

## Tire and wheel fusion

An airless tire under development may eventually obsolete conventional air-filled tires. While **Michelin** researchers are still years away from offering a production-ready non-pneumatic tire with integrated wheel for passenger vehicles, the unique construction of the tire-wheel combination—dubbed Tweel—represents a mobility milestone.

Tweel bypasses the need for tire pressure by a unique use of specific components, mainly consisting of “a cable-reinforced tread band of conventional tread rubber that connects to a shear band to generate the contact patch and replace



*According to Michelin, existing run-flat tires provide extended mobility, while the Tweel is more of an ultimate mobility solution: drivers will not have to worry about getting service for a tire-pressure issue.*



*“Tweel is a completely non-pneumatic, single-component tire and wheel assembly that, for passenger cars, is a long-term vision of the future with exciting possibilities,” said Michelin’s Terry Gettys.*



*The spokes are designed so that stiffness can be tuned and so that the manner in which loads are transmitted can be controlled.*

inflation pressure. That, in turn, connects to a hub via Michelin’s patented flexible, rectangular polyurethane spokes.

“This mechanical structure provides weight-carrying ability, shock absorption, ride comfort, rolling resistance, and mass similar to pneumatic tires, while adding suspension-like characteristics that greatly improve handling,” said Terry Gettys, President of Michelin Americas Research & Development.

Michelin’s Tweel grabs its first production application on an iBOT wheelchair from **Independence Technology**, a **Johnson & Johnson** company. Using technology invented by Dean Kamen, the iBOT wheelchair can climb stairs and navigate uneven terrain. **Segway’s** Concept Centaur, a four-wheel transportation vehicle that applies a self-balancing method first used on the Segway transporter, also employs Tweel technology. Other future applications include skid-steer loaders and military vehicles. A production-ready skid-steer loader application is likely in a couple of years, while “active research projects are under way with the military,” said Gettys.

In the long-term, passenger vehicles could be fitted with Tweel technology in the next 10 to 15 years. Preliminary findings are proving positive. “Our first prototype passenger car application of Tweel, demonstrated on the **Audi A4**, is within 5% of the rolling resistance and mass levels of current pneumatic tires. That translates to within 1% of the fuel

## Michelin loses air

It may seem like a step back in time that **Michelin** is researching an airless tire design, but it is not quite like the solid motor vehicle tires of the early 19th century. The Michelin Airless tire uses high-performance composite materials as its core, onto which a rubber tread is bonded. When it wears down to a specific level, the tread is removed to be replaced by a new one, which is bonded to the core structure. The central structure is designed to last the life of a vehicle—around 150,000 mi (240,000 km). The new tire would be tuned to a specific vehicle and could be on sale within a decade.

Didier Miraton, Michelin's Head of



*It may look much like any other tire, but this is Michelin's Airless.*

R&D, said that the Airless and other concepts are part of the company's portfolio of innovations to reduce braking distance, rolling resistance, and noise, and to extend tire life. "We are seriously focusing our research on these solutions that will make their way onto the market within a decade or so," he said.

*Stuart Birch*

economy of the OE fitment," said Gettys, who added, "Michelin has increased the lateral stiffness by a factor of five, making the prototype unusually

responsive in its handling."

Lessons learned from the first applications of Tweel, which are low-speed, low-weight, will influence passenger vehicle

modifications. "Our expectation is the Tweel components will be application-specific. For example, Michelin's early Audi A4 prototype uses an inset aluminum wheel, while the wheel of the iBOT is composed of polyurethane, except for a small metal hub for attachment to the device. The use of polyurethane in the wheel area allows the wheel as well as the flexible spokes to deform, increasing the suspension capabilities of Tweel," Gettys said.

Challenges still remain with regard to passenger vehicle applications. "As far as passenger car vehicles, there are issues with noise which we will need to address in order to find a natural resonance. We are confident we can achieve the same ride comfort of today's radial tires with excellent wear life and improved safety, handling, and convenience," said Gettys.

*Kami Buchholz*

## One LED, two colors

**Hella** and **Volkswagen** lighting specialists jointly have developed new combination rear lamps for the latest Golf Plus using LED technology. The unique feature of these lamps is that the LEDs being used as light sources are able to emit both red and amber light.

The combination rear lamps on the new Golf Plus have a two-part design. The taillight, stop light, and turn signal are positioned at the outside edge of the vehicle, with the reversing and fog lights inboard. When switched off, four white circles on a red base can be seen.

There are 36 LEDs on each side that provide the light sources. When the driver applies the brakes, the two sets of 16 red Power TOPLEDs in the two inner circles light up with increased intensity, and together with the third stop lamp in the roof-edge spoiler (which also uses LED technology) form the now classic optical "warning triangle."

When the driver switches on the turn signal, the respective set of 20 two-color Multi TOPLEDs in the outer lamp rings are activated and emit the prescribed flashing amber light. This works with the taillight switched on, since the LEDs have a two-color design and the flashing amber color outshines the red of the taillight. In the case of turn signal operation, the yellow



*New LED technology on the VW Golf Plus does not require colored lenses.*



*Twenty LEDs in the outer lamp rings glow yellow for the direction indicator.*



*All 36 LEDs glow red for the taillight. The 16 LEDs on the inner ring light with greater intensity when the brakes are applied.*

chips of the Multi TOPLEDs are powered with a nominal 130 mW for each LED. With the nominal luminous efficiency of 24 lm/W, the light output meets ECE regulations.

For the taillight, all 72 LEDs emit red

light. In taillight operation, all the LEDs are driven with considerably reduced power consumption because of the lower light output requirements.

LEDs have safety-related advantages, particularly with regard to the stop light and the direction indicator, because they react much more quickly than conventional filament bulbs. Traffic following the vehicle is therefore warned earlier. A further advantage is the homogeneity of the illuminated areas. Thanks to the use of LEDs, the functional lights can be implemented without colored intermediate lenses. The reversing and rear fog lights still use conventional filament bulbs as light sources, since this technology is better for these functions.

*David Alexander*

**Briefs**

The new **Land Rover** LR3 features hydroformed frames from **Chassis Systems** (a joint venture company between **Dana** and **GKN**) that are produced using Dana's patented Robo Clamp process. Dana is also supplying front and rear axles that feature Dana's Advan TEK design, which uses proprietary gear geometry, special bearing design, and advanced assembly processes. The vehicle also features air-suspension modules from **Delphi** that deliver automatