarities in the suspension architecture, too. Both cars have conventional MacPherson-strut front/twistbeam-rear setups. Despite the increased torque on offer from the turbocharged engines (240Nm in both cases), neither gets a torque-reducing trick front suspension layout (the Clio III had Renault Sport's double-axis PerfoHub setup). Instead, both have torquesteer-reducing electronics on the front axle. In the case of the Ford, it's the first time that the Torque Vectoring Control system first seen on the Focus (see *VDI*, Annual Showcase 2011) has made an appearance on the Blue Oval's B-car platform. It remains on even when the ESC is switched off.

Both cars still benefit from important revisions to the suspension hardware, however. In the Fiesta, the highlights are a new front knuckle and a revised rear torsion beam.

"We had long debates and long benchmark sessions about how sporty we wanted to set up the suspension," says Ford of Europe's chief engineer for performance vehicles, Jürgen Gagstatter. "I think we've come up with a setting that

CUTAWAY OF THE CLIO RS'S HYDRAULIC BUMP STOP TECHNOLOGY. MAIN IMAGES: CLIO (ABOVE), FIESTA ST (ABOVE LEFT)

SPECIFICATIONS

Clio Renaultsport 200 EDC
Dimensions: 4,090mm (L) x 1,732mm (W, no mirrors) x 1,432mm (H). Wheelbase 2,589mm. Track width 1,504mm (F), 1,500mm (R)
Dry weight: 1,204kg
Suspension: MacPherson strut front, twist beam rear. Maysan-Mando dampers. Rear anti-roll bar 10% stiffer than on Clio III RS, 60% stiffer than regular Clio IV. Cup chassis 3mm lower, 15% stiffer
Geometry (unloaded): Camber – front -51', rear -59'. Toe – front in 10' (17in rim), out 10' (18in rim); rear in 24'. Castor 5°40'
Steering: JTEKT EPS. Cup chassis has quicker rack
Brakes: Front – vented discs 320mm. Rear – solid discs 260mm. Switchable ESC
Wheels: 7.5J x 17in (Cup 18in)
Tires: Goodyear Eagle F1 Asymmetric 2 205/45 R17. Cup: Dunlop Sport Maxx 205/40 R18

makes a front-wheel-drive car easy to steer and, in a number of aspects, almost drive like a rear-wheel-drive one. I think it's something new and a bit special.

"To achieve the performance we wanted, we had to do more than just spring and damper tuning. We changed the camber of the front suspension by the modification of the knuckle to get more agility. We also modified the linkage to the steering gear and with that we have also achieved a different steering gear ratio. The standard Fiesta is 14.6:1 and this one is 13.6:1. That is then combined with a thicker anti-roll bar, which is now 19mm."

At the rear, a modified knuckle accommodates bigger brakes (the ST is the only Fiesta with rear discs, sourced from the B-MAX). The central section of the twistbeam has also been stiffened compared with a conventional Fiesta (Ford declines to say by how much). The principal geometry of the part remains the same but the change supports roll stiffness and allows more flexibility in the spring and damper tuning.

"You can achieve the higher torsional stiffness with the springs and dampers alone, but you end up with something that is not very pleasant for ride comfort," says Gagstatter. "It's a sporty vehicle, but we wanted to give up as little as possible in terms of ride comfort."

For the record, the Fiesta's springs and dampers have of course been revised. The car sits 15mm lower than other Fiestas, on 15% stiffer springs, while the Tenneco monotubes have different valving.

Meanwhile it is in the damping that the Clio RS plays its trump card, in the form of hydraulic compression stops. According to Ratti, the decision was taken in response to the slightly narrower track width of the new car compared with the Clio III, which had been extended to 1,520mm.

"The reduced width means that we can fit tires that are a little bit narrower than the current RS," he explains. "This helps CO_2 emissions but it's not as good for the handling. We needed to ensure the tire would not saturate with too much weight.

As you compress a normal bump stop in a quick corner, you increase the stiffness very much, putting more weight on the front and saturating the tire. We couldn't afford to make the car bigger, so the solution was to have the hydraulic bump stop.

"We had tested the hydraulic bump stop on the Clio Super 1600 rally cars in around 2004 and about a year later we even made a small series of Renault Clio 2 RSs with them fitted, for the UK and Switzerland," Ratti continues. "It was not exactly the same technology as we have today, but a similar principle. Testing showed that it was the right answer. You don't saturate the tire, so you can corner very well and the side-effect is that the new car is much more comfortable than the old one, even with big anti-roll bars, because you can run softer springs. It's a lot of work, and a little more expensive, but once you get it right it gives you a superb compromise between handling and comfort."

• *Jürgen Gagstatter interview, p30*

VDI SAYS

Cars like this are as fast, fun and predictable as it gets at legal speeds on modern roads – the mass-market sports cars of their day. We enjoyed the ST, but will reserve judgment on the ride until we drive it in the UK. Speaking of which, the Clio's promised extra comfort will be most welcome...

MOTORSPORT-IN-BRIEF

Hankook has moved into the WRC as the official tire supplier for the 2013 FIA Junior WRC Championship. The company's Ventus line of UHP tires will be used in Z-type specification for asphalt and R-type spec for gravel rallies on identical Ford Fiesta R2 cars throughout the season.

Aston Martin has agreed a racing partnership with leading damping and suspension specialist Bilstein, appointing it primary technical partner for Aston Martin Racing's competition program at the Nürburgring, focused on the N24h in May. The new agreement builds on the long relationship between the two companies; Bilstein dampers are fitted as standard on all Aston Martin road cars.

DC Electronics, well-known for its custom-built electrical systems, has released custom heatsinks for its Motorsport EPAS Systems. The heatsinks are designed to help radiate heat away from the motor. A cooler motor has less electrical resistance, which in turn allows more current to pass and therefore reduces the loss of assistance felt due to overheating.

The friction factor

TONY LEWIN SPEAKS TO THE HEAD OF SKF'S CHASSIS UNIT, AURELIO NERVO, ABOUT THE COMPANY'S INNOVATIVE BEARINGS FOR STEERING AND SUSPENSION

AURELIO NERVO (ABOVE) **AND SKF'S ROBUST STEERING RACK BEARING** (LEFT)

A career engineer with global bearings giant SKF, Aurelio Nervo is currently responsible for the chassis unit, charged with adding steering and suspension to SKF's traditional automotive core of wheel bearings.

Often seen as commodity items, they are small, relatively low in cost and decidedly short on glamor. But bearings are vitally important to anything that moves, and in any engineering project to reduce CO_2 emissions it makes sense to add bearing design to the list of systems up for review.

Yet, insists Nervo, there is much greater potential in bearings than simply reducing their friction and making them lighter.

Customer benefits, says Nervo, can go much further than the fuel savings enabled by the 20% friction reduction of the latest-generation bearings being rolled out this year. Moving into the steering and suspension areas of chassis gives SKF a real chance to use its expertise in managing friction to influence the way vehicles handle and steer, and thus how they are perceived by the driver: "If you get this friction right, there's a better feeling in how the car drives, and the perceived quality improves," says Nervo.

SKF claims its new robust steering rack bearings for vehicles with EPS give smoother and more precise steering, as well as improved durability. Service life, he reveals, is becoming an increasingly more important issue, especially in suspension strut top mounts where many cars have "huge problems" with noise from the suspension after a number of years.

"Our new line of robust products is a major advance, with a new sealing system to keep the dirt out," he says. Strut top mounts have become big business for SKF: it supplies close to 40% of global demand, with some of the largest car manufacturers as its customers.

Increasingly, says Nervo, the focus is beginning to move toward refinement and noise, a trend prompted by the widespread take-up in electric power steering and what he terms the "next frontier" of electric vehicles, whose largely silent powertrains serve to highlight the noise coming from chassis and body components. "For EVs we have embarked on a special project to develop a zero dB product, which will eliminate the transmission of vibration from the bearing itself," he explains.

SKF has signed a deal with Protean, the US-based wheelhub motor start-up, to develop the crucial central wheel bearings, and it is already working with an unnamed steering manufacturer on next-generation EPS systems. Yet, as with the suspension bearings business, Nervo's inclination is to hold back from becoming a subsystems supplier: "We don't want to go into this aspect of steering at the moment. Just as with suspension we are concentrating on the top mount and its roller bearings."

In the next breath, however, he concedes that his engineers are working with a premium auto maker on friction reduction in multilink rear-suspension systems as well as "studying damping" with regard to improving the NVH performance of strut-type suspension geometries on vehicles from the C segment upward. "These customers care much more about NVH," he asserts.

Another expanding line of business under the 'SKF Insight' brand is in semi-intelligent bearings that integrate a variety of sensors – a familiar example is the wheel bearing incorporating a wheel speed sensor for ABS and ESC operation.

For the moment though, SKF remains a solution provider in powertrain, chassis and steering applications – albeit it one with big ambitions to think beyond the confines of the commodity box.

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Winter games

COLD WEATHER REVEALS SOME UNWANTED BEHAVIOR IN **JOHN MILES'** FORD FOCUS

It's my belief that last winter's heavy snowfalls and sub-zero temperatures in the UK highlighted the need for strong government recommendation for people to invest in a second set of wheels fitted with winter tires, as is customary in parts of Europe. I refer to the specially compounded, and visually hardly different from standard, rubber that works so well in snow, and almost as well as the standard fitment on normal surfaces. On almost every weather report, we saw the hopeless floundering of rear-wheel-drive cars in these conditions – especially wide-tired BMWs, which could have done just as well on ice skates. Indeed, the lunatic trend for wider tires on everyday cars (except, it seems, on the Mk7 Golf – see page 76) has surely created lower tread-block loadings, and in turn intrinsically less bite on very slippery surfaces.

But for me the most disappointing experience of last winter was the snow and ice handling of my newly acquired Focus 1.6 TDCi Edge. I loved the gains in ride comfort and isolation and okay handling on the standard 215/55-16 section wheels and tires, so to discover its nervous, insecure and disconnected yaw/steering feedback characteristics on snow and ice was a letdown, especially compared with the relative driving security of my six-year-old Vauxhall Astra with its 'old-fashioned' twistbeam rear axle, and hydraulic PAS.

The whole experience reminded me of the lessons learned from driving with Magnus Roland in a prototype Saab 9000 compared against the first 'aero' Audi 100, back in the early 1980s. Boring to repeat, but the Saab was in another class for balance and controllability on the loose gravel. Roland and the dynamics understanding that flowed from Saab rally-car programs showed that in conditions of extremely low grip, anti-roll bars and spring rates have little effect on handling, because there is insufficient weight transfer to modify tire loadings; and that it is wheel steer that has the biggest effect, especially compliance steer, and to a lesser extent kinematic steer. That was more than 30 years ago, and I can't think of any situation I have experienced where that has not proved to be the case.

On the rutted mix of ice and snow, my Focus handled a bit like a rear-wheel-drive car with a preloaded-clutch type LSD, whereby the tire with a bit of grip forces its opposite number to rotate at the same speed, thus denying it any opportunity to gain grip, causing the rear tires to slither about randomly, one moment tied laterally, then rapidly slithering sideways, regaining purchase, then slithering again – all in contrast to the Astra's relatively progressive and connected behavior. The Focus's steering feedback also felt out of phase with the rear lateral slipping, further enhancing the insecure feel. I am not talking about high speeds here. This was all happening at about 20mph, with a chap in a Royal Mail van itching to overtake. The description of a naturally oversteering car? Absolutely not, because if the Focus has a dynamic fault at high speed, it is the sharp build-up of lateral force at the rear axle, and generally very strong steady-state understeer.

> "I am not talking about high speeds here. This all happened at about 20mph, with a chap in a Royal Mail van itching to overtake"

Much of the lack of snow and ice controllability ends up being felt (or in this case, not felt) through the steering, and it would be easy to blame the new Focus EPS. There is certainly an element of steering feel corruption that is not present in my old Astra.

Nevertheless, I don't feel this is the issue here. Much of the trouble seems to start at the rear axle and the extremely strong understeer it creates. In ideal conditions the car is pretty much rock stable except for a tendency to wander slightly at high speeds. Fine, but at the limit of adhesion – be it 0.9*g* or 0.09*g* or on a rutted surface – we know that the one thing a tire does not need is the car system to be aggressively adding rear-tire slip angle to that already demanded by the driver, because at the limit of adhesion, sudden, uncontrolled tire slippage is the usual result. Accepted, my old twistbeam Astra does not have the high-speed, locked-on-center feel of the Focus, but the Vauxhall's relatively laterally compliant twistbeam, and its balanced low-to-mid-speed yaw-gain characteristics, accelerate the body more gently, allowing the tires to maintain an intrinsically more stable purchase on very low-μ surfaces. Oh yes… I really must invest in a set of winter tires.

4 - 6 JUNE 2013
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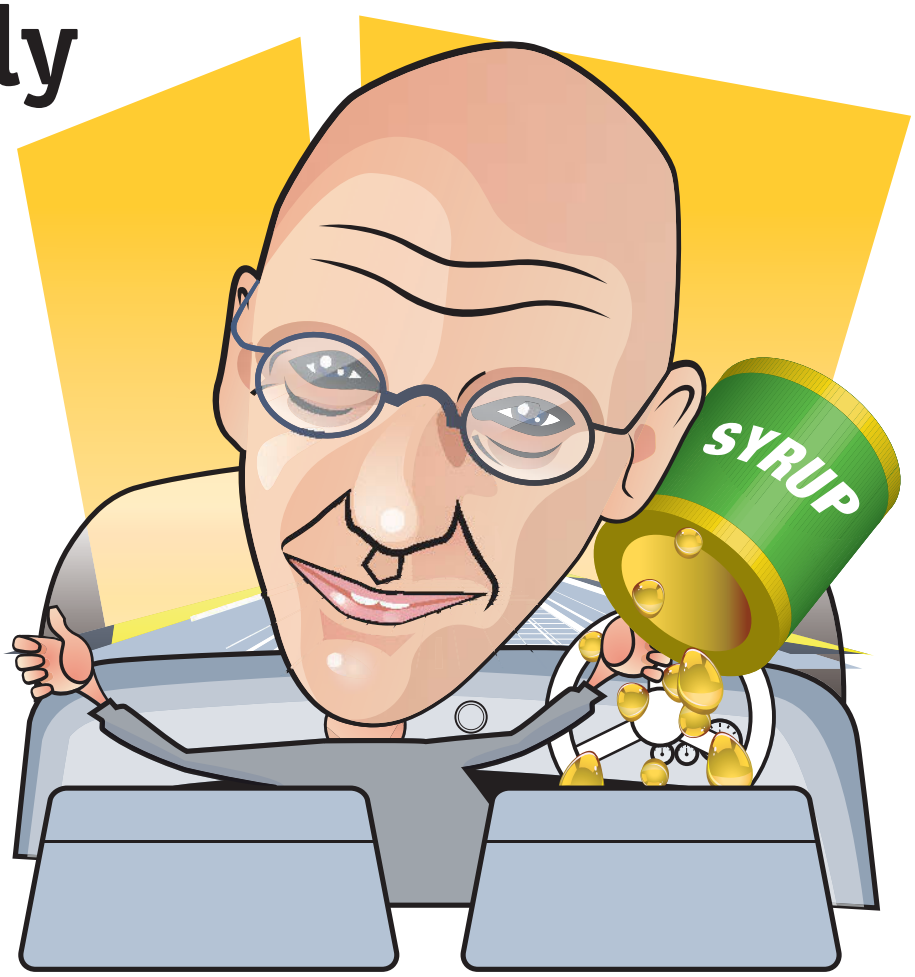
MATT DAVIS VENTS HIS FRUSTRATION WITH ELECTRIC POWER STEERING SYSTEMS



This column took a while to nail down this time around. First I grilled the boffins at the MINI John Cooper Works chassis department about their special potion for front-wheel-drive dynamics. I got all that I was after and more, but my mind had since moved on. Then I tried something similar for the front-wheel-drive chassis of the new Mercedes CLA-Class's Sport calibration but the deep specifics I sought there just never came through.

Instead, my thoughts turned to the accelerating tendency to make all steering racks electronically assisted. Be they governed by a ZF system and program or by those of JTEKT in Japan, the motors actuating things as well as their associated software synapses have quite some way to go before I'll ever write glowingly about them. Some are better than others – and it depends a lot on the particular chassis configuration – but I am not a fan. To clarify: this mostly pertains to vehicles and chassis with sporting dreams. If I'm in a Toyota four-door everyday ride, I couldn't really care less.

Mercedes and Audi never really have given us much hope anyway of having taut and nimble frontal chassis dynamics on their road cars, but Audi has actually gotten better over the past few years, while the latest calibrations from Mercedes have hit some new lows – see the civilian trims of both the SL- and A-/CLA-class, where the mid-curve vagueness is somewhat unprecedented.

Under the spotlight right now, though, are the current crop of BMWs and the legendary Porsche 911. I am getting fuming red about both of these situations, and you want to know why? It's simple. I'm pissed because the steering of the previous generations of both cars was damned near perfection. After discussing all of this with the various dynamics experts from Bavaria and Swabia, I think I understand their company-side logic for implementing this robot steering culture. But, still, something important has been lost.

From a modern BMW 5 Series, the car has grown so much and gotten so stuffed with goodies that I am starting not to need that car to carve perfect curves at speed anymore. But the 3 Series (including the new 4 Series) is an entirely different story and, while it is not awful in this case, I cannot keep loving a thing that caters to softies. The awards won by this new 3 Series are mostly warranted, but I fear are predominantly based on the afterglow of previous sensational generations. With 3 Series chassis of the past, we reveled in the steering and the feel of turn-in that connected directly to our brains via the seat of our pants. I'll need to wait and see what happens with the steering strategy on the next M3, but my radar is out and fired up for any fuzziness.

> "I'll need to wait and see what happens with the steering strategy on the next M3, but my radar is out and fired up for any fuzziness"

Another user of the ZF electromechanical steering is our old pal the Porsche 911. How can I put this delicately? Let's say that I find the 991 generation to be a purely beautiful design and made to grow in all the right ways. The powertrain and gearbox interface is solid, as is even the newest programming for PASM on the suspension bits. Nicely done.

But the steering is awful. The same system is much better on the Boxster/Cayman dimension of car, with all of its physical differences, but the 997 II generation had perfect steering for the 911. And this new strategy for the 991 is tremendously disappointing, as the fidelity of the steering feel in my hands has nearly vanished.

And so, not being a dinosaur by any means – just picky and demanding – I'll await the next generation of the software and electric motors. There are some bright spots out there – the aforementioned MINI JCW's rack isn't as good as it used to be in the days of hydraulic assistance, but it's still pretty good. Overall, though, EPS technology still has a long way to go before steering once again reaches the hydraulic heights.

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"As usual I met a lot of interesting people and spent the whole day talking to people – some new faces, as well as people I knew from before"

Koen Reybrouck, director, Reybrouck Consulting & Innovation

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Vehicle Dynamics International Awards 2013

THE WINNERS OF THE 2013 **VEHICLE DYNAMICS INTERNATIONAL AWARDS** HAVE BEEN REVEALED! THIS YEAR'S JURY IS BIGGER THAN EVER, BUT THE PRINCIPLE REMAINS UNCHANGED: TO RECOGNIZE THE BEST IDEAS, TECHNOLOGY, INNOVATION AND ACHIEVEMENTS IN VEHICLE DYNAMICS DEVELOPMENT

Car of the Year

It was impossible to nominate the Boxster roadster for this award without the Cayman coupe, given the high degree of commonality between these new-from-the-ground-up models. They also share a fantastic driving experience, built on a more rigid body and chassis that allows for softer suspension settings for excellent everyday usability, with no loss of handling performance. The 911-derived front end arguably performs better here than in the bigger sibling, with the EPS a particular highlight.

When it came to the judging, the Boxster and Cayman trounced some impressive opposition: the class-benchmark Golf Mk7 with its comprehensive kit of chassis technologies (see also page 76), the fluent Mazda 6 with its lightweight SkyActiv architecture, and the technology-packed Range Rover, which boasts some of the most complex chassis hardware of any car, anywhere. The result is Porsche's second *VDI* Car of the Year gong, following on from the Panamera's triumph back in 2009.

Jury members lined up to shower the Porsche siblings with praise; here are just a few of their comments:

"Boxster and Cayman are both so easy to drive very fast, and the levels of grip are so high! Impossible to resist…" (Christophe Congrega)

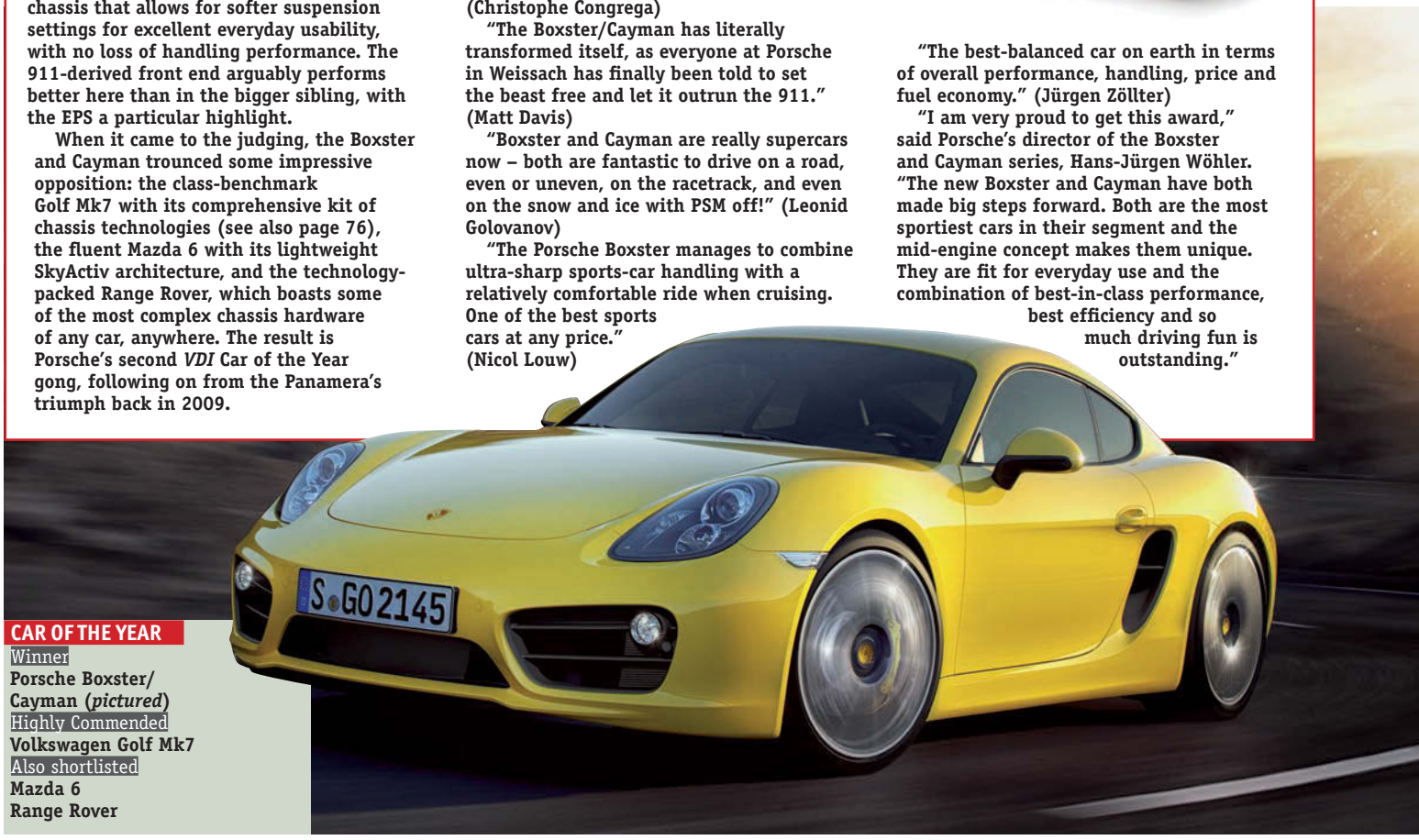
"The Boxster/Cayman has literally transformed itself, as everyone at Porsche in Weissach has finally been told to set the beast free and let it outrun the 911." (Matt Davis)

"Boxster and Cayman are really supercars now – both are fantastic to drive on a road, even or uneven, on the racetrack, and even on the snow and ice with PSM off!" (Leonid Golovanov)

"The Porsche Boxster manages to combine ultra-sharp sports-car handling with a relatively comfortable ride when cruising. One of the best sports cars at any price." (Nicol Louw)

"The best-balanced car on earth in terms of overall performance, handling, price and fuel economy." (Jürgen Zöllter)

"I am very proud to get this award," said Porsche's director of the Boxster and Cayman series, Hans-Jürgen Wöhler. "The new Boxster and Cayman have both made big steps forward. Both are the most sportiest cars in their segment and the mid-engine concept makes them unique. They are fit for everyday use and the combination of best-in-class performance, best efficiency and so much driving fun is outstanding."



CAR OF THE YEAR

Winner
Porsche Boxster/ Cayman (*pictured*)
Highly Commended
Volkswagen Golf Mk7
Also shortlisted
Mazda 6
Range Rover

THE JURY


Halit Bolkan, *auto motor & sport*, Turkey


Christophe Congrega, *L'Automobile* magazine, France


Carl Cunanan, *C!* magazine, Philippines


Matt Davis, Freelance & *VDI* columnist, USA


Padraic Deane, Automotive Publications, Ireland


Tarcisio Dias, *Mecânica Online*, Brazil

Development Tool of the Year

Underlining the importance of tire performance to vehicle dynamics, Continental's Automated Indoor Braking Analyzer (AIBA) was a runaway winner in the Development Tool of the Year category.

The new jewel in Conti's development crown is what's claimed to be the world's first fully automated, weather-independent tire testing facility. Located at the Contidrom proving ground near Hanover in Germany, the AIBA allows driverless testing on dry and wet road surfaces in a 300m-long, 30m-wide hall. In a fully automated process, an unmanned test vehicle is accelerated to speeds of up to 120km/h and then braked on interchangeable, hydraulically powered road surfaces with standardized pads, and the temperature precisely regulated to specified values. Continental claims the result is the most accurate means of measuring stopping distances in the world.

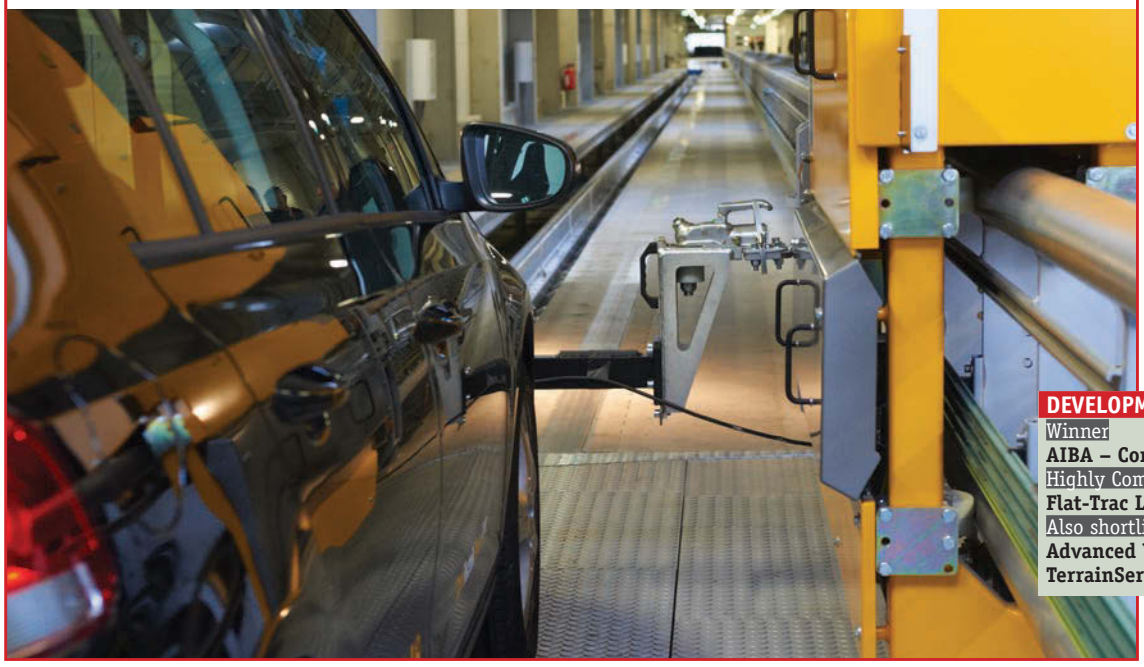
The judges were effusive in their praise for the winner. *Autocar India*'s Hormazd Sorabjee spoke for many when he said that, "Continental's new facility could change the face of tire development."

"With this innovative structure, Continental has solved one of the major problems that affects those who test cars: the weather!" offered Italian judge Lorenzo Facchinetti, while *Car&Tecno*'s Alvaro Sauras added, "Erasing the inaccuracy – and cost – of humans in a systematic way sounds a little harsh as a working principle – except when it comes to testing. So here you have it: automatic, accurate, reproducible, cheap, 24/7 tire testing."

Accepting the award, David O'Donnell (pictured, left), the head of R&D for passenger and light truck tires at Continental, said, "With our new, in-house-developed Automated Indoor Braking Analyzer at our Contidrom test track, we benefit from the most accurate braking test procedures in the world for our summer and winter tire models for passenger cars, SUVs, minibuses and vans.

"With the AIBA, which was built inside a record 20-month timeframe by our engineers at the Contidrom and Technology Center Hanover, we can combine the advantages of laboratory testing with those of outdoor testing for vehicles. It enables us to improve reproducibility by 70%, and to conduct tests all year round under fully air-conditioned test conditions, on interchangeable road surfaces with constant friction coefficients.

"Another positive effect is the considerably reduced physical strain on our test drivers and of course our ability to conduct testing 24 hours a day, 365 days a year," he continued. "Ultimately, it will enable us to make braking distances even shorter."



DEVELOPMENT TOOL OF THE YEAR

Winner
AIBA – Continental
Highly Commended
Flat-Trac LTRe – MTS
Also shortlisted
Advanced Vehicle Modeller – Bhai Tech
TerrainServer HD – rFactor Pro

Lorenzo Facchinetti, *Auto*, Italy

Leonid Golovanov, *Autoreview*, Russia

Graham Heeps, *Vehicle Dynamics International*, UK

John Heider, Dynamicist and *VDI* columnist, USA

Graham Johnson, UKIP Media & Events, UK

Matt Joy, Press Association, UK

Innovation of the Year

There were so many good nominations for this, one of the Awards' most sought-after trophies, that the shortlist was extended to six nominees from the usual four. There was huge variety among the finalists, too, but ultimately the category developed into a straight fight between McLaren's RaceActive Chassis Control suspension technology and Volkswagen's MQB platform architecture. In a battle that went to the wire, McLaren emerged on top by just four points!

The winning system, which was developed by McLaren specifically for the P1 hypercar (see p4), adds hydraulic control of vertical stiffness to the hydraulic roll control already seen on the MP4-12C.

"For a new road car – albeit an incredibly exclusive one – to appear with a brand-new suspension technology, previously unseen on road or track, is a once-in-a-decade moment," said Graham Heeps, *VDI*'s editor and chairman of the judging panel.

Meanwhile US dynamicist and writer Phil Morse observed that, "This is exactly the type of raw innovation that might inspire a youngster fond of sketching cars on the backs of notebooks to attend engineering school."

McLaren's vehicle dynamics manager, Paul Burnham, was delighted with the award: "It is a great recognition of the efforts the team at McLaren Automotive have made to bring new technologies to the market that offer real benefits for customers. We look forward to introducing many more innovations in the years to come, to bring stunning performance to cars in other segments of the market."

INNOVATION OF THE YEAR

Winner
RaceActive Chassis Control – McLaren
Highly Commended
MQB – Volkswagen Group
Also shortlisted
Active Retraction Caliper (ARC) – Mando
Multilink rear suspension – Nissan
Smart-Air-Spring – Torque And More/Veyance
Active Lean – Toyota

Dynamicist of the Year

The new ST versions of the Focus and Fiesta have attracted rave reviews. As Ford's dynamics specialist for all ST/RS vehicles, David Put (pictured, left) led the chassis tuning of each of these globally sold hot-hatchbacks. The Fiesta is a particular triumph, delivering excellent handling and everyday ride comfort from a simple but optimized MacPherson strut front/twistbeam rear suspension architecture.

When it came to the voting, Put was a clear winner, reflecting the fact that, since ST models are now sold globally, they can be appreciated by jury members from right around the world. His success repeats that of his colleague Jürgen Pützschler, who won this award in 2011 for his work on the C-car platform.

"David Put and his team are now developing their cars for a world market with one chassis setup – a great challenge," said *VDI* contributor Marc Noordeloos. "Anyone can feel that he or she is a very good driver with Ford's ST models," added Halit Bolkan. "More often than not, it's the car that's good!"

On hearing the news of his award, David Put himself (pictured) said, "Thanks for this special reward. It gives me even more 'drive' to make sure we can build affordable vehicles with class-leading dynamics, even in comparison with higher vehicle segments.

"Giving a car the highest possible fun-to-drive factor is both challenging and rewarding, and when you find you just can't stop driving, and find yourself smiling the whole time, you know you've hit upon the right compromise!"

DYNAMICIST OF THE YEAR

Winner
David Put – Ford TeamRS
Highly Commended
Mike Cross – Jaguar Land Rover
Also shortlisted
Gerry Baker – Vauxhall
Fabien Berthomieu – Renault Sport

THE JURY (continued)

Jim Kenzie, *Toronto Star Wheels*, Canada

Nikos Kounitis, *4 Wheels* magazine, Greece

Marc Lachapelle, *Le Guide de l'auto/MSN Autos US*, Canada

Jürgen Lewandowski, Ganske Publishing, Germany

Nicol Louw, *Car*, South Africa

Frank Markus, *Motor Trend*, USA

Dynamics Team of the Year

This category provided a victory for mainstream excellence over high-performance expertise, with Ford narrowly defeating Porsche to secure its second Dynamics Team of the Year prize, five years after its first.

Ford's dynamics team is now truly global, but the Blue Oval's dynamics expertise remains undiluted – and a major selling point. Highlights of the past 12 months have included the B-MAX mini-MPV, the Kuga/Escape SUVs and ST performance models, while the forthcoming Fusion (Mondeo) has received favorable first reports. Judges agreed that ride and handling developed at the Lommel Proving Ground often copes better with Europe-wide road conditions than products from other proving grounds, while Ford's electric power-steering systems remain the mainstream benchmark.

"For me, the new Fords are giving me back the driving pleasure that has been lost in a maze of new and complicated technologies," said Mexican judge Sergio Oliveira de Melo. Further north, Canadian expert Jim Kenzie explained his choice: "Ford wins for the overall excellence of its vehicles, across a wide range of categories." And in the UK, the Press Association's Matt Joy confirmed Ford's transatlantic appeal: "Giving the bread-and-butter models the kind of dynamics that are significantly above the class standard is a worthy achievement, yet what is more impressive is that the performance models manage to take that still further."

Ford's vehicle dynamics manager, Norbert Kessing, spoke of the "great honor" of winning the Dynamics Team prize for the second time, but stressed that Ford doesn't plan to rest on its laurels.

"The entire team is very proud of this public acknowledgement of our recent achievements," he said. "We remain fully committed to our strategy of learning and improving, further enhancing our understanding of how to objectify what we feel. This enables more upfront work through tests and simulation, thereby further improving our knowledge of the finest details of all the systems and components. That, in turn, provides the best possible basis for our 'tuning artists' to create the next generations of great-driving cars."

DYNAMICS TEAM OF THE YEAR

Winner
Ford
Highly Commended
Porsche
Also shortlisted
PSA Peugeot Citroën
Volkswagen

Yves Maroselli, *Le Figaro*, France

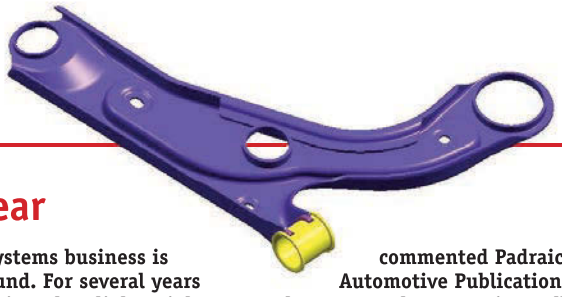
John Miles, Dynamicist and *VDI* columnist, UK

Phil Morse, Dynamicist and writer, USA

Marc Noordeloos, Freelance, USA

Sergio Oliveira de Melo, *El Informador*, Mexico

Tomaz Porekar, *Avto Magazin*, Slovenia



SUPPLIER OF THE YEAR

Winner
Magneti Marelli Suspension Systems
Highly Commended
Anthony Best Dynamics
Also shortlisted
NIRA Dynamics
rFactor Pro

Supplier of the Year

Magneti Marelli's Suspension Systems business is one of the most innovative around. For several years now it has been further developing ultra-lightweight steel suspension components, and two made production last year. Now it is turning its research focus to alternative materials, not just carbon fiber but – always with an eye on production feasibility and cost – basalt- and glass-fiber materials. Ultra-lightweight suspension arms have already been produced in prototype form using hybrid composite construction, while Marelli is also studying the potential for composite knuckles and working on a front subframe made from a composite material.

Given the importance of lightweight components to vehicles in the current CO_2-conscious climate, it's perhaps no surprise that the judges were more than impressed with Marelli's innovative approach, with them identifying the Italian-based supplier as a clear winner.

"Magneti Marelli has always been a highly regarded original-equipment and aftermarket supplier, and this reputation has been expanded with its growth in the suspension business thanks to innovation and the delivery of new developments," commented Padraic Deane from Automotive Publications. "Innovative and down to earth, Magneti Marelli is always supplying clever suspension components best suited to real world requirements," agreed Greek judge Nikos Kounitis, with *Motor Trend's* Frank Markus noting that, "Lightweight and composite suspension components will only become more vital in the years to come, especially if in-wheel traction motors are to have any chance as the fleet electrifies."

Acknowledging the accolade, Piero Monchiero, Magneti Marelli Suspension Systems' R&D director, stated that the company's aim was to help car makers achieve ever-more ambitious targets for sustainable mobility.

"In our business area, the R&D team is absolutely open to any challenge, wherever it comes from, in order to help car makers to achieve their desired performance and, in particular, their environmental targets. We are honored that the community of *Vehicle Dynamics International* has recognized our efforts. We have a daily commitment in going further in the development of new materials with high rates of UTS/density, focusing on industrial sustainability and cost factors."

HOW IT WORKS

The Vehicle Dynamics International Awards were first presented in 2008. The voting process works like this: nominations are received from *VDI*'s expert readership of chassis and dynamics professionals, and from the input of the editorial team. Between four and six shortlisted finalists in each category then go to the international and independent judging panel of automotive journalists, which votes for the winners. The judging panel was significantly expanded this year and now includes 29 judges from 19 countries! Once everybody had cast their votes, we added up the points to determine the winner and a Highly Commended runner-up in each category.

If you feel your product, technology or achievement is worthy of recognition, be sure to tell us about it! Then perhaps this time next year, one of our trophies could be sitting on your desk.

THE JURY (continued)

Alvaro Sauras,
Car&Tecno, Spain

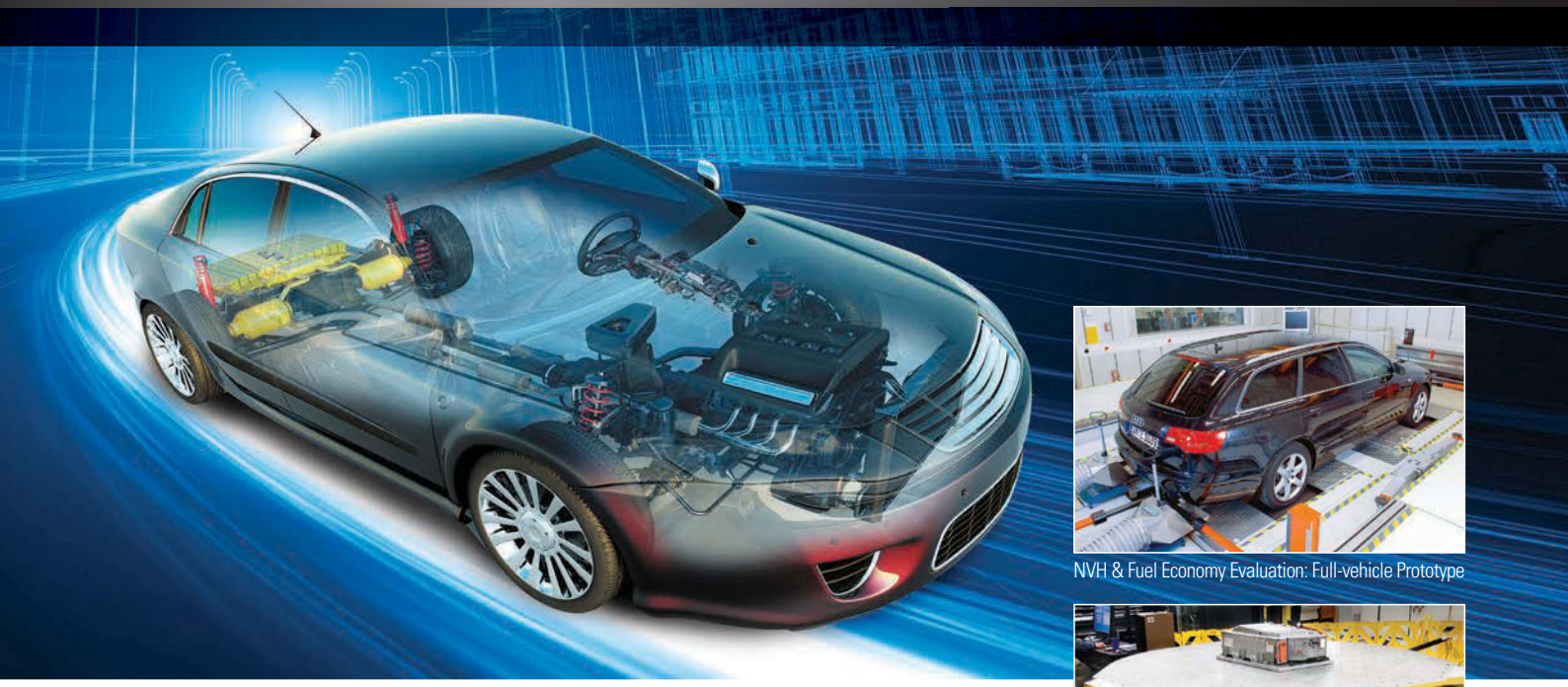
Hormazd Sorabjee,
Autocar India

Gabor Szecsenyi,
Az Auto, Hungary

Oleg Vasilevsky,
Auto Bild Ukraine

Jürgen Zöllter,
Freelance, Germany.

Ahead of the Curve



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MTS GROUND VEHICLE SOLUTIONS

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The A45, and accompanying CLA45, are the first two fully developed Mercedes-AMG models to break away from the tuner's traditional stamping ground. They are, however, the first of an onslaught that will see the AMG portfolio swell to 50 models by its centenary in 2017, as part of its Performance 50 ambitions.

How does AMG ensure that all-wheel-drive hatchbacks, SUVs and MPVs all behave like the rear-wheel drive sedans that forged the company's name? "Compromise really," explains Tobias Moers, AMG's director of vehicle development. "It's not possible to take the A45 drifting, for example, but the behavior still fits with our philosophy. It still has precise steering and you can really play about with it when driving."

So what exactly is the AMG philosophy? "We always like to create a car that handles quite neutrally," begins Moers. "We like to have a car that you can drive safely on a racetrack without electronic aids. Personally I like to play with a car. If I'm too fast into a corner, I like to play with steering and throttle input to control the car, and that ideology will always be our philosophy."

Achieving this neutral balance requires extensive revisions to the donor Mercedes-Benz. Moers explains that the predominant focus for his engineers is the front axle. "It is always a kinematic unit," he begins. "It is never elastokinematic. Our interpretation of roll-center height on both axles, as well as the roll-steer behavior and the car's engine mounts, are items we are very focused on."

The power struggle between the German big three has been, on paper at least, dominated by AMG. Its turbocharged V8 surpasses anything Munich or Ingolstadt could offer, but power is only half the challenge, and Moers believes that AMG has BMW M and quattro beaten in the handling department as well.

"We have a lot of respect for the BMW M guys, because they've focused on the M3 and they have a great-handling car, as it always has been," he states. "But what we have with the C63 is on the same level in terms of handling, and comparative handling tests show this. What we have in the overall portfolio, in comparison with the other two, puts us ahead. I believe the overall packages are just better.

LIMITED-RUN 'EDITION 1' A45 AMG COMES WITH 19IN ALLOYS AND COSMETIC ENHANCEMENTS

Little and large

THE JOB OF ADAPTING AMG'S TRADITIONAL LARGE-CAPACITY, RWD DYNAMICS TO NEW SMALL MODELS FALLS TO TOBIAS MOERS. **JOHN O'BRIEN** MET WITH HIM

A45'S 2-LITER TURBOCHARGED ENGINE WAS THE FIRST ROAD UNIT TO BE DEVELOPED BY MERCEDES-AMG F1 ENGINEERS. IT MAKES 360PS AND 450NM

SPECIFICATIONS

Mercedes-Benz A45 AMG

Dimensions: 4,359mm (L) x 1,780mm (W) x 1,417mm (H)

Dry weight: 1,555kg

Suspension: Bespoke MacPherson strut front, four-link rear

Spring rates (standard A200 in brackets): front 30N/mm (22.5N/mm); rear 70N/mm (40N/mm)

Geometry (standard A200 in brackets): front – toe 0.2° (identical), camber -1.8° (-1.02°), castor 7.54° (7.26°); rear – toe 0.3° (0.25°), camber -2.5° (-1.94°). All data refers to 3x 68kg passengers and a full tank of fuel

Brakes: Ventilated and perforated discs all round. 350 x 32mm (F), 330 x 22mm (R)

Steering ratio: 14.5:1

Wheels/tires: 19x8J, 235/40; optional 19 x 8J, 235/35

"The easy thing at AMG is that your competitive set is always very clear. You have the performance brands of quattro and M, but then you have the pure brands, such as the Porsche Panamera – a direct rival for the CLS63," he continues. "So you have to be constantly aware of what your competitors are doing."

Moers is all too aware of his rivals, with AMG having lost senior chassis engineer Arnd Meyer to BMW's M.

"At AMG we have over 600 engineers and it would be stupid of me to say my department focused on just the one person," says Moers. "I've known Arnd Meyer for years and we are good friends. I think it's a great opportunity for BMW, but for AMG it's not that big a deal." To further the point, he adds that not only has the position been filled, but a former Porsche engineer has joined, too.

A constant for AMG's chassis department is the Nürburgring Nordschleife circuit, which remains at the core of AMG's ride and handling development. "The Nordschleife is very important to everything we do," states Moers. "We have a strong numerical simulation group in my department, but they are still working hand-in-hand with the ride and handling guys, who are based up at the circuit. You can do plenty of simulation work, but that only gives you a guide as to where to start with your ride and handling setup."

BELOW: **THE SOON-TO-BE-LAUNCHED, MILITARY-DERIVED G63 AMG 6x6, WHICH WEIGHS 3,775KG, WILL BE AMG'S MOST EXTREME VEHICLE YET**

A45 AMG

Begun in 2008, the A45's extensive development had one goal – to ensure it delivered the same dynamic experience as its siblings.

"We designed a new front axle for that car," says Tobias Moers. "It's still a strut setup, but with high camber stiffness – we're running close to 2.0° of camber on the front [see *Specifications*]. It is a three-link unit with stiffer steering knuckles and totally new elastokinematic bushing mounts. We fitted it with newly developed, more rigid bearings in the lower link plane. The stiffer bearings also lead to greater camber stiffness, enabling higher cornering speeds. We modified the roll-center height, too."

The A45 also has some unique suspension arms on the newly developed four-link rear axle. Revised rear axle carriers now house stiffer bearings and the subframe is rigidly connected to the body.

"We also did some new calibration on the 4matic drivetrain," adds Moers. "With it being a Haldex system there is a certain preset for it, but we have done our own presets. It is a reactive system, but we modified it so that we could get a car that was not an understeerer. It fits in our portfolio and in our mindset – and more importantly, it's a lot of fun to drive."

AMG has a dedicated 2,000m² workshop in the Eifel, serving its numerous technicians and engineers who use the 20km circuit as a proving ground. Despite it not being wholly representative of real-world scenarios, Moers is quick to defend the 'green hell' as an ideal location to develop and set up machinery.

"We did some subjective comparison tests between the Nordschleife and a variety of local, country roads throughout Europe," he explains. "We found that the circuit isn't particularly different from the majority of them and the country roads around the circuit are just as diverse and fantastic, too."

In addition to that part of the development process, traditional proving grounds such as Nardò and IDIADA are also used by AMG. While he's adamant that there is no substitution for physical testing, Moers reveals that AMG has recently introduced VI-grade software to aid simulation work at the company.

This is one example of new technology being embraced by AMG, but a thornier one is that of the electronic power steering (EPS) systems spreading across the range.

"We weren't really in love with the EPS systems," admits Moers, "as you don't naturally get a feeling for understeer with them. The direct forces you feel through the rack if you understeer are less than before. With hydraulic steering there is a direct link, so you get this naturally.

"However, we introduced new logic and calibration to the software. The E63, I think, is a really good example of our system giving the driver the feedback, feeling and momentum that you want through the wheel when it is off center."

EPS may now be an accepted feature of an AMG model but some things remain off limits. Variable-ratio steering, for example, is unlikely to appear on AMG sports cars. "It's something we don't want as part of the AMG philosophy," says Moers. "Our ratio is a constant, as I want clear understanding, real feedback and the true reaction to the steering input."

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JÜRGEN GAGSTATTER IS THE NEW CHIEF PROGRAM ENGINEER, PERFORMANCE CARS, AT FORD OF EUROPE. **GRAHAM HEEPS** HEARS HOW HE'S CREATING GLOBAL CARS

When Ford asked Jürgen Gagstatter if he'd like to head up performance vehicle development in Europe, he gave the traditionally expected answer. "Can I have a think about it over the weekend?" asked the former Mondeo, S-MAX and Galaxy vehicle engineering manager.

"I did that, but strictly speaking it took me about five minutes to make the decision!" he smiles. "As in every new job, the employer's expectations are high – and in this case for good reason. When it comes to performance cars, everybody has a different opinion and it's not always easy to get them all under one umbrella. But that is the challenge and the end result, if you do it right, is very rewarding. Therefore, it really didn't take me long to decide."

Fine-driving cars though they are, Ford's current CD-car trio aren't the most obvious calling-cards for a performance-car development job. However, the amiable Gagstatter had added a couple of other strings to his bow during 20+ years with the Blue Oval. First, the German was chief engineer for the Mk2 Mondeo ST220: critically acclaimed a decade ago and evidently still rated by Ford's management today. Second, he's also a racer, having tackled the Nürburgring 24h on a number of occasions, most recently in a class SP4T Focus.

"I wouldn't call it crucial, but it helps," he says of his motorsport exploits. "To a certain extent, being capable of driving the vehicles at the limit is also helpful, because then you are not completely dependent on what others are telling you. You can say, 'Alright, I've seen the presentation, I've heard the explanation, let's now go downstairs

PHOTO: MATT JOY

and drive and I'll give you my view.' It makes life a bit easier."

Now seven months into the job, Gagstatter is part of a new structure that integrates Ford's performance vehicle programs worldwide. Like mainstream development programs in the 'One Ford' era, these now cater to all markets but are based in one territory. For B- and C-car STs and RSs, that means a European-based team working for Gagstatter and his right-hand man, engineering manager Tyrone Johnson, in TeamRS.

The reorganization was begun under Jost Capito around three years ago. He has since departed to Volkswagen, where he's had an instant impact in his new role as director of motorsport, leading the WRC team to rally victories in its first season. With Capito gone, Gagstatter instead reports to another colleague in

"When it comes to performance cars, everybody has a different opinion and it's not always easy to get them all under one umbrella"

RIGHT: **GAGSTATTER SHARED THIS CLASS SP4T FOCUS IN THE 2012 NÜRBURGING 24H. THE CAR WAS SHUNTED OFF SHORTLY AFTER MIDNIGHT AND WAS TOO DAMAGED TO FINISH THE RACE**

BOTTOM: **HAVING PREVIOUSLY BEEN CHIEF ENGINEER ON THE MONDEO ST220, GAGSTATTER HAD EXPERIENCE WITH HIGH-PERFORMANCE FORDS**

CHRISTIAN MOSKOPP/TRACKSHOOTS.DE

"A Focus ST customer uses his car from time to time to drive long distances, so you want a setup that isn't unpleasant"

Dearborn, SVT chief nameplate engineer, Jamal Hameedi.

Central to the new system is Ford's Global Performance Vehicle DNA, which integrates what were previously separate US and European-market requirements into one document.

"We have defined a number of attributes, but also requirements, globally, for performance cars," Gagstatter explains. "The performance cars are divided into several segments and for each group we have defined, precisely, where we want to be on a scale for various attributes, such as suspension, steering and braking. For every attribute there are a lot of measurements and we have defined very accurately where we want to be in the range."

On the chassis side, examples of measurable criteria on the list might include yaw gain, yaw response, or a certain ride frequency. Taking brake performance as an example, Gagstatter says, "You can relatively easily define typical measurements such as stopping performance from 100-0km/h, which typically everybody does – 10 stops like the critical *auto motor und sport* test. But we also define racetrack driving performance. The length and the duration of the tests the brake system needs to withstand is different from an ST to an RS. The 'race testing' is subjective on one side, so pedal feel and performance for example. But it's also done objectively, which basically means that we do not allow it to exceed a certain pedal travel, even in a heated-up condition. The same for fade resistance."

ST vehicles are now global, so now have to fulfill this DNA requirement in every market in which they're sold. The chassis tuning (tires included) is the same for all markets, although the cars aren't globally identical due to local requirements such as bodystyle or crash-test standards.

Global Performance DNA is doubtless a progression from processes that were already in place, but it nonetheless sounds like Ford has been able to swing the development pendulum toward objectivity – and judging by the new Fiesta ST (see page 10), without compromising the end result. Capito was fond of a dolphin (ST) and shark (RS) analogy; Gagstatter doesn't dismiss the notion out of hand:

"Wherever possible, the document tries to focus on measurables," he reiterates. "Obviously there are limits: you can't measure everything, so you need to do it subjectively as well to a certain extent. But this is a hundred-and-something-page book and I'm pretty sure that I've never seen the words shark or dolphin in there!

"I would also say, it is not a bad expression of the comparison. You typically have a certain hierarchy with the cars; an RS is much closer to racing in technology and setup than an ST. But there is also a certain hierarchy between the segments. A B-car ST is not necessarily the same as a CD-car ST. That's driven by the customer base and, to a certain extent, the competitive set as well. A B-car ST, I would say, is generally a bit more on the sporty side than the CD-car, with the C-car in the middle. A Focus ST customer uses his car from time to time to drive long distances, for example, so you want a setup and even a seat that isn't unpleasant."

Translating the DNA document's chassis requirements into a production-ready ride-and-handling setup begins for B- and C-cars on the Lommel Proving Ground in Belgium. Within the vehicle dynamics group at Lommel, David Put is now in charge of performance-car tuning. The radius then expands to include public-road running around Lommel, then into the Ardennes for some twistier, more mountainous routes, before heading across the border to the Nürburgring Nordschleife to confirm that the vehicle is also capable of being run on a racetrack.

The setup is also validated on public roads in the USA and the UK, while a separate racetrack durability program of around 5,000km is conducted at the Nürburgring or on the handling track at Nardò. Gagstatter has noticed no particular changes at the latter since Porsche took ownership last year.

With brand-new Fiesta and Focus STs on the market, what's next for Gagstatter's team? His B- and C-car focus means it won't be a new Mondeo/Fusion ST, a car that he'd be very well qualified to oversee…

"The company has already decided that the priority for CD-cars is the USA, which would also cover a performance car, so my colleagues in the USA would do that," he says diplomatically. "But I could foresee that, in that case, they would ask us for help and support…"

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ABOVE: **TESTS AROUND THE WORLD ENSURE TPMS FUNCTIONS IN ALL ENVIRONMENTS, INCLUDING DUST**

BOTTOM OF PAGE: **SCHEMATIC OF THE INDIRECT SYSTEM IN AN AUDI A6**

Pressure situation

AUDI'S TPMS DEVELOPMENT TEAM MANAGER, THOMAS ROSCHER, TELLS US ABOUT THE TECHNICAL AND LEGISLATIVE CHALLENGES THAT LIE AHEAD. BY **GRAHAM HEEPS**

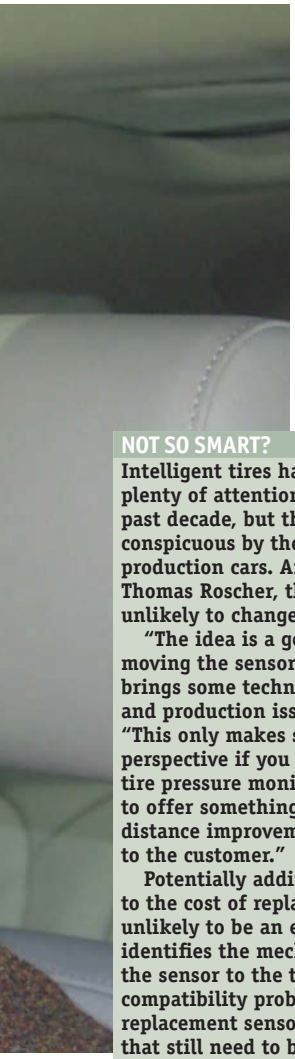
With its early adoption of NIRA Dynamics' indirect TPMS technology, Audi has been at the forefront of bringing reliable tire pressure monitoring into the mainstream. Since it was first fitted to an Audi TT back in 2006, it has been rolled out in countless vehicles across the Volkswagen Group, providing a maintenance-free answer to the regulatory demands of the US market in the process.

As such, the development procedures required to apply it to new vehicles are now well established, according to Thomas Roscher, who is responsible for TPMS development at Audi. He says that indirect system applications require greater upfront development effort than the in-valvestem direct-monitoring technologies, but that this is by far outweighed by the broader production and maintenance advantages derived from the indirect system's lack of additional hardware.

"We are gaining in experience all the time and are working in a number of areas to make this development process [for indirect systems] more efficient, including when it comes to the judgment of the tire's compatibility with the indirect system," he explains. "We have just defined a new method such that we don't need to drive in a car to judge the tire's compatibility to the indirect TPMS anymore. The tire manufacturers can do a pretty straightforward rig test upfront, and from it, have a good idea whether this tire is also – besides all the other criteria it has to fulfill – compatible with indirect TPMS."

He adds that a change in rolling radius and a certain vibration characteristic that can be picked up by the wheel-speed sensors – if not by the human driver – are the key signs of deflation. In most cases there should be no problem with a tire's compatibility with the sensing system, but with so many other performance criteria for the tire to fulfill, it's occasionally the case that a deflating development tire doesn't initially behave as required by the indirect TPMS.

"In that sense it's necessary to have a quick method to check for this particular property, rather than



NOT SO SMART?

Intelligent tires have attracted plenty of attention over the past decade, but they remain conspicuous by their absence from production cars. And according to Thomas Roscher, the situation is unlikely to change anytime soon.

"The idea is a good one, but moving the sensor to the tire itself brings some technology, process and production issues," he says. "This only makes sense from our perspective if you add value beyond tire pressure monitoring. You have to offer something like a braking distance improvement and sell that to the customer."

Potentially adding tens of dollars to the cost of replacement tires is unlikely to be an easy sell. Roscher identifies the mechanics of fixing the sensor to the tire and potential compatibility problems with replacement sensors/tires as issues that still need to be addressed. He thinks the technology could appear on high-end vehicles first, but even so, "I don't see it any time soon."

having the tires sent to the OEM first and driven on the test track before we can give feedback on whether the tire is okay," he says. "It's much more efficient if the tire manufacturer can do it themselves, much earlier in the development process."

Upcoming legislation changes will make it more important than ever for TPMSs of all varieties to accurately detect tire deflation. Whereas the US FMVSS 138 standard, introduced for 2008 MY vehicles, was born of a safety concern in the wake of the Ford/Firestone rollover incidents, the forthcoming EU legislation also seeks to address CO_2 emissions reduction through maintenance of the correct tire pressures. As such, the threshold at which a warning must be issued is cut from a 25% drop from the reference tire pressure in the USA, to a 20% drop in Europe. The difference is amplified by the ECE-R64 legislation's adoption of the 'warm' tire pressure as the reference – the pressure after the tire has driven a certain distance – whereas the US standard measures the drop from the cold tire pressure.

"Roughly speaking, the EU standard cuts the warning threshold in half, compared with the US one, which is a quite substantial tightening of the threshold," says Roscher. "As a result, we have concerns about possible customer acceptance issues from the EU-regulation TPMS systems, because the warning threshold comes quite close to the pressure that the customer is supposed to set the tire pressure to. Even if a warning were issued that this is still complying to the law, the customer might have some problems understanding it. We are not quite sure how that will play out."

Consumer research shown by NIRA Dynamics at the 2012 Vehicle Dynamics Expo would appear to underline his concerns, suggesting that 26% of respondents would regard the warnings they receive from ECE-R64-compliant TPMS as nuisance warnings, potentially undermining the credibility of TPMS as a safety system.

"In general I think there are only a limited number of systems already in the market that comply to this new standard, because I think all the OEMs want to wait as long as possible before introducing them," he continues. "Since the deadline is November 2014 for all newly registered cars, I think most of them are waiting until the middle of 2014 before they switch their systems to be ECE-R64-compliant."

Nonetheless, Roscher says that the new standard has already been implemented into Audi's TPMS development process, and he's happy that the technology will comply. However, the lack of consistent international standards remains a frustration for OEMs such as Audi that sell their cars around the world.

"There are now studies out by NHTSA that look at the effectiveness of FMVSS 138 in reducing under-inflation in the vehicle population," he says. "They made quite a substantial statistical analysis and investigation, and also estimated what TPMS actually adds up to in terms of a CO_2/fuel consumption improvement.

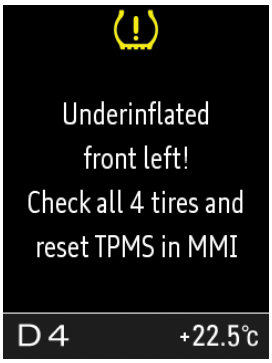
"Interestingly enough, FMVSS 138 is basically already doing what the EU legislation is supposed to do, both in terms of safety and in a fuel-consumption improvement achieved through bringing the average tire pressure back to the recommended tire pressure. These studies only came out last autumn; it would have been good to know that before the EU regulation [was finalized in 2010], because then maybe the EU regulation would not have been so strict, with also then the potential risk of customer complaints."

Next to join the regulatory train will be China, which is considering mandatory TPMS legislation. Roscher says the whole OEM industry is lobbying for the existing US standard to be adopted there, rather than the EU one or something else altogether.

"It's important to consider the consequences for all the stakeholders involved," he urges. "Not just the OEMs, but the TPMS suppliers, the drivers who in the end will use these systems, the aftermarket and everybody else. All these must be taken into consideration if you are creating a TPMS standard. Hopefully the result will be to adapt something that already exists."

ABOVE: **COLD-WEATHER TESTING OF TPMS IN NORTHERN SWEDEN. ROSCHER'S TEAM ALSO TAKES CARS TO SOUTHERN EUROPE AND THE USA FOR ENVIRONMENTAL TESTS**

BELOW: **TPMS WARNING MESSAGE IN AUDI'S IN-CAR MMI SYSTEM**



Rough with the smooth

VEHICLE DYNAMICS DEVELOPMENT IN CHINA IS STILL EVOLVING. **GRAHAM HEEPS** SPEAKS TO EXPERTS IN THE REGION TO ASSESS LIKELY FUTURE DEVELOPMENTS

More cars are now sold in China than in any other country in the world (although the USA still leads the way in terms of the value of vehicles sold). In fact, it's thought that more cars were sold there in 2012 than in the whole of the EU.

But China is not a mature market in vehicle dynamics terms. Customer requirements, although becoming clearer, are also less defined than in more mature car markets. Local OEMs lack the brand identity, expressed through their vehicles' driving characteristics, that we've come to take for granted in the West. Many chassis tuning projects are still led by western companies such as Lotus, MIRA, Porsche, Magna or Prodrive due to a paucity of local expertise.

All this makes for a very different environment for dynamic development and chassis engineering in China from the one familiar in other countries. To get a handle on the current situation, and discover what the future might hold, we spoke to a number of engineers with current or very recent experience of the Chinese market (see *The Panel*, opposite page); here's what they said.

The consumers

"In terms of functional expectations such as steering feel, ride comfort and ride quality, and handling – the usual areas considered vehicle dynamics – the general expectation in China is fairly low and the average customer doesn't pay a lot of attention to dynamics until he gets into a vehicle that has better dynamics," says John Heider of Cayman Dynamics.

"I have met very few people in China who could be classed as enthusiasts or would consider getting in a car and driving for fun. The concept of cruising, or going for a drive in the country, just isn't there. It's a historical and cultural thing; in the USA we grew up riding in the back seat of our dad's car, but the inherent automotive culture just didn't exist in China 15-20 years ago. Instead, a car in China is part status, but primarily transport, so steering and handling dynamics don't generally figure; ride more so."

That nascent automotive culture also shapes the outlook and experience of the vehicle engineering community in China, as we shall see. But in terms of driving behavior at least, it would seem that Chinese drivers have more in common with those in other markets than one might suppose: "The Chinese are usually new and inexperienced car buyers," says René le Grand, who works with Shanghai Cotech Engineering, a consultancy founded by Dr Ximing Huang, a Chinese-American. "But surprisingly, their longitudinal and lateral dynamics while driving are similar to those of drivers in Europe."

The roads

The fact that China has some roads that are of very poor quality is well known, not helped by the proliferation of overloaded trucks.

But the picture is much more complex than that, which makes chassis tuning correspondingly more difficult.

"China is vast and there are big differences between the roads in tier-one cities and tier-two cities (not to mention tier-three cities, where the situation is even worse)," explains IDIADA's Bo Zhu. "The state of surface repair also varies a lot. For urban roads with a 60km/h limit, there are always sunken manhole covers placed sporadically within the road, 20mm below the top asphalt layer. They're spaced right at a distance where you cannot avoid hitting one of them as a single-wheel impact. Lanes are mostly as wide as in the USA, and flat, with very little elevation change. Low frequency, large-amplitude vertical features are rarely experienced in China."

"The roads differ from city to city," agrees engineer Gao Yi of KHAT, a consultancy founded in 2007 by a local professor. "For example, Beijing's roads are very straight and smooth, but Guangzhou's roads have many junctions and corners, and there are many joints and breaks in the highway. I think one of the biggest challenges is how to tune cars to satisfy China's different areas."

For Cotech's le Grand, the surface material variations should also be considered.

THE PANEL

Mark Beasy
In chassis design and development since 1996, specializing in tuning. Formerly with GM Holden (he worked on the original HSV GTO coupe), he's undertaken a number of consultancy jobs in China.

Jean-Marc Finot
Formerly PSA Peugeot Citroën's head of chassis and vehicle dynamics, but recently appointed its VP of research and innovation.

John Heider
Long-time *VDI* columnist, ex-Ford vehicle dynamics manager and principal of USA-based Cayman Dynamics, with connections to Cotech, and project experience in China.

Nanda Kumar
Malaysian engineer, ex-Lotus Engineering and Bufori; now runs Radical Chassis Solutions. Is also a multiple national rally champion and has worked on Chinese rally-car projects.

René le Grand
Freelance dynamics engineer now in his fifth year in China. After two-and-a-half years at VW-Shanghai, he's now with the Cotech consultancy, serving almost all major Chinese OEMs and their JVs.

Clive Roberts
Currently director of vehicle integration at SAIC Motor Corp. Started out with Triumph in the 1970s; 14 of his almost 40 years in vehicle development and integration have been spent in China.

Gao Yi
Currently a senior vehicle dynamics development engineer (seven years' experience) at Chinese engineering consultancy and rig builder KHAT.

Bo Zhu
Helped design an SCCA Spec D racer before working as a vehicle dynamics development engineer with a Chinese OEM. Now with IDIADA.

DEVELOPMENT FACILITIES AND EQUIPMENT IN CHINA

- **There are five public proving grounds in China: Nong'an, Beijing, Xiangfan, DingYuan and Hainan**
- **There are 15 K&C test rigs in China. Seven were made by KHAT, one by Lotus, three by MTS and four by ABD**
- **There are two low-speed tire F&M test machines at Chinese OEMs and one high-speed tire F&M test machine at a tire supplier**
- **Two OEMs have their own damper tuning truck, as do half a dozen damper suppliers**
- **Almost all OEMs have handling test devices from Racelogic and Dewetron. Inertial Measurement Units tend to be Moog Crossbow VG700s and VG800s but OxTS's RT3100 is also used**

Source: Gao Yi, KHAT

AERIAL SHOT OF THE IMPRESSIVE NEW SHANGHAI GM/PATAC GUANGDE PROVING GROUND

RIGHT: **AS WELL AS OPERATING ITS OWN TRUCK (SEEN HERE AT BEIJING PROVING GROUND), COTECH BUILDS MOBILE WORKSHOPS FOR CLIENTS**

BELOW RIGHT: **WORK UNDERWAY ON THE FAW-VOLKSWAGEN GOLF CRC RALLY CAR IN BEIJING. NANDA KUMAR'S RCS ORGANIZATION DESIGNED AND BUILT SUSPENSION COMPONENTS FOR THE CAR**

"Typical Chinese roads are a mix of asphalt and concrete," he explains. "The asphalt roads have a high content of high-frequency roughness and very long-wave, small-amplitude undulations. This is usually mixed with a number of 'jumps' as bridges or underlying concrete structures stand more firm than the road itself, which over time usually sinks a bit. Meanwhile, the concrete roads have lateral ridges carved into them for higher grip, but this causes a high-frequency roughness, which can be a headache for tire noise and rolling feel development."

The setup

So now we know something about the car buyers and road conditions, we can turn our attention to setting up the car. Given the road conditions, it's no surprise that all the experts we spoke to agreed that comfort is the priority.

"Customers want a very smooth car, so the balance between comfort and handling is on the comfort side – soft springs, but also very smooth at low frequencies, approximately between 15-30Hz, so you don't feel the roughness of the road," says PSA Peugeot Citroën's VP of research and innovation, Jean-Marc Finot.

In hardware terms, this might take the form of better-riding tires with higher profiles and smaller wheels, lower spring rates, or reduced damper control compared with a European setup. But that doesn't necessarily mean that there's such a thing as a typical setup for Chinese roads.

"Not anymore," argues Clive Roberts, who has worked in dynamics development in China for more than a decade. "It was once characterized by 'avoid harshness from concrete highways', but it is now adjusted to meet the requirements of high-speed travel on the new asphalt highways. It's getting easier, perhaps."

"It's true that Chinese customers prefer a comfortable setup, but the lack of driving experience of most Chinese also makes them prefer stable cars, especially in roll," adds René le Grand. "This doesn't always go well together. Considering the road conditions and customer preferences, I'm usually surprised that most Chinese cars I drive have seriously stiff setups."

Mark Beasy, a former GM Holden engineer who's worked on many ride and handling projects in China (latterly with Prodrive), has this perspective: "Driving in China can be chaotic so my personal belief is that good handling and vehicle response is more important than isolating the ride. Chinese customers want both, but will always put comfort as a priority over handling.

"It's usual to copy [the setup of] another car, but the OEMs don't always understand the dynamics and compliance issues, so this is where they need help from western companies. Two companies copying exactly the same base car end up with dramatically different results."

Bo Zhu picks up on this issue of a lack of brand differentiation when it comes to driving dynamics.

"Without a single-minded Chinese brand that is willing to stand out in one particular character, most companies converge to a character that suits mainstream buyers," he says. "The trend for the mainstream still depends on the benchmark vehicles in each particular segment. Most of the European companies have to rely on global marketing consultancies with Chinese branches to understand the demands of local owners. They will adapt their chassis according to the market research."

Zhu also says that issues the Chinese brands inherit from tire and steering suppliers result in variance in mechanical trail, and steering hysteresis. The result is a need for countermeasures for poor on-center feel. The issues raised by inconsistent tire quality have been experienced by Heider, too.

"We're increasingly being questioned about how to prevent behaviors such as drift/pull and brake roughness, and desensitize the vehicle from them," he says. "Local OEMs haven't traditionally paid a lot of attention to the tires. Drift/pull and various vehicle vibration issues are often tire-induced problems, but the OEMs don't always realize it. The Chinese-brand tires aren't doing them any favors in this regard."

Proving grounds and equipment

It's clear from the comments of our panel that the low-quality, poorly maintained facilities and hazardous operating conditions of commercially available proving grounds in China

"You need to be patient and very hands-on: know how to measure toe and camber using rulers, sticks or anything you can find; know how to change parts in the vehicle; know shock absorbers and valvings, and expect to be building them yourself at some point. Be flexible and prepared to get your hands dirty. Don't push through a western style, but try to find a way to work together – the Chinese will appreciate it more. And don't expect to achieve anything in the first months or year. You will need to build up trust and mutual understanding first." René le Grand

makes the dynamicist's job harder than it might be elsewhere. With origins in truck or military-vehicle development and a focus on durability work, there is a relative lack of tracks dedicated to handling development. The problem is compounded when even moderate maneuvers to assess handling can be frowned upon or (as at Beijing proving ground) outlawed altogether. Le Grand, who as a foreigner in China isn't allowed to drive on every proving ground, notes that vehicle dynamics areas such as the one at Beijing can be unhelpfully rough-surfaced; ironically, other tracks are too smooth for ride development, so he prefers to head out onto public roads.

"Xiangfan proving ground, which was designed by MIRA, is the best proving ground for chassis tuning," adds Yi, referring to the facility in Hubei province near Dongfeng's base. "The roads at most proving grounds are for durability testing, and too severe for ride. For handling, most proving grounds just have the [vehicle dynamics] area, no real handling course."

Zhu agrees: "Xiangfan is better for handling than Beijing and has more test roads. But you have to pay an incredible amount of money to use their wheel alignment machine!"

It seems that the proving-ground situation is improving, however. "They were very poor until 2012," admits Clive Roberts, "but the new Shanghai GM Guangde Proving Ground and Maxxis Tyre's new facility [in Kunshan City, near Shanghai] have made a big step forward."

The picture is more complicated when it comes to chassis test equipment. There would appear to be plenty of cutting-edge rigs to assist in dynamics development programs (see *Development Facilities and Equipment in China*, p37), even if the seeming absence of a shaker rig is an obvious gap in the armory. The problem is a lack of expertise in knowing how to make the best of what's there.

"The number of new K&C rigs in China is amazing," notes le Grand. "Not all of them are properly maintained or operated. Systems are sometimes bought, installed and rarely used, either because the engineers don't know what to do with them, or simply because they overspent and need to save on electricity."

Cayman's John Heider has similar observations. "The local facilities and expertise varies," he says. "It's common for companies to spend money, but there doesn't seem to be a lot of cohesive planning. One OEM might have a state-of-the-art Anthony Best K&C rig, but no alignment rack in its facility. At another you might see brand-new Hunter alignment racks and wheel balances, but find that it is only now building a proving ground. All the OEMs have pieces of the puzzle in terms of facilities, but nobody has integrated everything together like a western OEM would."

A SUPPLIER'S PERSPECTIVE

"The Chinese vehicle manufacturers are developing very quickly and are keen to understand the technologies required to build globally competitive vehicles," says Olivier Raynauld (*right*), global manager for suspension technologies at Chinese-owned BWI Group. "Right now, these vehicles have to sell in their domestic market, which for local-brand manufacturers is very cost-competitive. The key things they value from BWI – which supplies braking and ride control technologies – are therefore fast development and an affordable product that is good quality and extremely robust without being complex. Simplification of the entire development program is also vital, not just because this further reduces costs, but also because it allows new products to reach the market more quickly. We are doing a lot with smart hydraulics, for example, which enables variable-state damping without any additional controls.

"We support all our Chinese customers from our technical centers in Beijing and Shanghai, as well as from North America," he continues. "This allows us to provide a wide range of expertise alongside test and development resources, so the right level of support can be provided for the vast diversity of local car manufacturers. These range from highly sophisticated with a global outlook and a desire for the best technologies, to those only just starting out in the automotive business, some of whom have no experience of development programs for volume vehicles."

CROSS-SECTION OF BWI'S SMART DAMPER VALVE, WHICH PRODUCES DAMPING CURVES THAT ALLOW THE SUSPENSION TO REACT DIFFERENTLY TO INPUTS OF DIFFERENT AMPLITUDES AND SPEED. IT'S POPULAR WITH CHINESE CLIENTS

Engineering culture

"To understand Chinese engineering and engineers, you first have to understand some aspects of Chinese culture," begins le Grand. "Engineering is about finding problems and finding solutions to these problems, while the Chinese get taught from birth to avoid any form of problems. Already, this doesn't bode well.

"Then there is the culture of 'Guangxi' (contacts) and 'Mienzi' (face)," he continues. "These cultural habits are all-important and the Chinese go to great lengths to find workarounds on any issues that may cause someone in the group to lose face, especially the boss. For a westerner, this whole process takes up a frustrating majority of a working day."

"In China, the concept of driving a vehicle and forming an opinion of what you think could be improved is a foreign concept," adds Heider. "In my experience, engineers there like and understand objective testing, but the concept of relating your subjective impressions to the objective data is difficult for them to grasp. They don't know what they like or what they should like."

The problem is deep-rooted, however, as many engineers don't even have a driving license, let alone basic vehicle evaluation skills. "Not many engineers in China can afford

to own a car, and the management doesn't always feel the need to teach them to drive," observes le Grand.

The short history of the Chinese car industry and the resulting absence of a 'car culture' is an issue, too; few engineers grew up tinkering with cars in their spare time. Taken together, these factors result in a lack of skilled, experienced development engineers in China. According to Yi, there are very few with more than 10 years' experience, making it inevitable that foreigners will continue to be called in to assist domestic OEMs for the foreseeable future.

Evidence suggests that the younger generation in particular is primed to step up and fill the gap, however.

"Most chassis design engineers are willing to cooperate with vehicle dynamics engineers by exchanging ideas at a component level, and learn more regarding its influence on whole-vehicle performance," says Zhu, a 30-year-old Chinese. "Within Chinese OEMs, the Chinese expats, or foreigners who have previously worked in foreign OEMs, provide valuable experience to the younger generation of engineers. The relative lack of hands-on experience offered in Chinese universities means that most of the [homegrown] vehicle dynamics engineers have a CAE or chassis-engineering background, so a holistic view is needed. Some Chinese OEMs are aware of this and have been developing their vehicle evaluation teams for years, so that they can do a better job as vehicle dynamics engineers. As a vehicle dynamics engineer myself, I also think there is a lot more to be learned."

RIGHT: **COTECH'S DAMPER TUNING TRUCK HAS A ROEHRIG EMA 2K DYNO. THE COMPANY IS ALSO THE SALES REPRESENTATIVE FOR ROEHRIG AND VEHICO EQUIPMENT IN CHINA**

The future

Everyone we spoke to agreed that the level of chassis and dynamics expertise within Chinese OEMs is growing. But not all our experts share Zhu's confidence in the future development of an indigenous pool of dynamics-engineering talent in China.

"Mostly due to the above-mentioned cultural habits, I don't think there will be any great cars, not based on other cars, coming out of China in the next 10 years," offers le Grand.

Heider is also skeptical, saying that he's seen only limited evidence of OEMs in China making progress toward designing, developing and engineering chassis systems themselves. He adds that none of the Chinese customers he deals with has big plans for Europe or North America.

Others are more optimistic.

"Chinese engineers are severely hampered by a lack of experience outside their home area, but they learn fast and soak up good training," says Roberts. "[In a decade] they will be capable of tuning for the domestic market, but the lack of global experience will continue to be a restriction. They're eager and clever, but so were we – and if it requires 10-15 years' experience to know how to put a good tune together, that is how long it will take an eager and clever person of any nationality."

"Most of the Chinese engineers I have worked with understand that they are nowhere near ready to tackle vehicle dynamics themselves and have stated that it is the next generation coming though who will be," says Beasy. "The kids that play with cars, run around making engine noises, modify their electric bikes, mopeds and eventually cars to make them go faster and handle better are the ones who will be up to scratch."

Zhu believes that the rise of homegrown expertise could at last lead to Chinese-brand vehicles developing more distinct characters.

"I think the managers of Chinese OEMs and joint ventures alike will be pleased to rely on Chinese talent to develop their vehicles, not only for a better alignment of the engineers' interests with the company's, but also for a better understanding of the end user's tastes."

What this will mean for the western consultancies plying their trade in China remains to be seen, but the market is only set to get tougher.

"I see a lot of things changing in this part of the world right now," says Nanda Kumar. "All customers, OE or otherwise, are constantly looking for cost-effective and efficient solutions. Some clients want access to K&C rigs, some just want the job done. Understanding what the client wants goes a long way. Whether or not this new generation of engineers will drive a shift away from western talent will depend on how the western talent deals with these changes."

OBSERVATIONS AND ADVICE FOR DYNAMICISTS WORKING IN CHINA

"Unlike in Europe and other places, tire development is rarely a part of the vehicle development process in China." ***Bo Zhu***

"Local engineers are happy to work with the foreigners who come to China. They can learn from them and can also make the project run smoothly. I have worked with engineers from Lotus and Prodrive. They are very professional and work hard. But sometimes overseas companies change their engineer mid-project: in the mule-car phase the vehicle is tuned by A, but they send B to do prototype-phase tuning. Chinese customers do not want this." ***Gao Yi***

"Language is not necessarily a barrier. A good Chinese engineer I met, who could also drive fairly well, didn't speak any English. My Chinese was equally poor, but we could communicate in the language of vehicle dynamics exceptionally well." ***Mark Beasy***

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The missing link?

VEHICLE DYNAMICS CONSULTANT **IAN WILLOWS** OF MIRA BELIEVES A NEW DESIGN COULD RESOLVE THE CONFLICTING DEMANDS OF WHEEL CONTROL AND ISOLATION

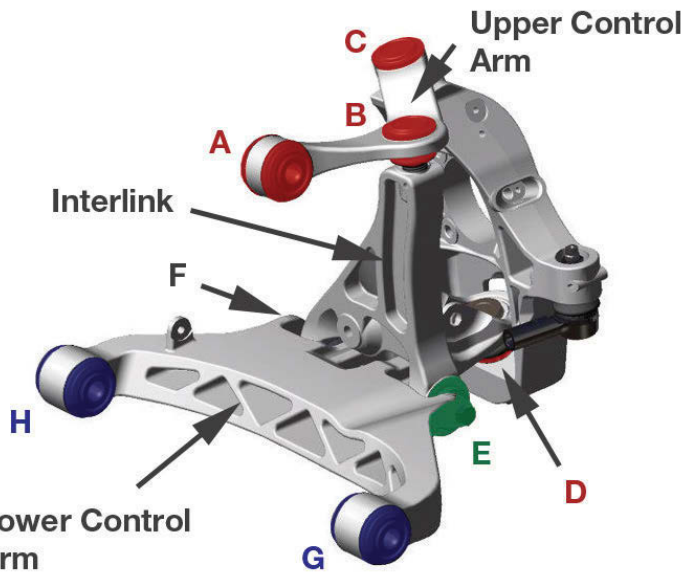


FIGURE 1: **IDWS DESIGN. A, B, C & D: SPHERICAL JOINTS; E & F: REVOLUTE JOINTS; G & H: COMPLIANT BUSHES. MIRA BELIEVES IT COULD BE APPLIED AS A FRONT OR REAR SUSPENSION, AND IS SEEKING TO DEVELOP THE CONCEPT WITH SUITABLE OEMS**

The demands on vehicle suspension performance – in terms of both accurate wheel geometry control and isolation – have increased steadily over the past decade as the requirements of steering, handling and styling have driven car makers toward ever-lower profile tire choices of a larger diameter.

Although the high cornering and inclination stiffness characteristics of these lower profile tires have benefited the steering and yaw responses of the modern vehicle, the associated increase in radial stiffness has reduced the tire's effectiveness as an isolator for ride comfort and harshness. Consequently, the modern suspension system has to ameliorate this loss of tire compliance while still retaining accurate wheel control if ride comfort is to be maintained. In particular, soft longitudinal rates at the wheel center for improved harshness and impact performance are increasingly desirable.

However, this requirement for longitudinal compliance has an unfortunate side-effect on hub control when braking forces are applied to the suspension system. The longitudinal elastic center of most suspension types generally lies somewhere in the region of the wheel center. Consequently, the hub rotates when the suspension is subject to braking forces, yet it remains relatively stiff when subject to impact forces, which are resolved at the wheel center.

The lower the longitudinal stiffness of the suspension, the greater the associated hub rotation under braking. In the case of a front suspension, this gives potential for excessive castor trail loss and attendant steering instabilities. Traditionally, because the castor and longitudinal stiffness are coupled, the only way to prevent high castor loss while lowering the longitudinal stiffness has been to increase the effective knuckle length, as exhibited in 'high top arm' wishbone systems and the MacPherson strut type. However, these tall suspension systems require more package space and higher bonnet lines than a short knuckle design such as the narrow spaced double wishbone.

A better solution would be a suspension whose longitudinal elastic center is moved vertically down from the wheel center to the ground plane region, thereby effectively decoupling the castor and longitudinal stiffness. A design of this type has been attempted previously by Honda, with its 'control pivot' suspension on the front of the NSX, while both Lotus, with its M100 'raft' front suspension, and McLaren, with its F1 road car 'ground plane shear center' front suspension, have each attempted to decouple the longitudinal and castor stiffness.

MIRA, a global engineering consultancy, has patented a new design, the Interlinked Double Wishbone Suspension (IDWS), based on the narrow-spaced short-knuckle double wishbone configuration. The IDWS features a longitudinal elastic center that can be positioned at or below the ground plane. The design retains the good kinematic properties and simple compact design of the traditional double wishbone layout but, by virtue of its elastic center placement, has now effectively decoupled the longitudinal and castor stiffness, allowing the former to be tuned independently of the latter.

The IDWS design (Figure 1) features a wishbone type lower control arm coupled to a single upper control arm via an interlinking wishbone. The lower control arm retains the normal, body-side, elastomer mounting bushes and connects to the interlink via revolute joints, enabling the interlink to hinge on the lower control arm. The upper control arm uses ball-joints for both its body-side and interlink connection points.

On first inspection, the IDWS appears to be over-constrained kinematically, but the constraint is successfully removed by allowing the upper control arm to rotate axially between the body-side and steering knuckle attachment points, and by offsetting the upper control arm connection point to the interlink from this axis.

The improvement in the response of the suspension system to braking forces, caused by moving the longitudinal elastic center down to the ground plane, is readily seen

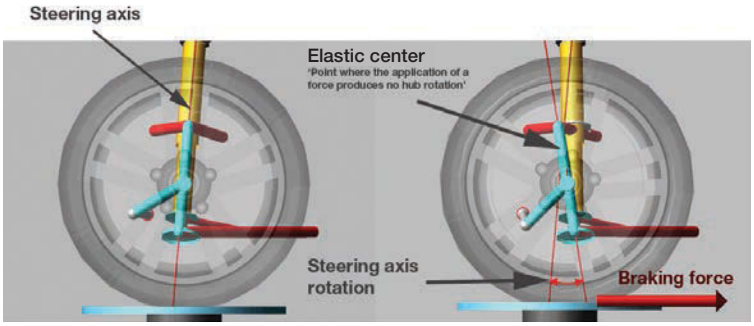


FIGURE 2: **RESPONSE OF A DOUBLE WISHBONE FRONT SUSPENSION TO BRAKING FORCES**

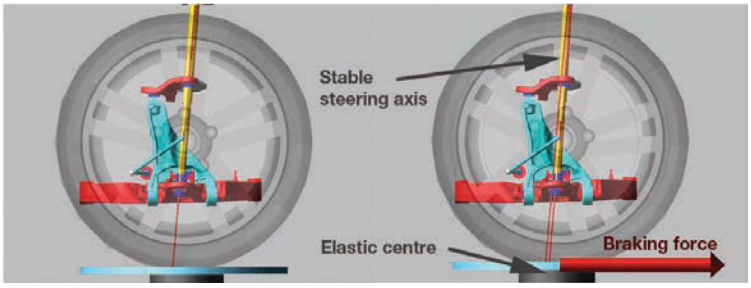


FIGURE 3: **RESPONSE OF THE IDWS TO BRAKING FORCES**

from the CAE analysis results in Figures 2 and 3. The response of a traditional double wishbone type front suspension to braking forces is depicted in Figure 2; the hub and steering axis rotation, loss of castor trail and approximate elastic center location are all apparent. In comparison with this, the response of the IDWS to the same forces (Figure 3), exhibits a stable steering axis and a high tire contact center stiffness associated with its below ground elastic center.

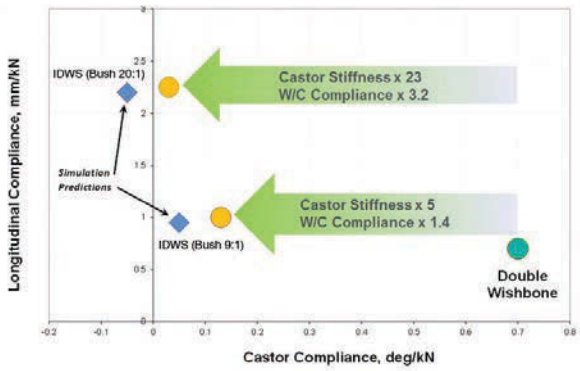
Both simulation and subsequent prototype testing have proven the effectiveness of the IDWS concept in decoupling the castor and longitudinal stiffness. Figure 4 illustrates the relative castor and longitudinal stiffness performance improvements, in the form of a cross plot of the longitudinal and castor compliances, achieved by using the IDWS in place of an existing double wishbone type front suspension, on a current high-end sports car. Results, both for the simulation predictions and subsequent physical measurements on the prototype vehicle, are illustrated for the IDWS when equipped with lower control arm body-side bushes of two different stiffness ratios (9:1 and 20:1, radial to axial stiffness respectively) in comparison to the standard vehicle double wishbone type suspension. Coincidentally, the bush with the 9:1 stiffness ratio is also that fitted to the lower control arm of the standard vehicle double wishbone suspension. The exceptional increase in castor stiffness conferred by the IDWS configuration is immediately apparent, together with associated improvement in the wheel center longitudinal compliance performance.

The longitudinal stiffness of the IDWS is controlled principally by the axial stiffness of the lower control arm body-side mounting bushes, while their radial stiffness contributes significantly to the castor stiffness of the suspension. Therefore a high ratio of radial-to-axial bush stiffness will provide the IDWS suspension with high castor stiffness and a low longitudinal stiffness. As this bush stiffness ratio increases the longitudinal elastic center of the IDWS moves below the ground plane, giving potential for a castor angle increase rather than reduction, under the application of braking forces.

The high castor stiffness confers benefits not only in steering-axis stability, but also in the suspension's compliance brake-steer characteristics. The absence of any significant hub rotation results in very low values of vertical displacement of the track rod (or toe control link if applied to a rear suspension) outer ball joint, and consequently the associated toe-in/toe-out changes are negligible.

The IDWS also allows for a unique treatment of anti-dive (or anti-squat) characteristics. These are now largely governed by the plan angle rotation of the interlink mounting axis on the lower control arm. Figure 5 illustrates the case for increasing anti-dive.

The IDWS design enables the lower control arm to be mounted horizontally (rather than inclined) to the chassis and the anti-dive/anti-squat properties to be tuned without changing the body or chassis mounting structure.



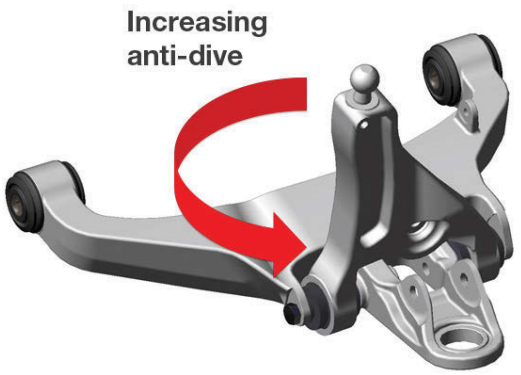


FIGURE 4 (FAR LEFT): **CASTOR AND LONGITUDINAL STIFFNESS PERFORMANCE IMPROVEMENTS**

FIGURE 5 (LEFT): **ANTI-DIVE IS CONTROLLED BY INTERLINK ROTATION, SO NO INCLINATION OF THE LCA IS REQUIRED**

Godzilla!

IT WAS THE HIGH-TECH CAR THAT CEMENTED THE GT-R NAME IN AUTOMOTIVE FOLKLORE. **BRIAN COWAN** PROFILES THE R32 NISSAN SKYLINE GT-R, NICKNAMED 'GODZILLA'

Later R33 and R34 variants offered a greater level of technical sophistication, but Nissan's R32 Skyline GT-R (produced between 1989 and 1994) remains the quintessence of its lineage. Bold, raw-edged and razor-sharp, it flipped the finger at supercar aristocracy and cemented the GT-R legend in the minds of performance car enthusiasts.

The R32 combined a near-unbreakable powerplant with transmission and chassis technology that was advanced for the time. Most importantly, the technology worked, flattering average drivers and offering prodigious levels of grip and balance for those who enjoyed pressing on.

History (not least by way of hundreds of expensive crashes) has shown that many of the top-echelon supercars of 25 years ago had knife-edge dynamics. The GT-R offered a satisfying alternative. At moderate speeds, it had the accuracy and balance of a front-engine, rear-drive layout; then, when traction limits approached, drive was progressively directed to the front wheels.

The car's ATTESA E-TS (Advanced Total Traction Engineering System for All, Electronic Torque Split) all-wheel drive system was based around a wet multiplate clutch, driven by a multilink chain from the back of the five-speed manual transmission and controlled electrohydraulically. Input variables considered by the ATTESA control unit included engine speed, throttle position, wheel speed readouts from the ABS units and

information from three centrally mounted *g*-sensors, two longitudinal and one lateral.

Compared with a similar system in its near-contemporary Porsche 959, which always had at least 20% of torque directed to the front wheels, the GT-R's default position was full rear-wheel drive. Theoretical maximum torque split was 50:50, but it could only be achieved under maximum acceleration. Typically, the front torque bias seldom topped 30%. In addition, the mapping saw it

MOUNTAIN MONSTER

In the 1950s and '60s the film monster Godzilla terrorized Tokyo. In 1991 and '92, its automotive namesake dominated the slopes of Mount Panorama, home of Australia's famous Bathurst endurance race.

The 1992 win, in what was then called the Tooheys 1000, was controversial. A sudden rainstorm in the closing stages caused multiple crashes and forced the termination of the event for safety reasons. One of the victims was the lead GT-R, co-driven by Mark Skaife and Jim Richards. Unable to continue, it had been passed by the Ford Sierra of Dick Johnson and John Bowe before the red flag was shown.

However, because the Nissan had been leading at the last completed lap, it was declared the winner. This provoked a backlash from the deeply tribal fans of Australian touring car racing, already smarting from the dominance of the turbo Group A Japanese model over their beloved Holdens and Fords. Heckling and jeering at the post-race winners' presentation was so severe that the normally easy-going Richards told the crowd, "This is bloody disgraceful … you're a pack of arseholes."

Public antipathy to the Skylines' success was partly instrumental in the dropping of the Group A-based Australian championship and the mandating of a two-model (Holden Commodore and Ford Falcon) series that subsequently morphed into V8 Supercars. That most basic of rivalries has lasted 20 years; only this year have the V8 Supercar regulations been opened up to other brands, with Mercedes and Nissan the first to respond. Nissan's contender is based on the Altima, however, not the current GT-R.

ABOVE: **JIM RICHARDS AND THE SKYLINE R32 GT-R ON THEIR WAY TO VICTORY AT BATHURST IN 1992**

MAIN: **1993 GT-R V-SPEC FEATURED MAJOR BREMBO BRAKE UPGRADE**

A TUNER'S DREAM

The RB26DETT in-line six fitted to the R32 had a capacity of 2.6 liters, chosen because under the turbo equivalence formula it fitted nicely for Group A, the racing class Nissan was aiming the car at. In road trim the R32 produced around 330bhp. Moderately simple modification of the turbo system could see this reach closer to 400bhp, while in race trim it was good for 600bhp+.

CLOCKWISE FROM ABOVE: **LEGENDARY CALSONIC GROUP A GT-R WON 1990 AND '93 ALL-JAPAN TOURING CAR CHAMPIONSHIPS AND FOUND FAME IN THE GRAN TURISMO VIDEO GAME; 1993 V-SPEC INTERIOR; RB26DETT STRAIGHT-SIX MOTOR**

limited yet further under high lateral acceleration, even when the rear-front rotational speed difference was high.

As a result, it was not difficult to induce power oversteer mid-bend. The trick was not to ease off as convention and experience might dictate but rather keep the hammer down, for as the lateral *g* dropped after mid-bend, the torque would feed progressively forward. It was for all the world as if the car was being pulled out of the corner – not only conferring a delightful sensation to the driver, but also contributing to impressively high exit speeds.

More than anywhere else, the genius of the R32's dynamics lies in the ATTESA E-TS system. In several fundamental respects the car was an understeerer, partly the result of a 59:41 front:rear weight distribution, a high polar moment of inertia and a fair amount of front aero lift.

Also contributing to the inherent understeer characteristics was the passive (mechanical) limited-slip rear differential. Based on friction clutches, it was eventually supplanted in the ATTESA E-TS Pro offered with the R34 model with an electronically controlled active differential, able to apportion torque across the axle as conditions dictated. The front differential in the R32 was open.

Equally simple was the model's three-channel ABS system – although it offered a significant advance on most of its contemporaries by being integrated with the ATTESA. Consequently, when lock-up was imminent on the front wheels, the controller would direct torque forward in response. As a result, the braking performance of the car was quite outstanding for its time.

However, when worked hard, the standard brakes – 300mm cross-drilled rotors with four-piston calipers in front and two-piston at the rear – were prone to overheating and cracking rotors. A major upgrade was offered with the V-Spec model in 1993, which used Brembo aluminum calipers and 325mm front and 300mm rear rotors, with a diamond shaped ventilated rib structure.

At low and medium speeds especially, greater handling agility was conferred by Nissan's HICAS (high-capacity actively controlled steering). The rear steering system had been used on several mainstream models before the R32 GT-R, but the model introduced a new generation, dubbed Super HICAS. This continued to use hydraulic actuation as its central design feature, but unlike its predecessors, which used only same-phase steering, it was able to countersteer as well.

In slow corners taken at low and medium speeds, the wheels countersteered by 1° on turn-in, then steered slightly the same way as the fronts to counter the subsequent yaw moment. Entering higher-speed corners, there was no rear-steer effect on turn-in but a little same-steer on exit, increasing to a full 1° at the highest speeds.

Actuation was by a hydraulic cylinder linking the inner ends of rear lateral arms in the car's multilink rear suspension.

Although it contributed to a feeling of increased agility at moderate speeds, the R32's Super HICAS was more a reflection of the technical fashion of the age than a huge leap forward in vehicle dynamics. The hydraulic system's responses weren't blindingly fast and could occasionally become tangle-footed – although a less than stiff body structure and high wear rates in the suspension bushes were as much to blame for handling idiosyncrasies in high-mileage cars as the HICAS. It was invariably disconnected when cars were to be used on track, and many owners of road models followed suit.

The multilink front suspension made its debut in the R32. It comprised a lower lateral link and angled tension rod, with a high-set, angled upper link and a third link connecting the upright to the coil-over damper and the axle housing. The design's geometry ensured minimal camber variation over a wide range of suspension movement.

The rear layout followed a design introduced a year earlier in the S13 Silvia and featured two upper links and a lower A-arm, the latter attached to the subframe in the manner of a semi-trailing arm. Its pivot axis was also inclined downward to provide anti-squat geometry. Compression of the mounting bushes and the lower arm geometry gave toe-in when required, while the HICAS operating arms acted as toe-control links as well.

In an effort to further counteract the chassis' understeering characteristics, the R32's engineers gave it a 'soft' front end, with a roll bar 20% thinner in diameter than its rear counterpart, and spring rates 11% lower.

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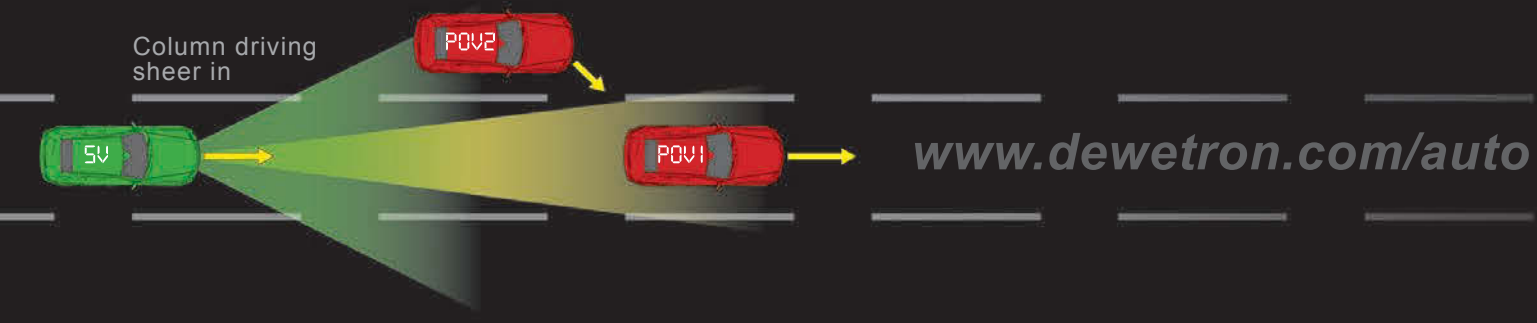

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Tool of the trade

KEITH READ DISCOVERS A RAFT OF IMPROVEMENTS TO MSC SOFTWARE'S UBIQUITOUS ADAMS PACKAGE THAT WILL HAVE DYNAMICISTS PURRING


MIKE COLLINGRIDGE


INGO PORSCHE


CHRIS BAKER

Few would argue that in the revolution that has been multidiscipline simulation, MSC Software has led the way – and continues to do so. Its Adams multibody dynamics technology platform – synonymous around the world with virtual simulation – has been greatly enhanced with the release of Adams 2013, which brings a number of time-saving and ease-of-use benefits.

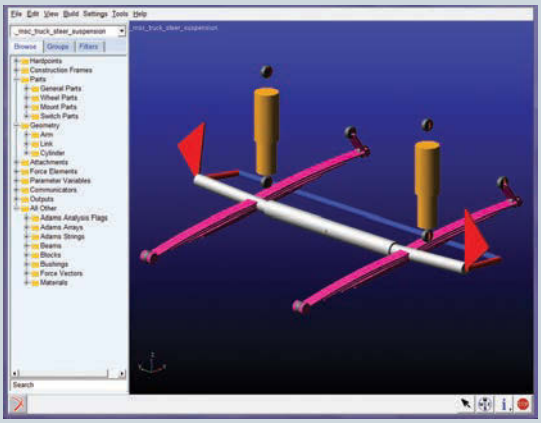
Key among these is faster performance. The Hilber-Hughes-Taylor (HHT) integrator now has a more efficient step size selection to make all classes of models faster as well as having the option of Adaptive Interpolation for improved solver speed – four times faster for a typical rough-road-ride simulation and a staggering 10 times faster for a straight-flat-road test.

One of the major features of Adams/Car 2013 is the inclusion of the leaf-spring preprocessor, previously available in Adams/Chassis, to define leaf-spring topology. A single-leaf model is also fully supported, reducing the need for custom solutions and enhancing ease of use. This new feature will benefit light- and heavy-truck CAE analysts.

MSC's SmartDriver virtual driver model has also been improved. "We've consolidated the various modeling paradigms into a new powertrain offering that also features automatic transmissions and very simple drivetrains," explains Ingo Porsche, Adams' development manager. "It's simple because the powertrain in our virtual car is just a means of getting the vehicle moving and enabling engineers to concentrate on dynamics. We just want to get the car on the road at certain velocities and simulate that. With a very sophisticated model you need all the realistic data for that model, but many of our customers asked us to provide a much simpler model."

Adams/Tire can now be applied to ride analysis with high fidelity and low computational costs. Chris Baker, Adams' product manager, says vehicle dynamics groups traditionally had an affinity with racing. The result was focus geared toward handling, at frequencies below 15Hz, rather than ride. "But customer groups are now demanding more in terms of ride comfort and quality, so vehicle dynamics organizations are taking more of an interest there – and that's what's driven development of our new tire model. In Adams/Tire 2013, the belt dynamics option offers validity up to 70Hz.

"In addition some of our current activities on the development side include embedded non-linear technologies that will help us model those higher-frequency events better. We're trying to bridge the gap between the ride and handling domains. Likewise there's interest from larger OEMs for us to bridge the gap between durability attributes and vehicle dynamics attributes. On a one- to three-year timeframe you're going to see a lot in terms of multibody dynamics tools


SCREENSHOT OF A LEAF SPRING SIMULATION IN ADAMS 2013

incorporating things of that nature. This will enable vehicle dynamics and durability groups to communicate more efficiently using common models. For that to happen we have to integrate the various technologies."

Baker says customers are demanding more from the OEMs, meaning the OEMs are leaning on the software industry. "But you're also seeing some push from our side. We're looking at our product portfolio. We have a lot of expertise and are considering how we can deliver more to our customers."

Mike Collingridge, director of development for Adams, believes current simulation can accommodate 80% of customers' demands. However, by integrating technologies he says the other 20% can be covered too. And when it comes to equipping OEMs in the future, one of the blue-sky areas that MSC has firmly in its sights is for simulation to become independent of physical tests. "A lot of our high-fidelity generations still depend on physical test data for various components – engine mounts, bushing, suspension components and tires. But we want to get away from dependence on physical testing and start incorporating virtual models for components that have non-linear amplitude as well as a frequency dependency. We want to be able to capture all that high fidelity virtually to facilitate quicker-to-market and more optimized designs."

Hardware development over the past 10 to 15 years means that what was once a task undertaken only on something like a UNIX workstation can today be done on a tablet. "If linear and non-linear FE capability is included in the body domain, you're talking about an explosion of CPU power requirement," says Porsche. "But it seems to me that the industry is going to make CPUs more affordable rather than more powerful, so it may be a couple of years before we see new versions that are really up to the task."

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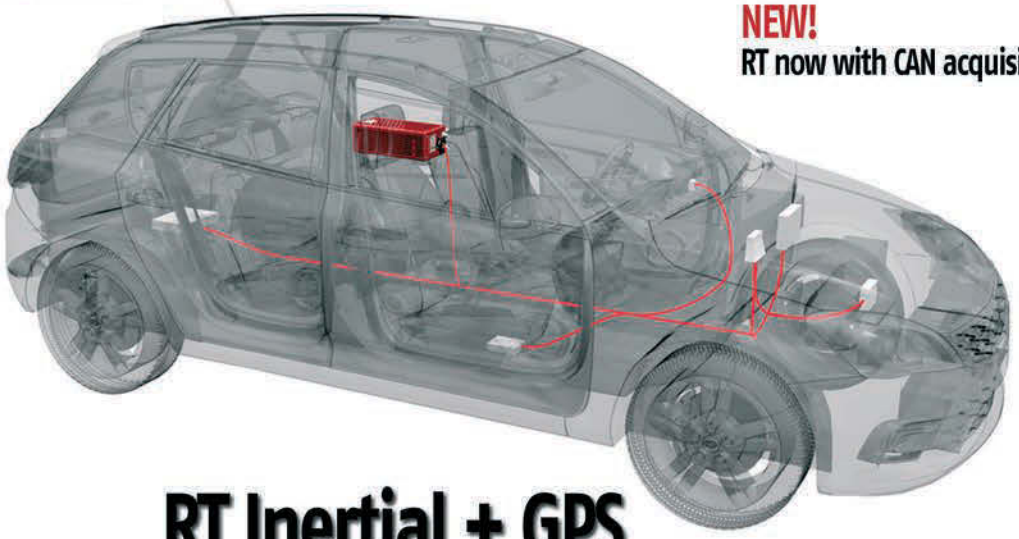

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MORE THAN 70 COMPANIES SERVING VEHICLE DYNAMICS DEVELOPMENT WILL BE AT MESSE STUTTGART ON JUNE 4-6, 2013. HERE ARE JUST A FEW OF THE HIGHLIGHTS...

WHO TO MEET

Maarten van Donselaar, CEO, Cruden

Dr Anna Schwarz, general manager, Danto Invention

Christian Kehrer, key account manager, ITI

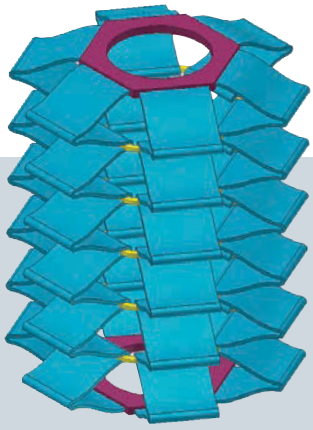
BOOTH V2318

MOTION CUEING DEVELOPMENTS

Cruden will be exhibiting again this year with a Hexatech simulator set up in an automotive driving configuration.

It will also be revealing new simulator motion cueing developments for the automotive market, and showing how custom cueing filters can be implemented for use with its simulators by simulator development engineers.

With its ePhyse plug-in, Cruden has introduced a way for its customers to seamlessly integrate their own vehicle dynamics models with the simulator, in addition to using Cruden-supplied internal models. This flexibility, and the growing confidence of simulator engineers, has generated demand for even more control over the simulator's motion cueing filters. In future, Cruden customers will be able to create their own motion cueing filters (e.g. in Simulink) while the Cruden software takes care of kinematics, safety aspects and workspace management.



BOOTH V2312

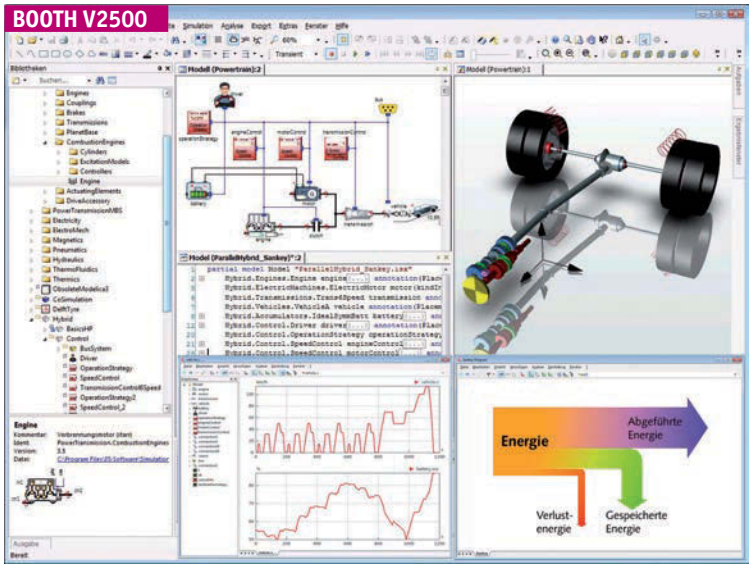
STEEL COIL SPRING REPLACEMENT

Danto Invention is a young company that was founded as a spin-off from the Technical University of Darmstadt, Germany. It offers innovative lightweight construction concepts with fiber-reinforced plastic composites.

In Stuttgart, the company will turn a spotlight on its newest invention – a coil spring made of glass-fiber-composite. The technology offers a distinct weight reduction of up to 70% and improved fail-safe behavior with no corrosion problems. Heavy spring caps and overload springs can be omitted or designed smaller; further weight reductions result from omitting or changing components. There are numerous variation possibilities and the direction of the reaction force is variable. Side-load compensation is possible; the spring characteristics are adjustable (declining or progressive); and the height ratio of unloaded to fully deflected spring is very high.

Furthermore, an improvement in vehicle dynamics from the reduced unsprung mass can be achieved, and the spring also provides increased safety and driving comfort, claims Danto. It has a higher longitudinal eigenfrequency, better damping characteristics and improved acoustic behavior. Finally, the spring offers minimal transport costs due to weight reductions, and it is suitable for a MacPherson strut.

BOOTH V2500



MODELING AND SIMULATION PLATFORM

Show exhibitor ITI specializes in physical 1D and 3D modeling, and system simulation. Its comprehensive engineering services support the development of new products from functional design through to virtual testing (HiL, SiL).

SimulationX provides a single platform for modeling, simulating and analyzing complex components and entire mechatronic systems. It is widely used for the design of powertrains with detailed functionalities, in the development of chassis systems and for the simulation of vehicle dynamics. By analyzing the dynamic behavior, level of power density, efficiency, flexibility and driving comfort in SimulationX, engineers can determine the extent of interaction between multiple physical systems to ultimately create next-generation powertrains. Elements and model libraries work out of the box to ensure an efficient workflow from start to finish – post-processing included. The software also offers various interfaces for other CAD/CAE environments and supports the Modelica language.

ITI says that renowned customers – including such as Audi, BMW, Continental Teves, Daimler, Fiat Auto, Ford, Honda, IAV, LuK, Porsche, Robert Bosch, Schaeffler, Toyota, VW and ZF – use and trust the SimulationX software, and benefit from a significant reduction in the time-to-market.

NEW SNOW CIRCLE

As part of an ongoing development project, regular Expo exhibitor Southern Hemisphere Proving Grounds (SHPG) New Zealand is constructing a large snow circle facility designed to accommodate the unique demands of constant *g*-force driving. The facility will be a valuable addition for torque vectoring ESC and other chassis and drivetrain developments.

Measuring 280m in diameter, the course will consist of 140m outer and 95m inner radii. The extra-wide 45m lane width will comprise compacted and groomed snow, with the ability to tailor ice and other winter mediums, and will be floodlit to facilitate 24/7 operation.

Construction is currently underway and is scheduled for imminent completion at a cost of US$1.8m. The project has required the blasting and removal of over 35,000m^3 of New Zealand's hardest 'Middle-Earth' rock and the removal and revegetation of over 140,000m^3 of earth. The facility will help align SHPG testing with the frozen lake facilities of the northern hemisphere winter, improving data correlation, procedural accuracy and testing efficiencies. Bookings will initially be made on a five-hour exclusive use arrangement, with SHPG's normal flexibility.

BOOTH 1258

ONE-PIECE CARBON FIBER WHEEL

Carbon Revolution, an Australian-based supplier of carbon fiber wheel technology, will be showcasing its latest development in the Vehicle Dynamics Zone.

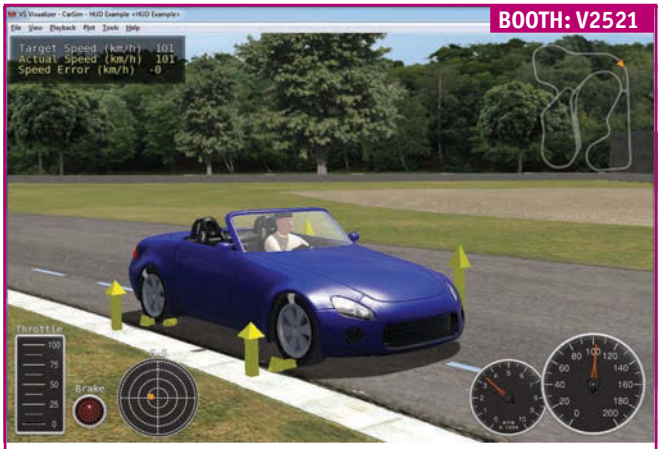
The company has designed and manufactured the CR-9, which it claims is the world's first commercially available one-piece carbon fiber wheel. Carbon Revolution also claims the CR-9 exceeds global OEM performance requirements and industry standards, while delivering significant vehicle dynamics and efficiency benefits due to reductions in weight and inertia of up to 40%-50% compared with OEM aluminum wheels.

The company claims that the technology reduces steering effort and improves steering feel, traction and suspension performance, as well as vehicle cornering response and acceleration and throttle response. It also notes that the application of CR-9 carbon fiber wheels to current sports cars noticeably improves the feel, performance and efficiency of current vehicle technology.

The company's R&D team is working with some of the leading car manufacturers to integrate the chassis technology into the next generation of supercars and lightweight vehicle platforms.

BOOTH V2421

BOOTH: V2521



ADVANCED CARSIM VISUALIZER

Regular show attendee Mechanical Simulation has released a new version of VS Visualizer, the animator provided with CarSim, TruckSim and BikeSim vehicle dynamics simulation software. The Visualizer has extensive capabilities for presenting information in a 'heads-up' display mode. The above image shows the photorealistic imaging capability of the Visualizer in a racing scenario.

In the upper left of the figure is a digital display of typical dynamic variables from the simulation, in this case showing the tracking performance of the speed controller. There are over 800 variables in CarSim, any of which can be displayed on the screen. Also illustrated are various types of graphics available to the user. This example shows throttle percentage, a brake application indicator, a G-G meter, tachometer, speedometer and a track map with location and heading. All graphics properties are under full control of the user.

CarSim, TruckSim and BikeSim also include a built-in speed controller based on a path preview algorithm.

Conference program

THERE'S A SUPERB LINE-UP OF SPEAKERS AT THIS YEAR'S VEHICLE DYNAMICS OPEN TECHNOLOGY FORUM – AND IT'S FREE TO ATTEND! READ ON FOR FULL DETAILS, AND CHECK ONLINE AT **WWW.VEHICLEDYNAMICS-EXPO.COM** FOR THE LATEST UPDATES

Tuesday, June 4

11:00am-2:20pm

Suspension

11:00am-11:25am

Lutz Axel May, CEO, Torque And More

Non-contact height-sensor system built-in air-spring units

Working together with Veyance (Goodyear), Torque And More has developed and produced a height sensor system that is placed inside an automotive air-spring unit. The resulting product, Smart Air Springs, increases the reliability of the height sensor device (which before was an externally mounted potentiometer or angle sensor), substantially reduces the overall suspension system cost, and is adding new and market-leading features such as reduction in fuel consumption, lower road noise, automatic axle-load equalisation, additional vehicle diagnostic features, and increased driving stability.

11:25am-11:50am

Prabhat Pustake, lead engineer – Suspension Design, Mercedes-Benz Research and Development India

Case study: suspension design challenges for the Indian subcontinent automobile market

In 2012 India occupied sixth position in global automobile production volumes and is predicted to be third by 2016. Four companies capture 76% market share, with the city of Chennai expected to be the world's largest auto hub by 2016 with capacity of over three million cars annually. With huge growth potential, the market poses diverse suspension design challenges. Road conditions, driving habits, climate, and real-world usage vary widely. This presentation will offer an insight into the suspension of a car on the Indian subcontinent, helping the vehicle dynamics community to better understand actual conditions.

11:50am-12:15pm

Robert Verschuren, research scientist, TNO

Four-point Hydraulic active suspension

TNO has developed the Four-point Hydraulic (4PH) active suspension system, which consists of four individually controlled hydraulic actuators replacing the original dampers. Each actuator has passive characteristics comparable to ordinary dampers. When actuated, the system is able to track force set points up to 10Hz without compromising its passive damping characteristics. Test results show the added value of the 4PH system for both comfort and vehicle handling.

12:15-12:40pm

Dr Massimiliana Carello, assistant professor, Politecnico di Torino – DIMEAS

Vehicle dynamics development of a small urban car

The study looks at a small urban vehicle XAM 2.0 with a double wishbone suspension on the front and rear axles. The kinematic analysis has been made to calculate caster king pin camber and toe angle as a function of bump and wheel travel. A full vehicle model has been developed to study the dynamic in terms of handling and comfort in AdamsCar, and it has been experimentally validated using the instrumented vehicle on a track with the same maneuvers. Thanks to the model, a new suspension has been optimized and proposed to improve the vehicle performance.

12:40-1:05pm

Prof Massimiliano Gobbi, university professor, Politecnico di Milano – LaST (Laboratory for the Safety of Transport)

Vibration and harshness analysis from indoor testing of automotive suspensions

A suspension is positioned on a rotating drum. Forces/moments, wheel accelerations and displacements at each suspension joint are measured up to 100Hz via dedicated 6-axis load cells. A first test refers to the assessment of suspension system vibration and harshness due to the tire/wheel imbalance up to the vehicle maximum speed by monitoring the forces transmitted to the chassis. During a second test, the suspension system is excited by different cleats fixed on the drum. By analyzing forces and accelerations measured on the suspension system in the time and frequency domains, a set of performance indices is obtained.

1:05-1:30pm
Dipl-Ing Magnus Roland, president & CEO, Swedish Advanced Automotive Business
Entry-level suspension with premium characteristics
Defining the communication links between an implicit driver-in-control action with a concurrent, explicit tire-to-road action, with stochastic and difficult-to-define input is the vehicle dynamics challenge. In the early 1980s a Saab, Lancia and Fiat joint development gave remarkable empirical results as the Saab 9000 could be driven on summer tires well above 200km/h on rutted winter roads in full control. Cross-coupled action in the multilink beam suspension had the capability to control tire-to-road dynamics with extreme precision. This understanding evolved into a powerful tool for virtual development, offering the possibility to predict vehicle control with minimum testing.

1:30-1:55pm
Sreedhar Aemalla, divisional manager, Ashok Leyland
Suspension behavior and driveline vibrations
Air suspension, particularly on rear engine buses, has an impact on driveline vibrations. This is of particular concern when the suspension is a two-bag suspension with a leading or trailing leaf. This presentation discusses the behavior of the different types of rear suspension that induce driveline vibrations on a midi bus. A relative comparison is made between a four-bag suspension, a two-bellow suspension (directly mounted on the axle), and a two-bellow suspension with leading or trailing leaf.

1:55-2:20pm
Darshan Wale, manager, Tata Motors
New-generation MacPherson strut for Tata Motors passenger car
The new-generation MacPherson strut for the Tata passenger car includes side-load compensated spring with double pigtail end; dual-path top-mount positive-locking dust cover; MTV (global valve); compact outer tube and piston size. This results in improved ride and NVH, and reduced side-load weight and IPTV.

2:20-4:50pm

Traction, stability, ride and handling

2:20-2:45pm
Dr Christian Baier-Welt, head of development BL-Motors, Continental
Brushless drive in MKC1 for significantly better pedestrian protection
The presentation describes the function and benefits of the BLDC drive in the Continental future brake system MKC1 related to active pedestrian protection.

2:45-3:10pm
TBC, Firestone/BWi Group
Presentation to be announced

3:10-3:35pm
Murat Okcuoglu, senior scientist, Automotive Safety Research
Deviations in vehicle trajectory and steering input correlation by ESC activation
This presentation will summarize findings based on empirical testing carried out with the use of a steering robot, comparing trajectory with ESC on and ESC off during sine with dwell maneuvers using multiple vehicles.

3:35-4:00pm
Bo Zhu, project engineer, IDIADA
On-track data analysis and vehicle characterization
Presenting LMP race-car handling and steering characteristics using the analysis method that is shared with road cars. With focus on grip balance and the driver's steering effort build-up.

4:00-4:25pm
Amir Masoud Soltani , research fellow, Cranfield University Automotive Department
Integration of enhanced stability program with electric power-assist steering
A modular and reconfigurable control system for the integration of electric power steering (EPS) and electronic stability control (ESC) systems to enhance driver comfort as well as vehicle safety is presented here. The high-level and low-level smart actuator controllers are designed using the neo-classical control method. The tire's self-aligning torque estimation is used for the road-tire friction coefficient. A novel adaptive control allocation scheme has been developed to coordinate the control of EPAS and ESC systems with low computational cost. An HIL system with driver-in-the-loop capability has been developed to validate the systems in a real-time environment.

4:25-4:50pm
Anand Subramaniam, deputy manager, The Automotive Research Association of India
Model-based development of traction-control systems
A traction-control system (TCS) provides better driveability and acceleration performance on low-friction surfaces. This presentation covers the development of an adaptive TCS, which tries to operate at optimum slip point, irrespective of prior knowledge of road condition. The system continuously monitors vehicle dynamics parameters and calculates road surface friction coefficient μ and corrects itself to achieve maximum available traction. The TCS has been developed for an SUV using the model-based development technique. This presentation includes the approach followed, strategy details and results obtained under various test conditions.

Wednesday, June 5

11:00am-4:50pm

Simulation and development tools

11:00-11:25am
Prof Giampiero Mastinu, university professor, Politecnico di Milano
A method for measuring the inertia properties of rigid bodies
This method allows the measurement of the center of gravity location and inertia tensor of a rigid body during a single test. The technique is based on the analysis of the free motion of a three-rod, non-linear pendulum to which the body is connected. The motion of the pendulum and the forces in the rods are recorded and the inertia properties are identified by means of a proper mathematical procedure. The full identification procedure takes less than 10 minutes. The natural frequencies of the pendulum and the involved accelerations are quite low, making this method suitable for many practical applications.

11:25-11:50am
Dr Sören Rosenbaum, managing director, Kendrion Academy
Model-based design of electromagnetic control valves for semi-active suspension applications
Kendrion develops and manufactures innovative high-quality electromagnetic systems and components for customers all over the world. Kendrion's electromagnetic control valves for adaptive shock absorbers face some of the highest demands in terms of robustness and performance, so a model-based design approach is required. This presentation shows the transient modeling of the motion ODE considering the non-linear influences in magnetics and fluidics provided by FEA/CFD. The obtained results are compared with test data from prototype valves.

11:50am-12:15pm
Dr Thomas Gillespie, director of product planning, Mechanical Simulation Corporation
Trends in engineering applications of driving simulators
Systems to simulate the driving experience aid

development of complex automotive hardware and software systems. CarSim provides high-fidelity vehicle models for driving simulators with broad levels of capabilities. An overview of various levels of simulator systems will be given. CarSim is also used by the Max Planck Institute for Biological Cybernetics to conduct basic research on human motion perception and vehicle simulation. For this, the institute has developed a unique simulator based on a serial robot arm on a linear sled and a closed cabin. This system offers high dexterity and the possibility to place users in extreme orientations.

12:15-12:40pm
Dr Paolo Pretto, project leader, Max Planck Institute for Biological Cybernetics
Perception-based motion simulation
The role of motion rendering in driving/flight simulators is to provide the impression of a realistic driving/flight experience within the limited workspace of the simulators. Our new approach to motion rendering uses the findings from fundamental research on human motion perception and control to create believable vehicle simulations. We embed experimentally validated computational models of motion perception in the simulator's control system to create motion that is perceived as realistic and is less dependent on the actual simulator motion. This scalable perception-based approach aims at real-time motion rendering and all-round compatibility with any simulator for an unprecedented driving/flight simulation experience.

12:40-1:05pm
Dr Robin Auckland, senior engineer vehicle dynamics CAE, Lotus Engineering
Virtual development of the Lotus 414e Torque Vectoring Control System
An introduction to the development of the Lotus Torque Vectoring Control System (TVCS) as implemented on the Lotus 414e vehicle. Through a combination of SIL, MIL and HIL testing, the TVCS has been developed to demonstrate the following powerful features: increased agility of the 414e vehicle combined with increased stability through damping of the oscillatory yaw behavior that would result from attempting to improve agility through passive means; enhanced steering response linearity, making the vehicle easier for a driver to position accurately on the road; improved stability through reduced vehicle response to road (bumps) and crosswind disturbances.

1:05-1:30pm
Dr Johan Andreasson, technical director, Modelon
The organizational impact of vehicle dynamics using Modelica and FMI
It is well known that simulation can be used to enhance product development. As such, simulation is used extensively in the automotive industry. Unfortunately the broader use of simulation within an organization is limited by difficulties associated with model and data sharing. Here the use of Modelica and FMI is changing the scene for the deployment of simulation tools throughout the organization. This gives an organization the ability to provide more engineers with the right simulation tool to efficiently solve their problems. This presentation will highlight the benefits of these technologies in vehicle dynamics engineering and research applications.

1:30-1:55pm
Javier Gutierrez, research and development engineer, Applus IDIADA
IDIADA Virtual Proving Grounds (VPG) for complete chassis development
Scanning your proving grounds opens a new range of possibilities for developing better simulation procedures. Today's hardware and scanning technology enables simulations with digital roads to be performed in affordable calculation times. The integration of IDIADA VPG within Adams enables detailed analysis of durability as well as ride and comfort. Moreover these high-resolution roads support model development activities through better correlation with experimental tests. This will end in less real testing and shorter development process times. In addition this data would be prepared for performance testing to support driving simulator and active system development.

1:55-2:20pm
Prof BongChoon (Brian) Jang, professor, Andong National University
Development of driver tunable variable EPS logic
The EPS control algorithm is an important issue in vehicle steering system dynamics. A new type of EPS control logic has been developed to enable the driver to select or tune the steering effort by varying the EPS control logic while driving. The new driver-tunable variable control logic was simulated based on MATLAB and CarSim. Also experiments with real cars were successfully carried out and the control logic was validated in the field.

2:20-2:45pm
Guido Tosolin, vehicle dynamics engineer, IDIADA
Optimization of subjective/objective correlation metrics: tools, methodologies and process
The use of optimization techniques could dramatically speed up any development process while pinpointing the best design solutions. However, for successful application to vehicle dynamics the optimization has to be funded on a robust process to generate targets at the systems and full vehicle level. In this presentation IDIADA illustrates its methodology to integrate handy optimization tools into a typical virtual development process aimed at improving the dynamic performance of a vehicle.

2:45-3:10pm
Diego Minen, engineer, VI-grade
VI-grade driving simulator solutions
Driving simulators are undoubtedly a promising platform for professional test drivers and engineers to assess/validate vehicle dynamics using virtual models. VI-grade provides engineering expertise and tools to configure turnkey systems, including all the required hardware and software components. The successful deployment of such complex systems requires harmonization of visual, acoustic and dynamic proprioception to make the driver feel 'right' on the machine. Vehicle virtual telemetry and unobtrusive measurement of human psychophysiological reactions during driving have to be considered to assess the driver's awareness, mental fatigue and preliminary symptoms of cyber sickness.

3:10-3:35pm
Robin Roy Ponnaiyan, manager – Simulation & Testing, Modine Thermal Systems India
Durability prediction of a heavy-duty truck engine cooling system
In this era of globalization, rising demand for better mobility drives the developed and emerging economies. Commercial vehicle OEMs have to meet increasing requirements in terms of vehicle performance, durability, reliability and stringent emissions norms. In heavy-duty trucks, engine cooling systems will play a vital role in reducing fuel consumption and meeting the increased emission control norms. It is important to predict the performance and durability characteristics of an engine cooling module before it is launched on the market. This presentation examines the challenges involved in the development and validation of engine cooling systems.

3:35-4:00pm
Dr Valentin Keppler, CEO, Biomotion Solutions GbR
Active car driver and occupant models for multibody simulation
Although complex car models can be deployed in ride simulation, driver models are still restricted to artificial torque-actuated steering-wheel motion. Occupant models are more similar to dummies than to living people. This makes sense for crash simulation as this data can only be validated by dummy tests and active motion has no influence on high dynamic impact. The presentation will propose the use of smart driver and occupant models for automotive ride simulation instead, and the

benefits of using a human body model as the actuator for the steering will be shown.

4:00-4:25pm
Matthieu Worm, engineering manager test systems, Moog
The role of Moog in vehicle development
The presentation will describe how virtual designs become alive and are validated with Moog test systems. Moog driving simulators simulate road conditions and are used to reduce the design and development time of car parts, accessories, bodies and complete models. The simulator makes it possible to accurately measure the effect of certain design choices. The new car model is loaded into the simulator and the driver can then test it. Driving simulators with various setups can also be used for other applications such as evaluating the ride and comfort of a car, investigating the behavior of drivers, and evaluating active driver assistance systems.

4:25-4:50pm
Dr Balaramakrishna Nizampatnam, deputy manager, Renault Nissan Technical Center
Improving damper model accuracy for vehicle dynamics simulations
Damper tuning is treated as an art in the vehicle dynamics industry. The main aim of this work has been to study the effect of damper characteristics such as velocity delay friction, delay compression, tension delay, etc, on vehicle handling and ride performance. The study has brought out the effect of hysteresis and has shown that the region of the force-velocity curve in which hysteresis is present is important. Among all the parameters, velocity delay has the dominant effect on vehicle handling and ride characteristics. Front and rear damper characteristics have shown the opposite effect on vehicle dynamic performance. This study has been useful during damper tuning at the proving ground.

Thursday, June 6

10:30am-12:10pm

Vehicle dynamic safety

10:30-10:55am
Dr Paolo Apollonio, director, SmartMechanical Company Srl
Smart wheel for improving the performance and safety of road vehicles
The measurement of contact forces between road and tires is very important when designing road vehicle control systems and looking for performance or safety improvement. The smart-wheel concept is based on a patented three-spoke structure connected to the wheel rim. The spokes are instrumented by means of strain gauges, enabling the smart wheel to measure three forces and three moments acting at the tire-road interface. Simple but carefully optimized design, good accuracy, dynamic behavior, limited mass and low cost represent the main features of the system. Several prototypes for cars and motorbikes are already being used.

10:55-11:20am
Valerio Cibrario, manager Automotive Industry Solutions, LMS
Real-time simulations with LMS Virtual.Lab Motion
Design and validation of control or intelligent systems involves developing reduced DOF models able to perform software-in-the-loop and hardware-in-the-loop simulations where it is necessary to run in real time. Typically such simulations require simplified models through the replacement of front and rear suspensions by means of look-up tables. The consequence is the use of a lower-confidence model with respect to the real world. Virtual.Lab/Motion Real-Time gives speed and accuracy through the 150DOF model in real time, even with chassis subsystem modeling using Imagine.Lab/AMESim fulfilling the difficult real-time requirement that is needed for hardware-in-the-loop and driving simulators.

11:20-11:45am
Prof Saied Taheri, associate professor and director, Virginia Tech/Center for Tire Research
Fusing intelligent tire concepts with V2X and CACC technologies
This study will reveal how a V2V/V2I would be greatly improved if vehicles equipped with intelligent tire technology reported instantaneous road conditions to the V2V/V2I networks. In addition this technology will demonstrate the impact of direct road friction measurement on CACC by developing, implementing and evaluating intelligent tire-based CACC control algorithms.

11:45-12:10pm
Peter Sachs, consultant, Prozessautomatisierung
Vehicle Power Bus concept
Vehicle Power Bus is a new concept for a safe and reliable alternating current power bus for all kinds of electrical systems in cars, airplanes trains and ships. In contrast to existing direct current implementations, it is designed to improve the safety of multiphase systems by digital communication control. In addition to the normal three-phase power lines, a digital bus adds information on power and safety. In a failure it reduces the possibility standing light arcs, which often lead to fires. The concept has additional advantages including reliability.

12:10-12:35pm
Dr Anna Schwarz, general manager, Danto Invention
GFC springs – approved technology with a new face
With the use of modern fiber-composite materials and their characteristic flexibility, new application possibilities are available. Using these materials reduces the weight of the vehicle, consequently reducing fuel consumption and emissions. The increasing demand for comfort and safety in modern vehicles limits the accessible space. In contrast to steel solutions, the readily forming features of fiber composites enable the development of individual concepts fitted into the available space. The combination of these characteristics facilitates the production of complete component groups with fewer components in fewer manufacturing steps – an economic solution that has potential for cost reduction.

12:35-1:00pm
Dr Matthieu Amblard, R&D program manager, ArcelorMittal
Steel suspension weight savings – the effects of stiffness reduction
Steel is a better choice of material than ever to reduce the weight of automotive parts while keeping costs competitive. Its low cost, high strength, high Young's modulus, high formability and ease of assembly are some of its benefits. In this presentation a deep '5 Whys' analysis of the hurdles to further reducing the weight of a front engine cradle and lower the control arms will be discussed. Topics including front suspension kinematics and compliance, vehicle ride and handling, NVH and fatigue of welds will be covered and lightweight steel solutions presented.

1:00-1:25pm
Sreedhar Aemalla, divisional manager, Ashok Leyland Ltd
Weight optimization of a semi-integral chassis
It is a well known fact that the semi-integral bus chassis – especially the city bus – is mostly of welded construction. Furthermore if these vehicles are targeted at the Asian subcontinent, it should be recognized that the duty cycles and loading behavior are different – in fact quite abusive. It always becomes a challenge as to exactly how much the chassis should be strengthened. A welded chassis is considered the safest and easiest option but it is stiffer and heavier. In this presentation a new chassis with few extruded joining members is described, in which the overall weight is reduced.

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Hybrid simulation

INSET: **mHIL STEER SYSTEM**
MAIN IMAGE: **mHIL QUARTER SUSPENSION SYSTEM**

Testing of vehicle components and subsystems usually occurs separately, and this is why problematic interactions between the two are not revealed until the prototype is at the proving ground. At this point, unfortunately, these interactions are difficult to diagnose and expensive to resolve. This is why MTS developed mechanical hardware-in-the-loop (mHIL) testing, a unique implementation of hybrid simulation that gives OEMs an effective way to gain insight about component and subsystem interactions earlier in the development process.

While conventional hardware-in-the-loop testing combines virtual models with electronic hardware, such as power control units, mHIL test solutions combine mechanical testing hardware and virtual models in a real-time control loop.

Specifically, a computer model (virtual simulation) of a vehicle draws low- to mid-frequency dynamics from a test rig applying mechanical loads to a damper, suspension system, or some other component. Data exchange occurs in real time, enabling the vehicle model and the test rig to act on new data with each clock tick. In this way, the physical response of the component affects the behavior of the model – and vice versa.

This approach delivers big benefits for OEMs under pressure to bring new vehicles to market faster. It allows for physical inputs from difficult-to-model components and subsystems, as well as the subsequent simulation of their interactions with other vehicle systems. In so doing, mHIL generates high-fidelity vehicle, system and component behavior data much faster and more cost-effectively than traditional standalone testing or analysis. As a result, validation and optimization of component and subsystem designs can occur earlier, with fewer and faster iterations, and long before the prototype hits the track.

While mHIL is conceptually straightforward, executing it with accuracy and repeatability posed several technical challenges.

The first challenge involved the complexity of vehicle models, which must undergo significant adaptation before they can be integrated with physical components or subsystems. MTS tasked its programming experts to explore a variety of available modeling architectures and develop the skills and techniques required to work effectively within each one, so that they could seamlessly replace virtual features in the model with actual inputs from physical test rigs.

Another challenge was optimizing the response of the test rigs. MTS employed an array of special control techniques to address this issue. One example is feed-forward optimization, in which the control system anticipates future movements of the test rig and prepares it to deliver the appropriate force and motion at precisely the moment required by the real-time simulation.

The last challenge was synchronizing the models and the test rigs. Real-time, closed-loop control requires a seamless flow of data between the two. Commands must be sent, received and executed, and each step raises the risk of latency. To achieve dynamic control compensation, MTS developed a proprietary supervisor interface that handles logistics, timing and sequencing during initialization and test execution. The result was smooth data synchronization

automotive testing expo 2013 europe
EXHIBITOR

ABOVE: **mHIL FOUR-CORNER DAMPER SYSTEM**

and stable, system-wide control. Without this interface, the model, test rig and controls would have to be programmed separately and fine-tuned during the test. The resulting test data would also have to be synchronized off-line. All of these complex processes demand a great deal of attention from already-overloaded test engineers.

MTS fine-tuned its original mHIL solutions through a series of pilot projects undertaken with major OEMs. Among the first was a four-corner damper system designed to help Nissan accelerate development of a hydraulic body motion control (HBMC) system for a new vehicle platform – when the first track trial was only six months away. The MTS mHIL solution replaced the model's virtual dampers with four real ones in test rigs, enabling analysis at the component, subsystem and vehicle level. Capable of running thousands of test cases per month, this testbed enabled Nissan to quickly detect irregular behavior in its HBMC system and correct the issue well in advance of prototype production.

MTS went on to develop even more complex mHIL solutions, including one for Hyundai used to validate a new semi-active suspension system. This quarter-suspension mHIL system enabled Hyundai Mobis to perform component and system validation on a single testbed without a full-vehicle prototype. Complete subsystem evaluation involved maneuver-based tests, fault and limit handling event testing, and durability evaluation. This work revealed an unexpected interaction that was causing an ECU fault. On the test track, the cause of this problem would have been extremely difficult to identify. With a lab-based mHIL system, however, Hyundai engineers easily isolated the root cause and refined the design accordingly.

Most recently, MTS worked with a major vehicle OEM to develop an mHIL system for steering. Featuring a 5DOF test rig with ultra-low torque measurement capabilities, this system is used to evaluate electric power steering (EPS) system designs quickly and easily. It is also used to establish better benchmarks and validation targets for suppliers of EPS subsystems. The system's test capabilities are wide ranging, and include steering rack durability and characterization, steering effort evaluation and EPS pre-tuning. All of these tests incorporate a real steering rack, column, I-shaft, tie rod ends, controls and wiring.

The possibilities of mHIL are diverse and exciting. The four-corner damper, quarter suspension and steer solutions represent only a fraction of the potential applications for mHIL technology. For example, MTS engineers are already working on mHIL systems for tires, brakes, roll bars and axles, as well as a configuration that incorporates kinematics and compliance deflection measurement (K&C) inputs. Additional configurations could take the concept further, incorporating multiple subsystems – such as dampers, braking and steering – running in concert, all providing real-time data to the model. A future mHIL system could theoretically enable all vehicle subsystems to run simultaneously. MTS is already working on the technologies needed to meet that challenge.

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Quote ref VDI 001

Brake system innovation

BOTTOM: **MANFRED MEYER, VICE PRESIDENT GLOBAL BRAKING APPLICATIONS ENGINEERING**

BELOW RIGHT: **TRW'S ELECTRONIC STABILITY CONTROL SYSTEM**

The increase in vehicle safety requirements has led to the development of several braking innovations that offer advanced functions. The industry has seen some key developments over the past few years, with electronic stability control (ESC) systems becoming mandatory in Europe and North America and automatic emergency braking systems expected to soon follow suit. The pace of change is significant – from sophisticated technology features to different demands on weight, cost, packaging and integration, as well as ever reducing customer cycle times.

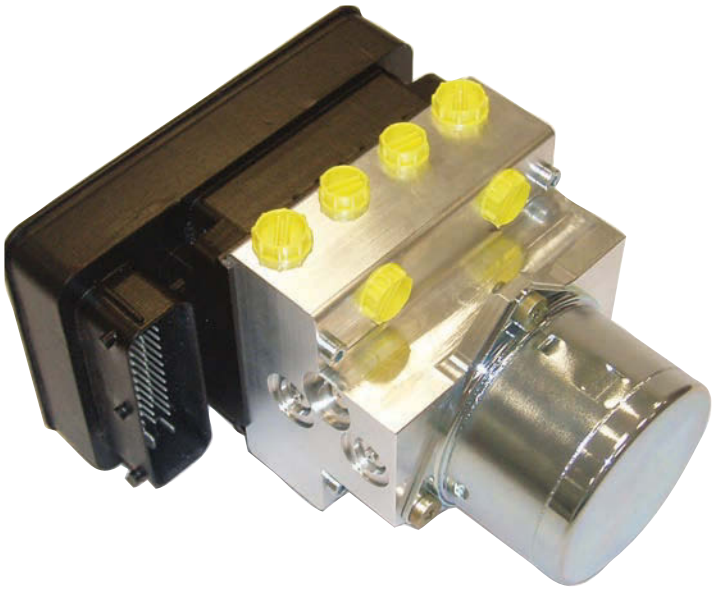
Manfred Meyer, TRW's vice president global braking applications engineering, says, "The wide number of features available on many production vehicles today is extraordinary. At TRW for instance, we are working with premium vehicle manufacturers to equip vehicles with the highest level of braking functionality enabled by technologies such as ESC, EPB [electric park brake] and our actuation systems.

"But as well as offering advanced solutions, we need to consider how we can tailor functionality through certain 'plug and play' hardware modifications. Offering modular solutions ensures we can deliver the highest specification to luxury vehicle models as well as the possibility of adapting our systems to meet global market requirements – even in emerging markets for more affordable cars."

At a recent winter testing event, TRW demonstrated its broadest range of braking features available on the production Mercedes ML. The ML is equipped with TRW's ESC system, which offers a number of off-road functions such as low-speed all-wheel drive control – allowing the driver to creep very slowly across rough areas and rocky surfaces – and hill descent control (HDC), which assists in severe driving situations on off-road hills. The HDC keeps the vehicle at the set speed by applying the brakes independently from the driver and also interfaces with the engine controls.

Steering torque control (STC) is a further feature enabled by the ESC and gives the vehicle more stability during split-μ braking by controlling steering torque and vehicle yaw simultaneously. Brake disc cleaning (BDC) also improves braking performance – for example on rainy days; the ESC applies a little pressure to clean water from the brakes and help enhance safety.

Additionally, TRW's ESC system on this vehicle features the latest



generation trailer stability control, roll-over prevention and torque vectoring braking – an enhanced function that enables the vehicle to be more dynamic in bends. For example, when accelerating during a bend, torque can be transferred from the inner wheel to the outer by braking the inner wheel accordingly.

Lastly, within the ESC system, additional pressure sensors are available as an add-on to a standard configuration, enabling enhanced adaptive cruise control (ACC) with follow-to-stop functionality, lane-keeping assist and indirect tire pressure monitoring.

The ML is also equipped with TRW's EPB – a fully integral part of the brake system that also enables emergency brake control. When combined with TRW's ESC system, emergency braking is executed through the ESC unit on both axles for full four-wheel ABS stop functionality if required. This is electronically controlled deceleration.

Meyer continues: "We have proved that we can deliver outstanding braking performance in a demanding vehicle segment that requires functions at the highest level. The feedback from road tests

LEFT: **THE MERCEDES ML IS EQUIPPED WITH TRW'S ESC SYSTEM**

BELOW CENTER: **THE VEHICLE IS ALSO EQUIPPED WITH TRW'S HDC SYSTEM, WHICH ASSISTS IN OFF-ROAD DRIVING ON HILLS**

BELOW: **THE ELECTRONIC PARK BRAKE DEVELOPED BY TRW**

and reviews has shown that this vehicle has achieved best-in-class stopping distances and stability compared with other vehicles in the top segment."

A clear trend is emerging for VMs to design vehicles suitable for both mature and emerging markets, and as part of this process they have started to reduce the number of platforms and are more focused on delivering models that can be tailored for multiple regions. Modular solutions are proving to be increasingly desirable as they can be easily adapted to suit a broad range of vehicles worldwide.

TRW's ESC family is one example of how the company is offering modular technologies. It features everything from basic units – some even developed to remove the pressure sensor to lower cost without compromising performance – through to premium units with six-piston pumps that can rapidly build and apply brake pressure for driver assist functionality such as emergency braking.

Meyer adds: "The wide range of functions on the Mercedes ML demonstrates our ability to adapt our ESC system to different end-consumer expectations and requirements. The idea is that we share the maximum number of parts across different system architectures.

"For example, we offer three main product architectures – ABS, ESC and ESC Premium – each with distinctly different packaging sizes but sharing components for standardization purposes. Within the architecture the product can be configured to suit the vehicle manufacturer's braking, vehicle sizing and functionality requirements. Many functional upgrades are achieved via software that can be scaled up with different microprocessor sizes. The aim is to help our customers meet the needs of all their markets in a short time without increasing costs."

Working with one supplier to develop the predominant part of the braking system can offer several advantages to vehicle manufacturers, for example simplifying communication and project management across all components and subsystems, and delivers a partner who has full understanding of all technology functions.

Meyer emphasizes: "To realize a project like this you need to establish a very tight network and have a good understanding of the whole vehicle architecture and its overall performance – such as tire and drivetrain behavior.

"Supplying and integrating the full system is also becoming more important for Chinese vehicle manufacturers who are keen to compete on the global stage quickly, as well as new global customer collaborations."

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New damper technology

RIGHT: **CUTAWAY OF DAMPTRONIC SKY SHOWS THE SEPARATE VALVE MODULE, WHICH CAN BE SHIFTED AXIALLY TO MEET A VEHICLE'S PACKAGING REQUIREMENTS**

The driver's demands on vehicles in the premium segments can be very high, including maximum ride comfort, and for this reason electronically controlled adjustable damper systems have established themselves as standard in such models.

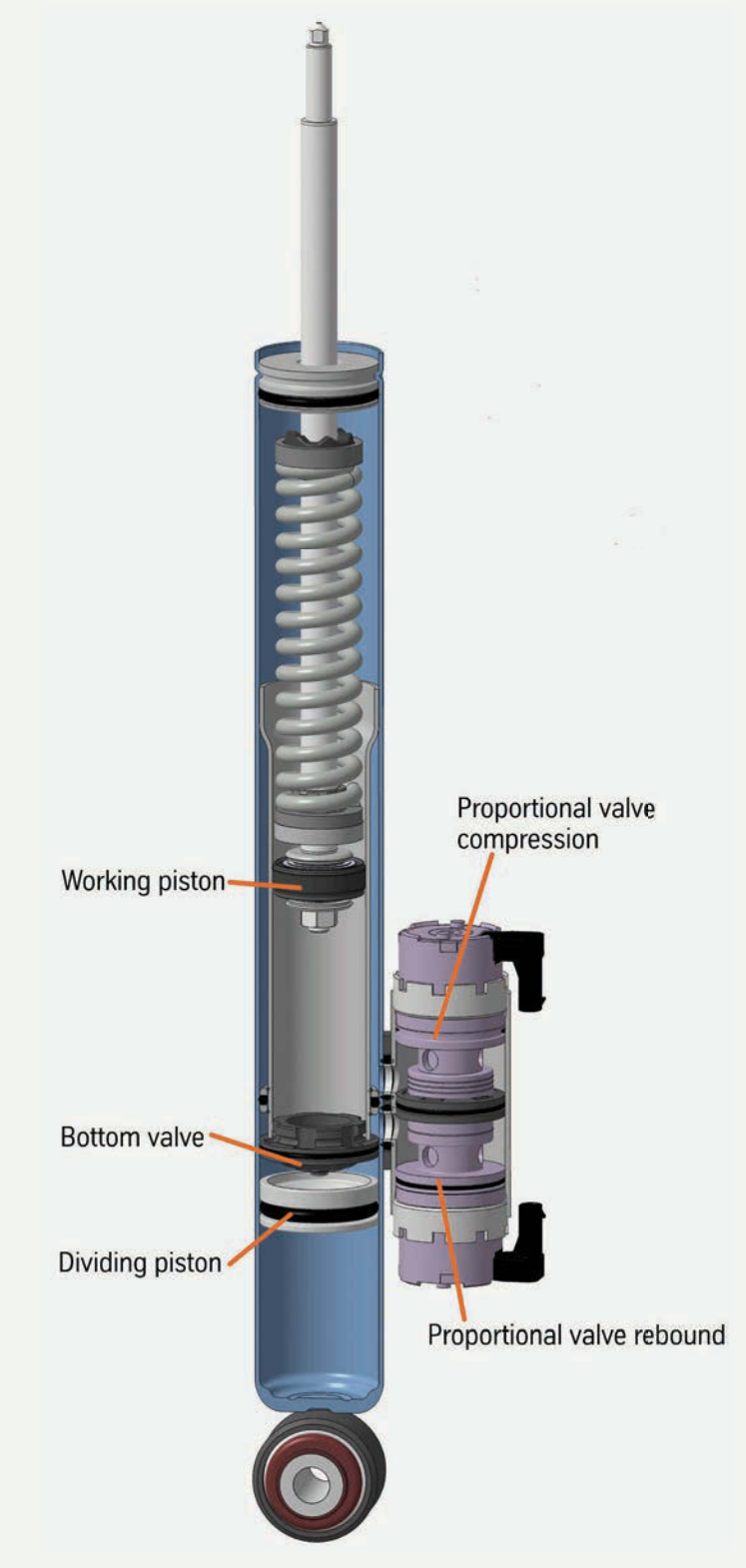
The damping control of the system is regulated by a central ECU, which processes a variety of signals from the CANbus and also takes into consideration additional information provided by the body acceleration sensors and the wheel sensors. A regulation strategy is then derived from these for the control of the dampers in order to achieve the best possible ride comfort together with the necessary agility in suspension, while also taking account of the specific road conditions.

The essential element in the regulation system is the damper, the task of which is to convert the control signals into a corresponding damping force within milliseconds. However, the overall impression for the passenger should not be of an unintended erratic application of the damping forces or even of any resultant noise.

To address and meet such high demands, the DampTronic sky damper was developed. The principle involved in the function of the DampTronic sky damper is based on monotube technology, where the oil and gas spaces are separated by a dividing piston. The damper is also fitted with a bottom valve, whereby the gas pressure – in contrast to conventional monotube dampers – can be reduced to give less friction at the piston rod seal.

A module tube is laterally connected by a flange to the damper tube. In the module tube, two proportional valves are arranged axially to each other. The hydraulic circuit created has the effect of bringing these valves into parallel activity with the main working piston at the piston rod.

When the valves are closed, the hard damper setting is essentially defined by the main working piston. When the valves are opened, the main volume flow passes

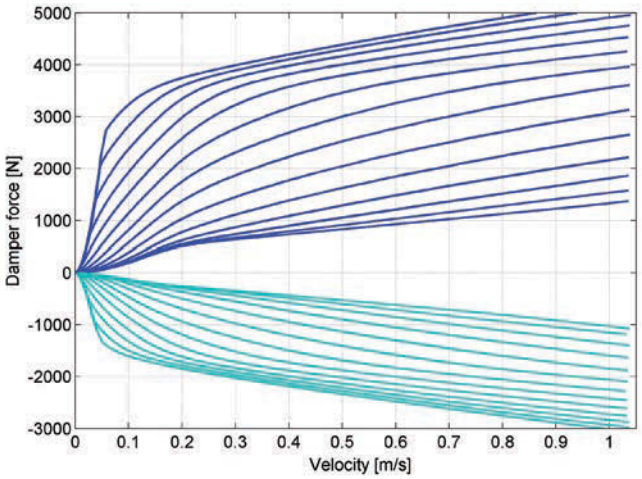


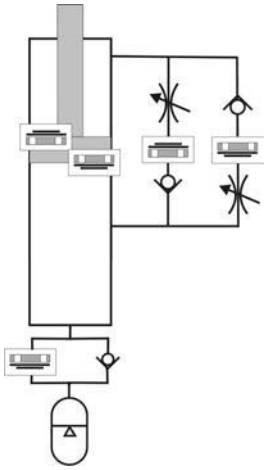
these valves and the soft damper setting is achieved.

An essential feature of the DampTronic sky damper is the separation of the volume flow from the rebound and compression stages by check valves. This enables completely independent adjustment of both working directions. That means that the upper proportional valve is only responsible for the variation of the compression stage, and the lower proportional valve for the rebound stage. These important characteristics enable any desired damping force ratios between rebound and compression to be generated as required – a necessity for the Skyhook control approach.

In comparison with adjustable dampers that have only one adjusting valve, the DampTronic sky damper, with its dual-valve technique, has particular advantages with high-frequency wheel excitations. According to the working principle, it does not require any alteration of the damping force ratio between the rebound and compression stages at high frequencies in the area of the natural frequency of the wheel. All high-frequency excitations are correctly damped by the basic hydraulics of the dual-valve technique, without phase delay. For the Skyhook approach the DampTronic sky damper switches between different rebound and compression ratios only with the natural frequency of the body. These characteristics ensure the best possible implementation of the Skyhook algorithm without frequency limits.

The adjusting valves are designed as displacement valves with a high degree of positioning accuracy. The valve principle enables very soft settings for excellent comfort on the one hand, and on the other, a high potential for firm settings in order to be able to react for stability in dynamic ride conditions. The adjusting valves are available in two versions to address the range of customer demands. The normally closed version generates the hard setting without energizing the valve; the normally open version has an inverted function and generates the soft setting without energizing. As normal road conditions usually have a higher demand for soft damper settings, the energy absorption of the normally open valves is around 80% less than in the normally closed version – an important argument in the ever present CO_2 discussions. Despite the different functionality of the various valves, it has been possible to keep the external geometrics of each of the designs identical, and this underscores the modular concept for development and production.





ABOVE LEFT: **FORCE-VELOCITY CURVES FOR THE SKY DAMPER**

ABOVE: **SCHEMATIC OF OPERATION**

To tune the DampTronic sky damper to the requirements in the vehicle as precisely as possible, disc valves are fitted at all relevant tuning areas (main working piston, bottom valve and comfort valve). Because of the high degree of variability of these valves, the hydraulic setting can be adjusted precisely to the targeted requirements of the vehicle. The excellent high-frequency behavior of the disc valves is mirrored in the overall excellent comfort impression of the damper in the vehicle.

In order to accommodate the increasing requirement for the installation of more appliances in the axle area, the basic design of the DampTronic sky damper possesses a high degree of flexibility. For example, the externally arranged valve module can be constructionally shifted axially within limits, or the connecting flange between the damper tube and the valve module can be extended, as required. Where the required unit is too long, it is possible to eliminate the gas chamber normally integrated to the lower part of the damper and replace it with an external gas chamber fitted laterally via a flange to the damper tube. This will considerably reduce the overall length of the damper.

With its DampTronic sky damper, ThyssenKrupp Bilstein believes it has been successful in developing a high-end product in the field of semi-active damping. It is characterized by a dual-valve technique with continuous and independent adjustment of the rebound and compression stages. With the great spread between this damper's minimum and maximum settings, all the relevant working areas for comfort and agility can be covered. A very attractive price-performance ratio can be obtained by the systematic addressing of design-to-cost aspects in the development and a highly automated manufacturing process.

Several series contracts have already been obtained for the DampTronic sky damper. The first series production application will appear later in 2013.

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Traction improvements

On icy lakes near the Arctic Circle in Arjeplog, Sweden, and under extreme conditions, BorgWarner successfully tested its latest all-wheel-drive (AWD) technologies including the Generation 5 (GenV) coupling, the electronically driven all-wheel-drive (eAWD) system for electric and hybrid vehicles, and the front-wheel-drive electronic limited-slip differential (eLSD), suited for dynamic vehicles based on front-wheel-drive (FWD) platforms.

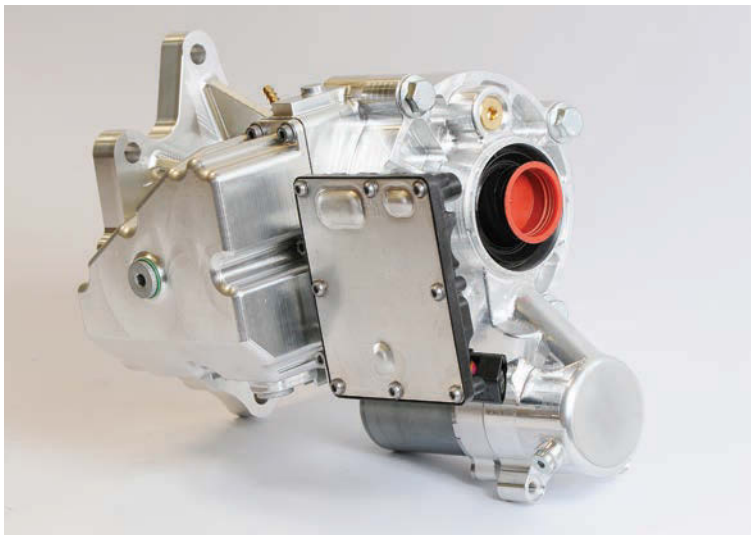
Based on a patent by Swedish engineer Sigvard Johansson in 1988, Haldex Traction has produced intelligent AWD systems since 1998, and BorgWarner completed the acquisition of the Traction Systems division in February 2011.

The GenV coupling is the youngest member of the traditional family of AWD systems. It's an electronically controllable AWD coupling designed to automatically distribute power between the front and the rear axles without any driver input. The GenV includes an electronic control unit with vehicle dynamics software that can be customized to meet each car maker's particular desires in terms of driving characteristics. In addition, the GenV coupling is very fuel efficient, distributing only the requested amount of torque to the rear axle, optimized for every driving situation. As the function of the GenV is independent of the differential speed between the front and rear axle, full locking torque, if needed, is available at any given time and speed. The new electrohydraulic clutch actuator uses a specific centrifugal overflow valve, which regulates the high-pressure oil to operate a piston to accurately distribute power between the front and rear axles via a wet multi-plate clutch. This concept makes an accumulator, solenoid valve and filter – as used in earlier generations – dispensable and therefore reduces cost and weight. The integrated ECU calculates and delivers pre-emptive and immediate response with high torque accuracy. The GenV coupling is currently supplied to two European auto makers and can completely lock front to rear axles for torque distribution up to 100% dependent on road conditions and vehicle load distribution.

BorgWarner's second new innovation solves a dilemma concerning electric and hybrid vehicle manufacturers: how to provide AWD traction and stability without adding the weight and driveline losses that reduce fuel economy and increase emissions.

The eAWD combines AWD and hybridization into one compact robust package for hybrid and electric vehicles. The system consists of two electric motors. The first provides propulsion torque to the rear wheels through a planetary gear arrangement on each side. To improve lateral dynamics, a much smaller (1/10) second electric torque vectoring motor adjusts the differential torque left to right between the rear wheels on a balance shaft that is not rotating when there is no differential speed between right and left wheel. Thus, vectored torque can be applied independent of vehicle speed, delivering increased stability with exceptional vehicle dynamics. Torque vectoring is an optional function for improving both stability and vehicle dynamics. The always active eAWD system with built-in torque vectoring functionality can reduce fuel consumption by up to 25% compared with conventional mechanical all-wheel-drive systems.

In addition, the system can also be used in plug-in hybrid vehicles or battery-powered vehicles by upgrading the propulsion motor. Furthermore, the torque vectoring concept can be applied in a mechanical driveline where the propulsion motor is replaced with



RIGHT: **BORGWARNER'S eLSD FOR CARS BASED ON FWD PLATFORMS**

LEFT: **eAWD OFFERS AWD AND HYBRIDIZATION IN A SINGLE PACKAGE FOR HYBRIDS AND EVs**

a conventional driveline. The eAWD system uses by default an oil cooling concept integrated with the lubrication system. The system can be complemented with air- or water-cooled heat exchangers for use as high-power versions.

BorgWarner also displayed its new FWD electronic limited-slip differential (eLSD), suitable for sporty vehicles based on FWD platforms. The new differential uses proven AWD coupling technology and provides improved vehicle traction, handling and stability under all road conditions, and enhances fun-to-drive characteristics under normal conditions. The eLSD acts as a differential brake for instantaneous control of the right-left differential rotational speed. Its controllability permits implementation of an active interface with the traction and stability control systems for system optimization, and reduces the number of harsh brake interventions. BorgWarner's eLSD builds on the platform developed for the 5th generation of longitudinal AWD couplings and carries over many of its main modules. Electrohydraulic clutch actuation and controls provide responsive and accurate limited-slip control of the front differential. The eLSD mates laterally to the front differential and features a dedicated ECU, which together with the centrifugal electrohydraulic actuator manages application of the hydraulic power to a wet multiplate clutch, and consequently the generated torque transfer, based on vehicle state information from the CANbus system and logics coded in the software. One of the key features of the new eLSD is the centrifugal electrohydraulic actuator, which provides pre-emptive and immediate response. An upgraded axial piston pump with new centrifugal pressure control eliminates the need for accumulator and solenoid valves as used in earlier coupling generations. To reduce vehicle level complexity, the engineers integrated the control module within the system. A further benefit is the enhanced vehicle traction by direct distribution of the available driveline torque without a brake based system intervention. BorgWarner's eLSD is expected to enter series production in the second quarter of 2013.

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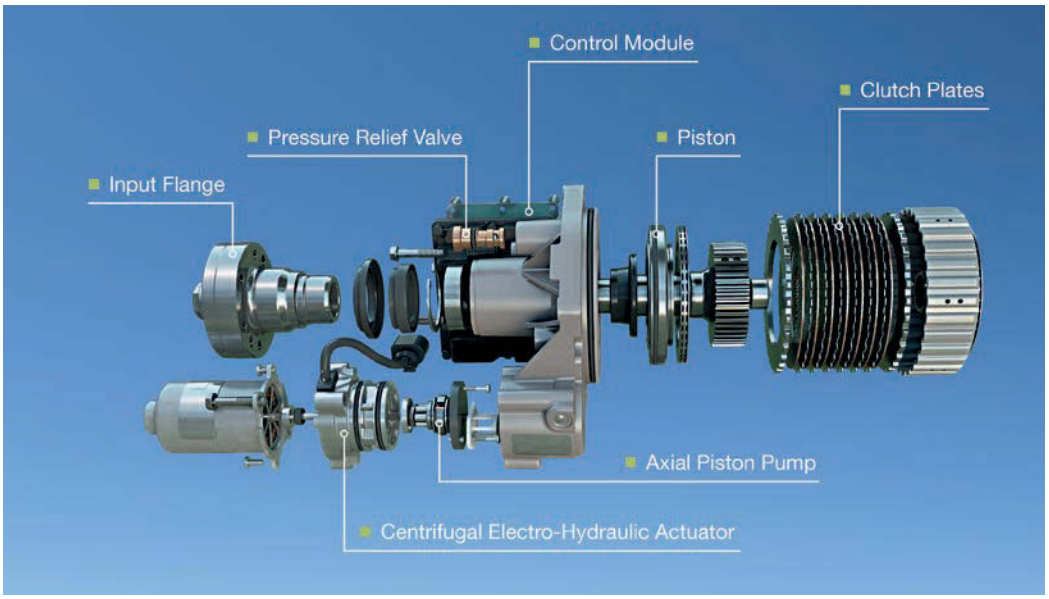
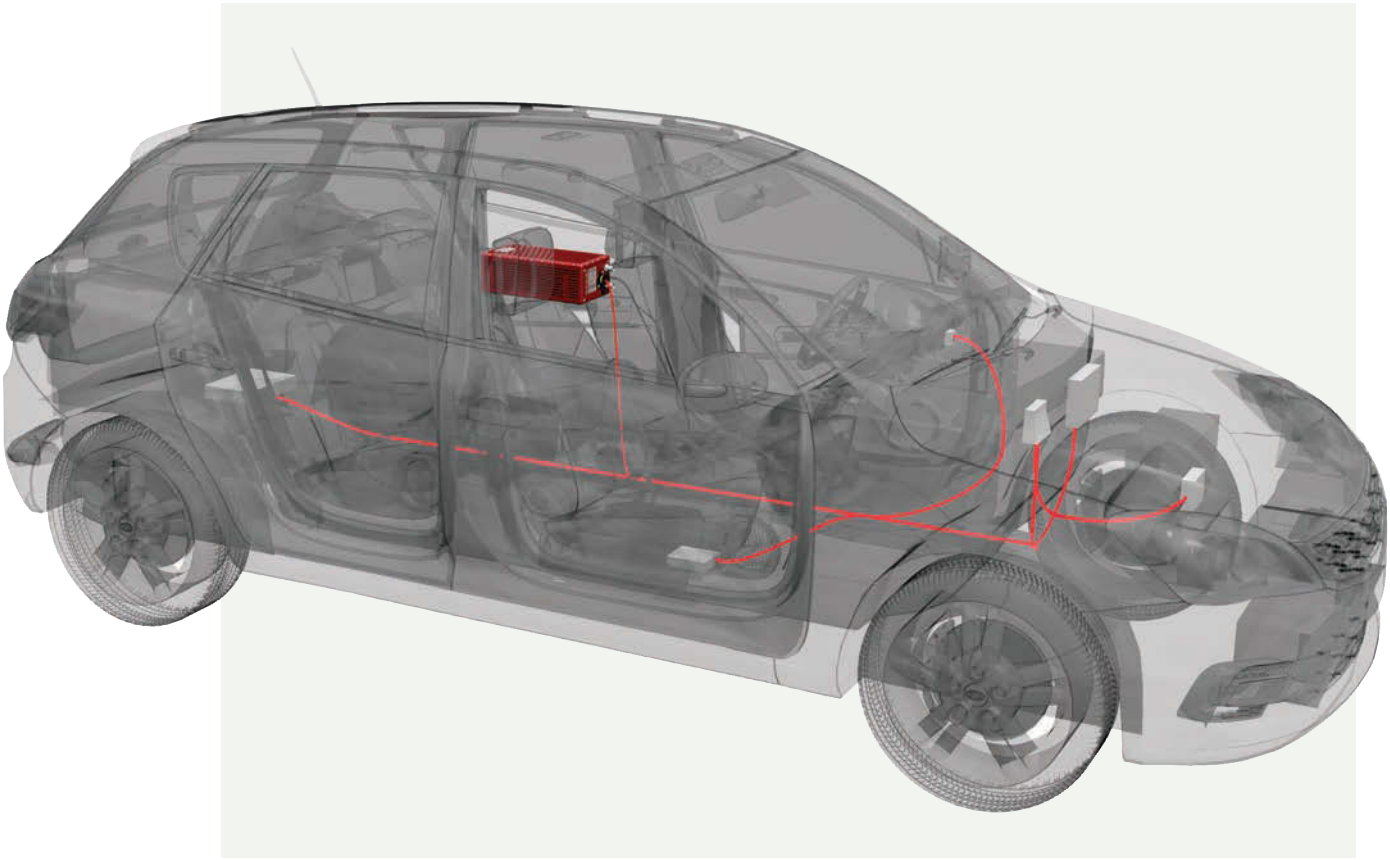
Quote ref VDI 004



BELOW: **COMPONENT PARTS OF BORGWARNER'S GenV COUPLING**

automotive testing expo 2013 europe
EXHIBITOR

Efficient CAN acquisition



NEW SOFTWARE ALLOWS OXTS'S RT SYSTEM TO LOG EXTERNAL CAN DATA DIRECTLY, WITHOUT THE NEED FOR A SEPARATE DATA ACQUISITION SYSTEM

Oxford Technical Solutions (OxTS) has enabled vehicle testers to acquire CAN signals directly into the OxTS RT inertial and GPS navigation system, which removes the need for a separate data-acquisition system in the vehicle. The RT will capture the data internally or write it straight to a CSV file on a PC for analysis.

The RT GPS-aided inertial navigation systems from OxTS are among the preferred measurement systems used globally for vehicle dynamics work. A new feature now gives users the opportunity to log up to 12 messages, which is typically 48 signals, from a third-party CANbus directly into the RT. It means that important information, such as when a vehicle alerts the driver to a potential collision, steering torque and steering angle (where available), can now be viewed in real time along with inertial navigation measurements. It also reduces the time, cost and complexity of installation because the RT represents a true one-box solution for automotive engineers and removes the need for an additional data-acquisition system.

The software isn't limited to vehicle CAN data either. Once configured, any CAN packet may be recorded by the RT. This is preferable for most users because it means they can simply import externally generated channels into the RT, rather than finding something capable of handling the large amount of inertial navigation information the RT can output via CAN.

Incoming CAN signals are sampled at either 100Hz or 250Hz depending on the speed of the RT model. They are then time stamped and incorporated directly into the RT's internal data file. This means they can easily be viewed, manipulated and exported along with all existing inertial navigation data using the RT software tools. The CAN signals can be saved to a CSV file on the user's PC, giving immediate access. Logged CAN signals can be viewed in real time along with the RT's native data using OxTS's Enginuity software.

To reduce the workload on end-users, the management and configuration of CAN libraries is handled by the RT-Config software. A new acquisition tab in the software enables users to build large libraries of CAN identifiers by importing DBC files. Twelve messages, typically 48 signals, can then be selected for acquisition. The system is configurable to interface to any CANbus with a bit rate of 1Mbps, 500Kbps or 250Kbps.

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Quote ref VDI 005

Park assist technology

What has a park assist function to do with vehicle dynamics? Park assist technology is currently one of the most requested features related to steering systems. Many new vehicles coming onto the market offer an optional park assist feature. Initial market reports suggest that the take-up rate is between 20% and 33% when it is offered as an option.

Some 61% of *auto, motor und sport* readers rated park assist as one of the new technologies that will most likely catch on in the market, just behind the fuel consumption and emission focused lightweight construction and cylinder deactivation technologies. The new Holden VF Commodore comes with park assist as a standard feature.

What does this mean for the dynamics of a vehicle? After all, we are only talking about camera and sensor systems, additional software and the challenges of car parks, aren't we?

There are several advantages for vehicle manufacturers. Firstly park assist can offer an important feature for customers for relatively little extra cost. Additionally, such a feature, when offered as standard, gives the designers more freedom as they do not have to pay so much attention to the need for the driver to be able to estimate the position of the vehicle's extremities.

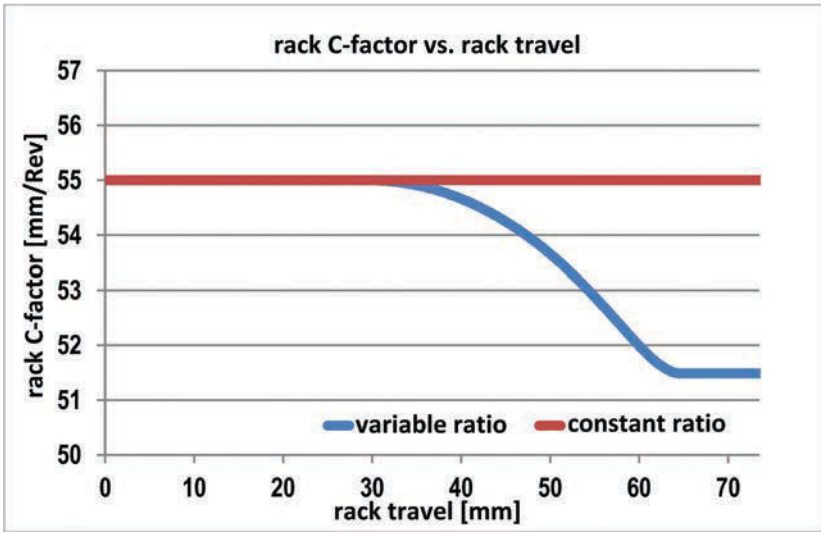
Nevertheless, park assist technology introduces further demands on the mechanical side of the steering system. The steering gear must now be capable of moving the front wheels without the assistance provided by the driver. Furthermore, it is usually specified that the system must achieve this at higher turn speeds than the average driver uses. The increase in maximum torque requirement for the servo-assist system can be in the region of 5-10Nm.

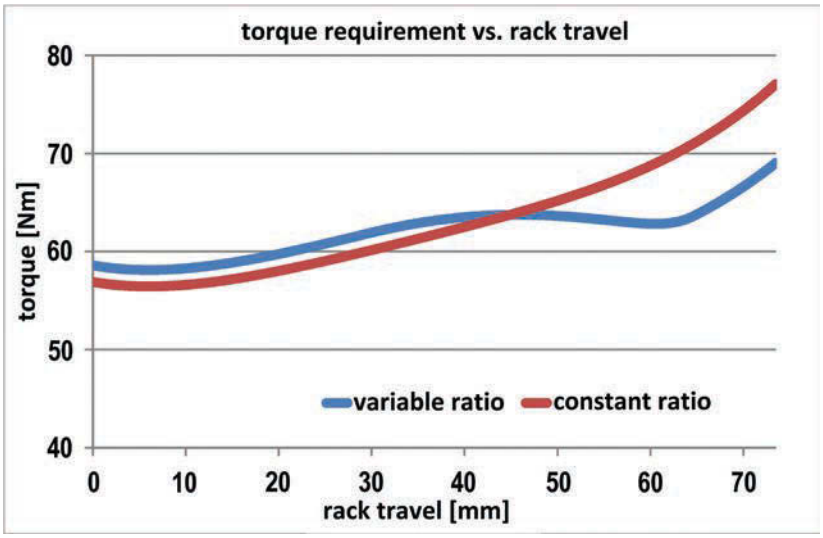
In today's environment, where the cost of motors is exploding, every additional unit of torque required is expensive. When an existing or planned system does not have sufficient torque available to safely meet these additional requirements, the options are either to increase the motor size or to reduce the rack gain, which directly reduces the torque requirement for column and pinion power-assisted systems. A reduction in rack gain (or C-Factor) immediately affects the vehicle dynamics, making the steering less direct.

A further alternative is the use of a steering rack with variable ratio rack gain in the parking region only. This leaves the straight-ahead and handling region rack gain, and hence the vehicle dynamics characteristic of the vehicle, unaffected.

The typical change in rack gain required to cover the absence of the driver input during parking results in an increase in turns to lock of about 8-10°. This change is hardly noticeable for the driver and becomes irrelevant when the park assist function is doing the work.

Ultimately, the introduction of park assist technology does not need to have any impact whatsoever on the vehicle dynamics behavior of an automobile.





LEFT: **EXAMPLES OF HOW THE USE OF A VARIABLE RATIO STEERING RACK CAN REDUCE THE MAXIMUM TORQUE REQUIREMENT OF THE POWER ASSIST SYSTEM FOR A PARK ASSIST APPLICATION**

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automotive testing expo 2013 europe
EXHIBITOR

GPS-aided gyro system

RIGHT: **GENESYS' THIRD-GENERATION AUTOMOTIVE DYNAMIC MOTION ANALYZER WITH AN OUTPUT RATE OF 1,000Hz**

For more than a decade, GeneSys Elektronik, based in Offenburg, Germany, has produced a GPS-aided gyro system called the Automotive Dynamic Motion Analyzer (ADMA). It has been developed and produced specifically for measurements of vehicle dynamics and driver assistance parameters in the automotive sector.

With significantly enhanced computing performance, interface extensions and an improved real-time capability, the new generation of ADMA meets customers' needs worldwide. Previously, the maximum achievable output rate was 400Hz with limited data records. ADMA 3.0 now offers an output rate of 1,000Hz with unlimited data records and a data latency of less than 1ms. Besides CAN-bus interfaces, the device now includes new Ethernet interfaces for data output, configuration and updating. Measurement data is available for an evaluation in real time, enabling user access at very high data rates.

Driver assistance systems are becoming increasingly significant in automotive engineering, due to their ability to further enhance the safety and comfort of modern vehicles. When measuring vehicle dynamics in the automotive sector, the accurate determination of all movements is an important requirement. The ADMA permits a high-precision dynamic measurement of all states of motion including acceleration, velocity, position, rotational speed, position angle and slip angle of the vehicle.

With the new ADMA 3.0 generation, the data output rate has been increased to 1,000Hz by using a very fast signal processor and a modern FPGA. A total of three Ethernet and five CAN-bus interfaces allow for rapid data transfer, the various Ethernet interfaces serving for data output, configuration and updates.

In practice, such high data rates in real time prove particularly valuable in developing driver assistance systems. For example, the position of a vehicle moving at 62mph (100km/h) can be resolved to less than 3cm. Thus, many new applications with even more accurate results are made possible.

Another positive feature in addition to the extremely high sampling rate is the ability to transmit GPS correction data via Ethernet. In the case of distance measurements, for instance, it was previously necessary to equip each participating vehicle with a receiver for DGPS correction data. With the latest generation of ADMA, it suffices to simply link the target vehicle to the correction data service. All other vehicles can be connected free-of-charge via WLAN to the target vehicle. This saves time and additional connection costs.

Enhanced computing power with a very fast DSP, in conjunction with a modern FPGA, permits relative data calculations directly inside the newly developed ADMA. The target vehicle sends its position data to the following Ego vehicle via WLAN. Calculations of the distance, the relative speed and the position angle with respect to the Ego vehicle still take place inside the ADMA 3.0, and the data is available online right away. Besides its usage for classical data output, the Ethernet interface is also a convenient and simple means of configuration and firmware upgrade. A linkage to a robot driver for an autonomous vehicle guidance is still possible.

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VEHICLE DYNAMICS ZONE 2013 EXHIBITOR

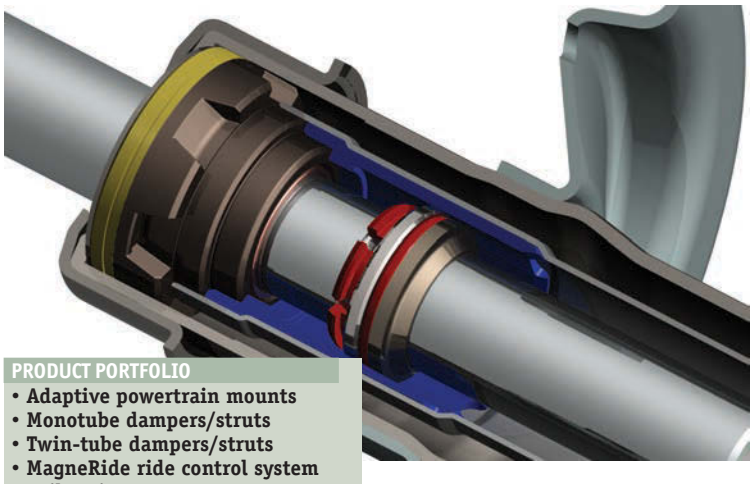
Chassis expertise

In the three years since it became an independent company, BWI Group has acquired a global reputation as a leading supplier of premium chassis systems. The product portfolio is split into two complementary groups: ride and handling technologies and braking technologies. BWI's product range in each sector is extensive, ranging from high-quality volume items such as twin-tube dampers and braking components, through to highly sophisticated active suspension, brake and control systems that are found on some of the world's most prestigious vehicles.

BWI's global network, with extensive in-house electronics capability and substantial vehicle-level experience, enables the company to quickly and reliably deliver complex, tightly integrated solutions in any region. As vehicles acquire a growing range of sensors and an increasing ability to share data between systems, the importance of closer integration is likewise increasing as additional functionality options become available. BWI products are building on these opportunities by offering compatibility with open architectures and a modular structure that takes both time and cost out of development programs.

At a component level, BWI's strategy of delivering a comprehensive, well-supported portfolio of brake and suspension products enables the simplification of vehicle manufacturers' engineering, purchasing, manufacturing and logistics processes by using one supplier for complete corner assemblies. Simplification is increased by the high level of electronic configurability, resulting in broad model ranges and global platform strategies with minimum impact on complexity.

The desire to minimize complication is reflected in the design of all BWI systems, which demonstrate the application of successful innovation to deliver the best possible performance using the simplest, most elegant technologies. An excellent example of this is MagneRide, which is widely recognized as a very advanced production ride control system. Using fixed-orifice dampers, whose response can be changed by electromagnetically controlling the rheological properties of the damper fluid, MagneRide enables vehicle engineers to achieve an exceptional combination of ride and handling performance. Unlike conventional, valve-based semi-active suspension systems, MagneRide is mechanically simple, with no valves or other small moving parts.



PRODUCT PORTFOLIO

- **Adaptive powertrain mounts**
- **Monotube dampers/struts**
- **Twin-tube dampers/struts**
- **MagneRide ride control system**
- **Coil springs**
- **Air suspension**
- **Corner and axle modules**
- **Brake components and assemblies**
- **Friction components**
- **Brake control systems**
- **Brake apply systems**
- **Electronic stability systems**
- **Roll-control systems**
- **Systems integration**

MagneRide is an excellent example of BWI Group's strategy of applying robust innovation to solve each customer's unique challenges at an affordable price, whether that requirement is to deliver groundbreaking dynamics or to simplify vehicle assembly. Combined with the company's in-depth electronics capability and vehicle-level integration expertise, it is also the strategy that will help vehicle manufacturers take the next step, further improving dynamics, refinement and safety by building on the growing synergies between vehicle systems.

Innovation is also fundamental to BWI's high-volume technologies. In passive damping, the company is implementing several weight-reduction projects including variable wall thickness tubing for struts, and the use of composite materials for highly stressed structural components. Other BWI innovations add extra functionality at minimum cost; for example, using advanced hydraulic design to provide smart functionality in a conventional damper. The latest developments in this range include super-progressive compression valves and a tunable hydraulic rebound stop.

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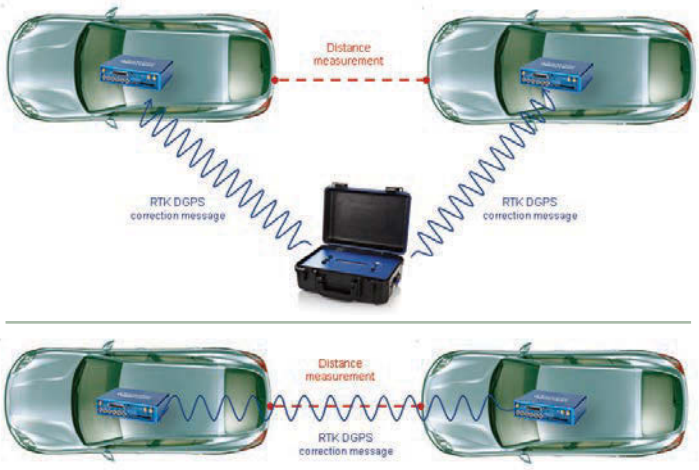
Quote ref VDI 008

CLOCKWISE FROM LEFT: **BWI'S TUNABLE HYDRAULIC REBOUND STOP; MAGNERIDE CONTROLLED SUSPENSION SYSTEM; AND MAGNETO-RHEOLOGICAL POWERTRAIN MOUNT**

automotive testing expo 2013 europe EXHIBITOR

Open-road ADAS testing



SETUPS FOR STATIC BASE STATION (RIGHT, TOP) **AND MOVING BASE STATION** (BELOW) **OPTIONS**

The number of ADAS systems being introduced into passenger and commercial vehicles is increasing, while additional regulations are making the testing and sign-off of a new vehicle more complicated than ever.

One of the issues encountered by engineers looking to sign off ADAS features is how to test in a realistic environment. Test tracks provide the most controlled and repeatable conditions – but real road driving is, of course, more indicative of how the systems will operate in normal use.

Using high-accuracy, fast updating GPS dataloggers is the only practical way to develop and validate ADAS applications such as blind spot detection, adaptive cruise control, collision mitigation warning and emergency braking.

To obtain the accuracy required, a battery-powered, static RTK Base Station is commonly used nearby to transmit correction information via a radio link to each roving datalogger at an update rate of once per second.

This real-time RTK message enables the roving GPS engine to achieve a position measurement accuracy of a couple of centimeters, as long as this radio link is maintained. Although this is fine for short-range work, any separation greater than 2km can cause dropouts between the base station and the vehicles under test, leading to reduced accuracy. The broadcast range can be increased by using more powerful telemetry modems, but this will almost certainly require licensing. Also, accuracy is reduced considerably when the separation between the fixed base station and roving receiver is greater than 8-12km.

In an ideal world, test drives would be conducted without any of these constraints, because there is no substitute for real-world evaluation of systems in their true environment. On the test engineer's wish list is the ability to drive the subject and target vehicle(s) along normal roads, over reasonable distances, among other road users and alongside roadside furniture while maintaining a high positional accuracy.

To overcome this limitation, Racelogic has recently released a 'moving base' solution, which is available as a firmware upgrade to the VBOX 3i. In a typical setup with two such units, the subject vehicle takes over the role of the base station and transmits corrections to the target vehicle at an update rate of 20 times per second, rather than just once per second, as employed in a traditional base station setup.

The moving base solution uses this higher correction frequency to cope with the fact that all the receivers are constantly moving. Accuracy is further enhanced by signals from the Russian Glonass system, as well as a method that uses refined delta positions obtained from carrier phase measurements. This reduces the noise levels of pseudo-range measurements (raw distances to each satellite) and removes positional jumps.

This means Racelogic can now offer a completely mobile testing solution that provides a relative car-to-car measurement accuracy of 2cm. For those who already use the VBOX 3i RTK system, all that is needed is an additional 2.4GHz telemetry modem per VBOX. For new acquisitions there are significant cost savings to be made as no base station is required.

The range over which the two VBOX systems can retain RTK lock is approximately 300-400m, more than sufficient for validating a variety of ISO standards, such as ISO 15622 (adaptive cruise control) and ISO 15623 (forward collision warning). For more complicated tests, the subject vehicle can transmit corrections to two target vehicles.

To further simplify the analysis process, the Racelogic Video VBOX can be seamlessly integrated with the moving base setup, providing fully synchronized, multiple camera video footage onto which the ADAS parameters can be graphically overlaid. The resulting images are great for understanding the actual conditions present, providing a useful visual reference to the positions of all vehicles involved and obstacles encountered during the test.

By using a laptop or one of the VBOX-compatible displays, all the measured and calculated parameters can be viewed in real time inside the subject vehicle containing the moving base unit, giving the engineers instant feedback during the duration of the test.

Time spent validating newly developed ADAS features on the highway can result in a shorter development process than using a test track under artificial conditions. With the new moving base solution from Racelogic, the same level of accuracy is now available in both situations, giving the test engineer ultimate flexibility in the choice of environment for each test.

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Quote ref VDI 009

Test system requirements

automotive testing expo 2013 europe EXHIBITOR

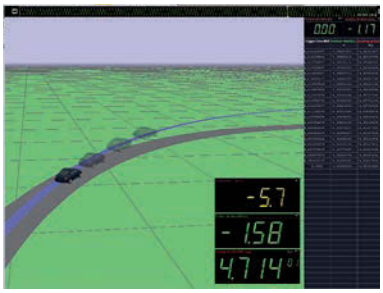
Leading car manufacturers are introducing ever more ADAS systems, such as forward collision warning, lane departure warning and active cruise control. The ISO 26262 standard for functional safety of road vehicles relates to this. There are also all the traditional vehicle dynamics maneuvers such as ISO lane change, steady circle test, and many more. For testing departments, the problem is choosing the right evaluation tools for all these tasks.

Dewetron has addressed this issue by creating an automotive toolbox to cover everything with a set of flexible and scalable hardware, and a single modular software suite. All developments have been based on the practical experiences of test engineers all over the world.

Depending on the test, many parameters may be required, such as driving speed; vehicle longitudinal and lateral velocity; pitch, roll and yaw angle (leveled and vehicle-related to the road surface); position; steering-wheel angle and torque; wheel forces, torques and speeds; wheel movement in x, y and z directions; vehicle float angle; slip angle on all vehicle wheels; and longitudinal, transverse and yaw acceleration… there are almost unlimited parameters.

Dewetron produces data acquisition systems based on its leading technology for synchronized measurements. These systems enable test engineers to synchronously record analog data; digital states; encoder/counter values; bus data such as CAN, FlexRay or XCP; video frames; and GPS data. As a member of the Driveability Testing Alliance, Dewetron guarantees that for any required parameter, there is an available sensor that is compatible with the measurement system.

The company's software is developed to enable quick setup of test procedures, and templates for several tests are included. The sequencer guides the test driver through the maneuver using, for example, audio commands. The result can immediately be seen online without any additional post analysis.



DEWE2 A4 WITH BATTERY OPTION AND XCP (LEFT) **AND FUNCTIONAL SAFETY SCREEN** (BELOW)

In the setup section, basic information such as sensor scaling, car size, test track and fixed objects are entered, depending on the maneuver.

Definition of the test track can be done by charting cones or other markings on the proving ground, by defining the track in the software, or by recording a master ride. Any of these methods are easy to carry out.

There is even a procedure available to place the cones, an ISO lane-change test supported by the high-precision GPS antenna, which significantly saves preparation time.

Any maneuver can be driven either following the markings on the proving ground or exclusively following the track shown on a 3D display on the screen ('virtual track'). The chance to freely drive a maneuver brings a lot of advantages, for example, saving preparation time when testing on an iced lake.

For testing the controllability of a vehicle in case of a (simulated) sensor malfunction, accurate lane deviation and yaw rate are needed, complemented with ABS/VDC internal data via XCP. As well as following a marked path, it is possible to run free maneuvers. The vehicle just needs to be in a steady condition for three seconds to enable solid prediction of the travelling path and to be able to do all the calculations after inducing the sensor malfunction.

One of the challenges when testing active cruise control is measuring precisely the relative position and velocity between cars in the case of longitudinal control systems, and car-to-track in the case of lateral control systems. But the most important feature for gaining high-quality measurement data is perfect synchronization of all signal sources.

Many graphical displays and controls are available to cover the varying requirements of different maneuvers. Based on this high-quality data, an immediate report can be generated or further analysis can be performed.

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Quote ref VDI 010

automotive testing expo 2013 europe
EXHIBITOR

Virtual suspension setup

LEFT: **THE ASM VEHICLE DYNAMICS SIMULATION PACKAGE DEVELOPED BY DSPACE**

BELOW LEFT: **SIMULATION RESULTS OF HARD AND SOFT SUSPENSION SETUPS**

Automotive simulation models (ASMs) from dSPACE have become widely used simulation tools in the development process of ground vehicles. For example, the ASM Vehicle Dynamics Simulation Package provides an excellent basis for developing and testing vehicle dynamics ECUs, such as ESC, steering and active damping. It is also ideal for vehicle dynamics investigations in early development phases. Simulation can be performed on all kinds of vehicles, ranging from passenger cars and trucks, to large road trains and off-road vehicles.

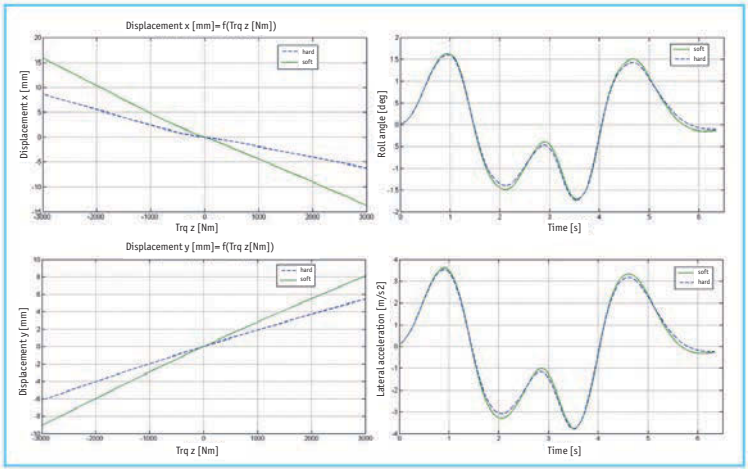
The extension of the ASM Kinematics and Compliance (ASM KnC) test bench opens up the totally new application area of designing and simulating vehicle suspensions. On the basis of the test bench's ASM Vehicle Dynamics model, users can test and optimize suspensions for various vehicle variants and maneuvers. The suspension kinematics and mathematical compliance maps necessary for real-time-capable vehicle dynamics simulation are calculated from geometric descriptions of the axle. The geometric linkage points of the control arms at the chassis and the knuckle, as well as the spring, damper and stabilizer connections, can be read from CAD sketches, for example. The non-linear spring and damper characteristics of the bushing elements can be taken direct from assembly data sheets. This time- and cost-saving parameterization of the entire suspension can be performed in just a few minutes using a graphical user interface.

To obtain visual feedback of the suspension assembly during wheel movement, and of the impact of the forces and torques acting on the wheel, ASM KnC provides a suspension analysis function that generates 3D animation of the virtual test bench. After the user is satisfied with the configuration, maps for the kinematics and the compliance can easily be generated with one button click. The resulting parameterization can be exported to dSPACE ModelDesk to manage the vehicle variants and reuse the parameters for offline simulation of ASM Vehicle Dynamics within a MATLAB/Simulink environment and also online simulation on a dSPACE real-time processor.

ASM KnC generates the kinematics and compliance maps of all commonly used suspension types, such as MacPherson, double-wishbone, three-link, four-link and multilink. The test bench also provides special variants for control blade suspensions and subframes.

Not only are rigid control arms considered, but also the elasticity of specific suspension types such as the bending of the damper strut in a MacPherson suspension or the flexible control arm of a control blade suspension.

ASM KnC can be fully automated for optimization tasks to let users adjust the simulation results to real measurement data, such as camber and toe changes during jounce and rebound. The automation interface can also be used to make a prognosis of single assembly characteristics in order to meet improved target vehicle dynamics performance criteria. Because the simulation parameters correlate directly to real vehicle assemblies, test engineers can optimize real car setups more efficiently. As a result, this greatly reduces the number of actual test runs.



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HELD ALONGSIDE
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PLUS Specialist Feature area for Vehicle Dynamics

From the publishers of Vehicle Dynamics International magazine

transportation weight loss diet conference 2013

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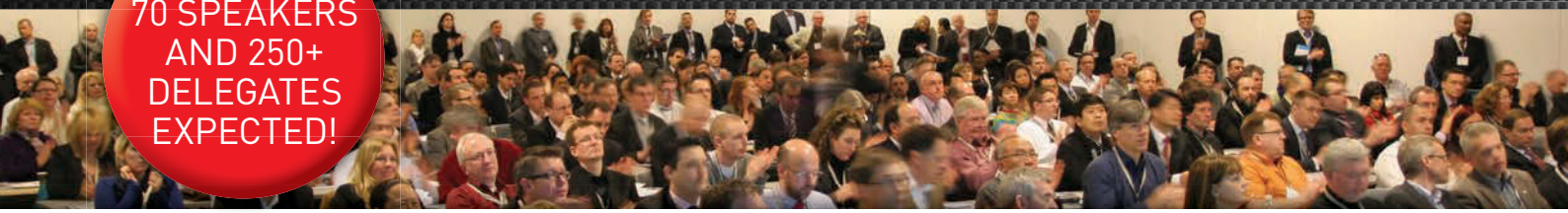

CONFIRMED SPEAKERS TO DATE:

Dr Stéphane Abed, ceo, Poly-Shape 3D Generative Manufacturing • Richard Adams, cto & senior vice president, CPS Technologies Corporation • Sarah Banfield, research manager, Tecvac Ltd • Vincent Banton, thermoset development technical support, IDI Composites Europe • Dr Donald Baskin, senior associate, Exponent • Phillip Bell, product line manager, Corning Incorporated • Jacques Belley, director r&d standardization and innovation, Bombardier Transportation North America • Edwin Buechter, ceo/president, Clean-Lasersysteme GmbH • Jörn Buss, partner, Oliver Wyman • Ian Butterworth, researcher, automotive polymer composites, Cranfield University • Guillaume Cledat, key market developer, CCP Composites • Hendrik De Keyser, technology officer, Vyncolit NV • Klaus Decking, product segment manager lightweight, Georg Fischer Automotive AG • Ian Donaldson, director r&d auburn hills tech center & materials engineering americas, GKN Sinter Metals • Dr Dan Dragulin, head of r&d, Belte AG • Akbar Farahani, vice president, engineering, ETA Inc • Terry Gordon, epoxy development chemist, Permabond • Jeffrey Gross, director of product development, The Acme Group • Phil Hall, managing director, Caterham Composites • Frank Heppes, head of Research & Development, Drahtzug Stein Combicore GmbH & Co KG • Prof Santiago Hernandez, professor, University of Coruna • Gail Hite, market development director, RTI International Metals Inc • Walter Kiersch, CEO, Carbon Conduction Technoloies (CCT) GmbH • Dr Alexander Kling, head of structural mechanics department, DLR, Institute of Composite Structures and Adaptive Systems • Jannis Kranz, researcher lightweight design for Laser Additive Manufacturing, Technical University Hamburg-Harburg • Gaurav Kumar, senior lead engineer, MBRDI • Robert Langlois, ceo, Powder Coating Solutions • Mikhail Levit, global technical leader, aerospace and mass transportation, DuPont Protection Technologies • Quaranta Lorenzo, development manager, Sandvik AB • Mogens Løkke, ceo, ECOmove ApS • Nicolas Meilhan, senior consultant, Frost & Sullivan • Michael Mowins, president - global licensing, Phillips Screw Company • Giri Nammalwar, responsible for Global CAE Strategy Planning, Ford Motor Company • Dr James Njuguna, lecturer - transport lightweight structures, Cranfield University • Fredrik Ohlsson, product development director, Oxeon AB • Gulsen Oncul, Senior Expert , Turkish Aerospace Industries, Inc. • Stephen Philipson, business development manager Carbon, Oxeon AB • Andrew Rich, president, Element 6 Consulting • Javier Romo, project manager, Cidaut Foundation • Dr Stephen Rudzewski, head of Technics and Innovation, Semcon Holding GmbH & Co KG • Armin Schneider, product applications manager, Carpenter Technologies GmbH • Dr Anna Schwarz, general manager, Danto Invention • Jody Shaw, director, technical marketing and product development, United States Steel Corporation • Norman Starke, CEO, Proof Technologies • Sébastien Stassin, managing partner, Kiska GmbH • James Stike, president and CEO, MIT LLC • Ashutosh Tomar, senior research engineeer, Jaguar Landrover • Dr Isabel Van de Weyenberg, research engineer, Flanders' Drive • Oliver Walter, responsible product manager BMW i3, BMW • Prof Nicholas Warrior, Head of Polymer Composites Research Group , University of Nottingham • Mark Watkins, automotive plastic bearing development manager, BNL (UK) Limited • Patrick Weichand, researcher fiber-reinforced materials, Institute for Manufacturing • Technologies of Ceramic Components and Composites, University Stuttgart • Randall Wilburn, global manager automotive sector, Molex Inc • Jens Winiarz, product manager lightweight, Hennecke GmbH • Tom Winters, market development manager Mass Transit High Performance Foams , Rogers Corporation • Ingo Wuggetzer, vice president Cabin Innovation and Design, Airbus Operations GmbH • Dr Simon Xu, engineering group manager for Vehicle Optimisation, General Motors • Dr Robert Yancey, senior director - global aerospace, energy, and marine, Altair • Richard Zemann, head fiber-reinforced polymers activities, TU Vienna

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Speakers include

Simon Xu engineering group manager, Vehicle Optimization, Architecture Strategy, General Motors, USA
Ingo Wuggetzer vice president, Cabin Innovation and Design, Airbus Operations GmbH, GERMANY
Jacques Belley director R&D Standardization and Innovation, Bombardier Transportation North America, CANADA
Oliver Walter responsible product manager BMW i3, BMW, GERMANY
Jody Shaw director, Technical Marketing and Product Development, United States Steel Corporation, USA
Giri Nammalwar responsible for Global CAE Strategy Planning, Ford Motor Company, USA
Ian Donaldson director R&D, Auburn Hills Tech Center & Materials Engineering Americas, GKN Sinter Metals, USA
Ashutosh Tomar senior research engineer, Jaguar Land Rover, UK
Michael Mowins president, Global Licensing, Phillips Screw Company, USA
Quaranta Lorenzo development manager, Sandvik AB, FRANCE
Klaus Decking product segment manager, Lightweight, Georg Fischer Automotive AG, SWITZERLAND

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JUNE 5-6, 2013
MESSE STUTTGART, GERMANY

DAY 1, WEDNESDAY 5 JUNE, ROOM 1 9.00-10.15AM

Opening keynote session

Aerospace vs automotive – perspectives on composites needs and requirements
Dr Robert Yancey, senior director – Global Aerospace, Energy, and Marine, Altair, USA

ROOM 1 MORNING

10.30 - 12.30 Increasing Composite Potential: Affordability, Lifecycle and Thermal Properties

This session will look at the developments in composite materials to make them more useful to OEMs. Some of the limiting factors have been the cost, and issues concerning lifecycle as well as thermal properties which limit their application. This session will look at developments in processing techniques aimed at reducing the cost, recycling and using recycled composites, and increases in thermal resistance that allow them to be used in new applications.

10.30 - The development of processing techniques for affordable carbon composite materials
Prof Nicholas Warrior, head of Polymer Composites Research Group, University of Nottingham, UK

10.55 - Cradle-to-cradle use of carbon fibre
James Stike, president and CEO, MIT LLC, USA

11.20 - Thermo-impact resistance of PA66 composites for automotive structural application
Ian Butterworth, researcher, Automotive Polymer Composites, Cranfield University, UK

11.45 - Competitive lightweight structures with increased thermal stability
Patrick Weichand,researcher fibre-reinforced materials, Institute for Manufacturing Technologies of Ceramic Components and Composites, University Stuttgart, Germany

ROOM 1 AFTERNOON

13.30 - 15.30 Designing and Creating Composite Structures

This session will investigate developments in optimising composite structures using examples from aerospace and motorsport to demonstrate how composite structures can be improved and what potential the composite structure has for weight reduction by incorporating electrical conduction into the structure.

13.30 - Weight reduction by optimised reinforcement structures
Fredrik Ohlsson, product development director, Oxeon AB, Sweden

Stephen Philipson, business development manager Carbon, Oxeon AB, Sweden

13.55 - Effect of fibre treatments on mechanical properties of flax/tannin composites
Dr James Njuguna, lecturer - Transport Lightweight Structures, Cranfield University, UK

14.20 - Composite honeycombs for weight savings in aerospace and ground transportation
Dr Mikhail Levit, global technical leader, aerospace and mass transportation, DuPont Protection Technologies, USA

14.45 - Low-density thermoset composites for transportation ATT (automotive truck train)
Vincent Banton, thermoset development technical support, IDI Composites Europe, France

16.00 - 17.15 The Relative Value Of Weight: How Much Is A Kilogram Reduction Actually Worth?

16.00 - Panel
Ingo Wuggetzer, vice president Cabin Innovation and Design, Airbus Operations GmbH, Germany

Jacques Belley, director R&D standardisation and innovation, Bombardier Transportation North America, Canada

Nicolas Meilhan, senior consultant, Frost & Sullivan, France

ROOM 2 MORNING

10.30 - 12.45 Challenges in Aerospace Mass Reduction

10.30 - Cabin Concept 2050 based on a bionic structure
Ingo Wuggetzer, vice president Cabin Innovation and Design, Airbus Operations GmbH, Germany

10.55 - Understanding weight loss for VTOL aircraft
Dr Daniel Schrage, professor and director, Georgia Tech, USA

11.20 - Advanced methodologies for weight minimisation of aircraft structures
Prof Santiago Hernandez, professor, University of Coruna, Spain

11.45 - Design solutions to reduce weight during assembly operations
Gulsen Oncul, senior expert, Turkish Aerospace Industries Inc, Turkey

12.10 - Validation approach for robust primary thin-walled CFRP structures
Dr Alexander Kling, head of structural mechanics department, DLR, Institute of Composite Structures and Adaptive Systems, Germany

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ROOM 2 AFTERNOON

13.30 - 16.00
Lightweight Electric Vehicle Design and Materials

This session will look at the challenges of designing and building actual modern lightweight electric vehicles.

13.30 - BMW i3: a battery electric vehicle from the beginning
Oliver Walter, responsible product manager BMW i3, BMW, Germany

13.55 - Strategies of global OEMs to reduce future car weight
Nicolas Meilhan, senior consultant, Frost & Sullivan, France

14.20 - Advanced light architectures specifically designed for electric vehicles
Javier Romo, project manager, Cidaut Foundation, Spain

14.45 - Automotive solar applications changing the rules in car design
Norman Starke, CEO, Proof Technologies, Germany

15.10 - Half-weight vehicle with new materials: chassis, body and driveline
Mogens Løkke, CEO, ECOmove ApS, Denmark

ROOM 3 MORNING

10.30 - 12.30
Optimising Manufacturing Processes

10.30 - Combining extrusion, flow-forming and friction stir welding to design lightweight aluminium wheels
Hervé Vericel, engineer, Saint Jean Industries, France

10.55 - Automated multi-disciplinary optimisation (MDO) process development for full vehicle weight reduction, performance balancing and time-saving
Giri Nammalwar, responsible for Global CAE Strategy Planning, Ford Motor Company, USA

11.20 - A multi-disciplinary stochastic optimisation (MDSO) approach to reduce vehicle weight and meet performance targets
Dr Simon Xu, engineering group manager for Vehicle Optimisation, General Motors, USA

11.45 - High pressure meets lightweight
Jens Winiarz, product manager lightweight, Hennecke GmbH, Germany

ROOM 3 AFTERNOON

13.30 - 15.30
Growing Lighter: How to Benefit From Additive Manufacturing Techniques

Additive manufacturing allows a parts manufacturer to 'grow' high-value, custom-designed parts layer by layer, enabling the manufacture of complex shapes from a wide range of materials without the need for new tools or machinery. Even using extremely lightweight materials, additional mass reduction can be achieved by minimising the use of those materials. This is an exciting technology for mass reduction and this session will look at case studies to demonstrate its value.

13.30 - Additive manufacturing technologies for producing innovative lightweight structured components
Dr Stéphane Abed, CEO, Poly-Shape 3D Generative Manufacturing, France

13.55 - Lightweight design and laser additive manufacturing: exploiting new potentials
Jannis Kranz, researcher lightweight design for Laser Additive Manufacturing, Technical University Hamburg-Harburg, Germany

14.20 - Lightweight fibre- and particle-reinforced Al-metal matrix composite structures
Richard Adams, CTO & senior vice president, CPS Technologies Corporation, USA

14.45 - Powder metallurgy delivers weight savings in automotive powertrain applications
Ian Donaldson, director R&D Auburn Hills Tech Center & Materials Engineering Americas, GKN Sinter Metals, USA

DAY 2, THURSDAY 6 JUNE

ROOM 1 MORNING

09.00 - 10.15
Will Steel Still Be Relevant? Future Steel Vehicle - Special Presentation

09.00 - Future Steel Vehicle: innovative development and mass-reduction strategies
Akbar Farahani, vice president, Engineering, ETA Inc, USA

Jody Shaw, director, Technical Marketing and Product Development, United States Steel Corporation, USA

10.30 - 12.30
Mixed Material Design Challenges

This session will look at the practical experience of integrating different materials into the design of a vehicle in order to fully exploit and optimise the mass reduction potential of each material.

10.30 - Daimler hybrid transmission: making it better through weight optimisation
Gaurav Kumar, senior lead engineer, MBRDI, India

10.55 - Lightening the way ahead
Phil Hall, managing director,Caterham Composites, Germany

ROOM 1 AFTERNOON

13.30 - 15.30
Innovations for Lighter Interiors

13.30 - Silicone foam allowing weight reduction through thinner cushion
Tom Winters, market development manager Mass Transit High Performance Foams, Rogers Corporation, Belgium

13.55 - Big windows, light weight
Phillip Bell, product line manager, Corning Incorporated, USA

14.20 - Low-weight, low-energy infotainment
Ashutosh Tomar, senior research engineer, Jaguar Land Rover, UK

14.45 - Suspension fabrics – a new era in seating
Jeffrey Gross, director of Product Development, The Acme Group, USA

15.45 - 17.45

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Intelligent Design: Lighter Materials Are a Requirement, But They Are Not All That Is Necessary

This session will consider some of the more philosophical issues concerning the lightweighting of vehicles. Apart from the question of whether the change is best achieved incrementally or through a complete paradigm shift, it will also focus on the need for designers to think less about using lighter materials merely to replace vehicle structures and components and more towards appreciating the potential of new materials to completely change the way vehicles are designed and assembled.

15.45 - Automotive body-in-white mass-reduction philosophy
Dr Donald Baskin, senior associate, Exponent, USA

16.10 - Lightweight – the paradigm shift
Sébastien Stassin, managing partner, Kiska GmbH, Austria

16.35 - Composite structure is not making a black sheet metal structure
Andrew Rich, president, Element 6 Consulting, USA

17.00 - Truck of the future – evolve or leap?
Jörn Buss, partner, Oliver Wyman, USA

ROOM 2 MORNING

10.30 - 12.45 Innovative Uses of Composite Materials

This session will look at innovations in the uses of composite materials for major reductions in mass, for example to replace heavy components such as engines, springs and bearings.

10.30 - PM2 engine concept – a composite innovation
Hendrik De Keyser, technology officer, Vyncolit NV, Belgium

10.55 - Weight-loss potential of composite spring elements
Richard Zemann, head Fibre-Reinforced Polymers Activities, TU Vienna, Austria

11.20 - Using plastic bearings in automotive applications
Mark Watkins, automotive plastic bearing development manager, BNL (UK) Limited, UK

11.45 - GFC leaf-spring: approved technology in a new form of appearance
Dr Anna Schwarz, general manager, Danto Invention, Germany

12.10 - Conductive connection of carbon structures for failure detection safety and repair
Walter Kiersch, CEO, Carbon Conduction Technologies (CCT) GmbH, Germany

ROOM 2 AFTERNOON

13.30 - 15.45 Advances in Bonding/Joining Technology

The use of new materials in lightweight vehicles requires a revision of bonding and joining techniques for efficient and cost-effective vehicle assembly as well as consideration for aftermarket repair. This session will look at advances in bonding and joining materials and techniques.

13.30 - Adhesives for composite assembly
Terry Gordon, epoxy development chemist, Permabond, UK

13.55 - Potential of vibration joining for carbon composite assembly parts
Jeanine Vluggen, researcher, BMW Group, Germany

14.20 - Durability testing for adhesive joints in the vehicle industry
Dr Isabel Van de Weyenberg, research engineer, Flanders' Drive, Belgium

14.45 - Shedding weight while ensuring maintainability and recyclability with threaded fasteners
Michael Mowins, president - Global Licensing, Phillips Screw Company, USA

15.10 - Sustainable laser surface cleaning for joining preparation in lightweight production
Edwin Buechter, CEO/president, Clean-Lasersysteme GmbH, Germany

16.00 - 17.00 Coating and Painting Developments for Composites

This session will look at developments in techniques and materials that will enable composite vehicles to be coated and painted effectively and affordably, making their use by OEMs easier to integrate.

16.00 - Lightweight fibreglass composites for automotive
Robert Langlois, CEO, Powder Coating Solutions, Canada

16.25 - SMC composite material for automotive on-line painted body panels
Guillaume Cledat, key market developer, CCP Composites, France

ROOM 3 MORNING

10.30 - 12.30 Advances in Lightweight Metals

10.30 - Heat treatment of light alloys structural castings for automotive applications
Dr Dan Dragulin, head of R&D, Belte AG, Germany

10.55 - Weight savings with castings in iron, aluminium and magnesium
Klaus Decking, product segment manager lightweight, Georg Fischer Automotive AG, Switzerland

11.20 - Stable inlay aluminium tubes for HPDC and other casting processes
Frank Heppes, head of Research & Development, Drahtzug Stein Combicore GmbH & Co KG, Germany

11.45 - Replace die-cast in control modules for dramatic weight savings
Randall Wilburn, global manager Automotive Sector, Molex Inc, USA

ROOM 3 AFTERNOON

13.30 - 15.45 Advances in Lightweight Metals – Part 2

13.30 - A new stainless-steel material for weight reduction
Finn Petersen, technical marketing, Sandvik SMT, Denmark

13.55 - New material concept for weight reduction
Armin Schneider, product applications manager, Carpenter Technologies GmbH, Germany

14.20 - Enabling lightweight high-load bearings
Sarah Banfield, research manager, Tecvac Ltd, UK

14.45 - Magnesium/MnE21 lightweight solutions – the eco-friendly solution of the future?
Dr Stephen Rudzewski, head of Technics and Innovation, Semcon Holding GmbH & Co KG, Germany

**This programme may be subject to changeSed eos dolest adis utempor ionsenim*

Volkswagen Golf Mk7

1.6 TDI S

VOLKSWAGEN HAS GONE BACK TO A TWISTBEAM REAR AXLE FOR LOWER-POWERED GOLFS. JOHN MILES PUTS IT TO THE TEST

"At no time is one conscious of EDL/XDS working or EPS steering feedback being modified and contributing to the stability and balance"

Ruthless attention to weight saving on every engine, trim, electrical, air-conditioning and chassis component, and also the greater use of hot-formed, high-strength steels, plus laser welding, has enabled Volkswagen to save up to an extraordinary 114kg on some models of the new Mk7 Golf, even though it is 59mm longer and 13mm wider than before. All models are built using VW's recently introduced Modular Transverse Matrix (MQB).

For the *VDI* assessment, a more basic Golf S 1.6 TDI (105PS @ 3,000-4,000rpm and 250Nm torque @ 1,500-2,750rpm) was chosen, mainly because VW has reverted to a twistbeam rear axle (saving 14kg) on all low-powered models. The big weight savings are not as apparent on this model, which is only 23kg lighter than the nearest-specification Mk6.

The basic S models may not have refinements such as the driver profile selection, pre-crash braking, distance control, and driver alert system found on the SE and GT, but they do have engine stop/start, trailing-throttle high battery charge, and the important stuff: seven airbags, ABS and the EDL/XDS extension of ESC, which provides driven-wheel slip-management (faux limited slip differential) and individual wheel braking for active yaw balance. There is also VW's clever EPS with 'steering recommendation torque feedback' via input from ESC data for lateral and longitudinal acceleration, yaw rate, steering angle, plus a strain-gauged lower column. These inputs enable the EPS to cancel out steering pull and crosswind wander, plus nudge the driver to correctly counter-steer if the car starts to go out of control.

The Golf retains an airy driving compartment feel and better visibility than many of the current competitors. Gearshift quality is a little notchy, and one does feel the lack of a six-speed gearbox found on base model Foci, and more up-spec Golfs. Its 1.6 diesel powertrain refinement is first class at all speeds, and idling is vibration free.

SUB-140PS GOLFS GET A NEW TWISTBEAM REAR AXLE

Dynamics? No lack of response or grip is apparent from the taller (and narrower) than usual 195/65-15 Goodyear Excellence tires on pressed steel wheels. Quite the reverse, because in cold and wet conditions the car proved well balanced and tenacious in turns, and there is little if any of the slightly corrupted EPS steering feel found elsewhere. Although light for parking, steering loads firm up sufficiently, yet it does not get ponderous at speed. Generally speaking, the steering is 'connected' and linear in response, but during main-road running at speed, a slight sideways shuffling motion at the rear axle on small transient steering inputs was noted, and is so typical of a twistbeam system's lack of lateral stiffness (and presumably the reason for the current Astra's additional Watt linkage).

Paradoxically this around-center response lag is not apparent on bumpy roads, when the car demonstrates truly excellent directional stability and control, unaffected by bumps, ruts or grooves. Moreover, this comes without the determined understeer and slight on-center vagueness of a Focus. At no time is one conscious of EDL/XDS working or EPS steering feedback being modified and contributing to the stability and balance, yet there is likely to be some activity when driven hard on the worst surfaces, if only to stabilize the car by eliminating unwanted kickback. Smart getaways do not generate significant 'tramp', which is a testament to the newly revised powertrain mounting system. A general trend to sharp initial braking response is overdone here, but on the plus side braking stability is excellent up to and including the ABS locking point, plus there is minimal braking pitch.

Driven hard, primary body control is strong, well balanced, and fluid enough, however the Mk7 twistbeam platform has a somewhat wooden ride undertone on the UK's rough aggregate/chipping surfaces, and no obvious reduction in road roar was apparent, perhaps reflecting the ultimate axle location/isolation compromise inherent in a twistbeam axle. We can confirm the minimal wind noise and road noise refinement on smooth roads. Secondary ride shake/shudder emanating from the powertrain and rear axle masses is felt, but more obviously so with two people on board.

The Mk6 Golf platform has been used by competitors for several years as the Class C benchmarking car. The Mk7 shows that chassis dynamics in this hotly contested sector can still remain competitive with a twistbeam axle. For UK roads a small comfort drawback exists, but it is unlikely to deter most customers. As ever, it is the Golf's build quality, hidden mechanical/electronic technology, general refinement, and class leading 50+mpg fuel economy that counts – if not the cost price…

Harsh reality

JOHN HEIDER ASSESSES THE CHALLENGE OF LOCAL MARKET TUNING IN THE 21ST CENTURY

"Vehicle dynamics and chassis engineers need to sharpen their pencils and make sure their passports are up to date, as it will only get more challenging"

We live in a global economy. Manufacturers tout their efficiency in sharing platforms across multiple brands, multiple countries and multiple continents. Never before has the phrase 'local market tuning' struck so much fear into the mind of the vehicle dynamics development engineer.

For the vehicle dynamics engineer, local market tuning refers to adjusting the tunable components of the various chassis systems to optimize them for the market in which they are being sold. These adjustments are required to address local market driving conditions, customer expectations or a combination of both. To ensure the success of a vehicle, the final vehicle dynamics tuning adjustments are normally performed on proving grounds or public roads in the destination country. For manufacturers with assembly plants in foreign markets, another level of complexity is introduced when developing a vehicle for new local markets – local market chassis-component suppliers.

Local market driving conditions have been studied and well understood by the vehicle dynamics departments of the leading OEMs. German autobahns, Californian freeways, European secondary roads, and the long, straight freeways in the USA, all demand special attention when developing suspension, steering and wheel/tire packages. Customer expectations are similarly well understood: don't assume the average American consumer will install snow tires in winter; changing brake pads and rotors simultaneously is acceptable in some markets, not in others; and vehicle-handling expectations in the eyes of the law are not consistent.

Within the past decade, a new 'harsh' reality has set in for the vehicle dynamics development engineer responsible for local market tuning: two of the fastest growing and most important markets are so-called 'severe usage' markets – namely China and India. Harsh is an appropriate adjective for the traffic conditions, the road conditions and the vehicle ride comfort, should a manufacturer choose not to take the time to understand the local market requirements. In the western world, we had the luxury of the road systems, traffic control systems and driver education systems developing in parallel with the automobile. In China, India and other emerging markets, the evolutionary process has essentially been reversed. Modern cars capable of traveling at high speed have been dumped in large quantities into markets with underdeveloped road systems and driver education systems. Who would have thought an S-Class Mercedes, ox carts, goats and cows would all be occupying the same stretch of road?

The dilemmas for the development engineer occur at multiple levels. The first level is dealing with roads that vary from good in urban areas, to those which are normally only seen on proving grounds to intentionally inflict accelerated, or immediate, failure of chassis components. For many manufacturers, the second level includes managing the road inputs with chassis tunable components sourced from local suppliers. The supplier names may be familiar, but despite major Tier 1 suppliers' best efforts, the challenge of developing Tier 2 and 3 local suppliers for items such as rubber compounds, damper components and steel is a daunting and lengthy task. The third level of dilemma is a result of the first two: how to balance customer expectations with vehicle performance expectations created by corporate guidelines, brand image and established vehicle pedigree. If there is a three-pointed star, roundel or blue oval on the deck lid, what is the expected driving experience?

The premise of local market tuning is straightforward. The reality is that we have never faced the variety of road conditions, driving conditions and customer expectations that exist in today's global economy. Vehicle dynamics and chassis engineers need to sharpen their pencils and make sure their passports are up to date, as it will only get more challenging.

John Heider is from Cayman Dynamics LLC, providing vehicle dynamics expertise to the transportation industry: www.caymandynamics.com

CHEVROLET VOLT IN CHINA. THE COUNTRY WAS ONE OF THE FIRST TO RECEIVE THIS RANGE-EXTENDER VEHICLE

ON THE WEB

Further comment from Heider at vehicledynamicsinternational.com

Is this a setup?

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

CASE 26: JAGUAR XJ L, BY GRAHAM JOHNSON

Too much rake. That was my initial thought when I first took the helm of Jaguar's XJ. A corner later, and I wondered if it was running a great deal of toe-out because it turns in with the aggressiveness of a race car. Seriously, it's BMW-MINI-eat-your-heart-out stuff. And maybe the rear is crazy stiff: this setup would be pointy for a hot hatch, let alone a large sedan.

A couple more miles in and my thoughts moved to damping. The springs are supple enough, but the shocks work hard and fast. Too hard and fast for the springs. Could they be the reason why this car's nose is so overly swift, why it's so very keen to get into the corner? Perhaps it's all of the above. One thing is for sure, the back feels nervous – and like it's located about 10 miles behind the front wheels. This car feels big and loose.

I didn't push this long-wheelbase, supercharged V6-powered XJ anywhere near hard enough to discover whether the rear is as unhinged as that initial turn of the beautiful wheel suggests, but then I wouldn't have had the confidence to do so. My guess is you could play with the powered wheels all too easily on a proving ground with ESC disabled. British consumer motoring magazines do love this car, after all.

The Jaguar's ride quality is a disappointment, as well. Too much bump and thump. Too much rut intrusion. It fidgets like a child needing a wee.

If I were responsible for setting up its behavior, I'd make a big Jag glide and waft. I'd let it float a little more than a Merc S or a BMW 7. I'd give it lazy turn-in…

As it is, it's a confused car. Just bloody beautiful to look at, to sit in and to touch, but too frenetic and we'll say 'sporty' to be a luxury limo.

But here's the thing – I kind of want one…

SPECIFICATIONS

Jaguar XJ L

Dimensions: 5,252mm (L) x 2,105mm (W) x 1,457mm (H). Wheelbase 3,157mm

Engine: 3-liter V6 petrol supercharged. 340PS @ 6,500rpm, 610Nm @ 3,500 to 5,000rpm

Suspension: Wishbones front and rear. Air springs at the rear. Bilstein DampTronic adaptive damping all round

Steering: Variable-ratio, speed-sensitive Servotronic

Brakes: Conti. Front discs 18in, rears 17in with EPB. Bosch ESP tuned by Jaguar

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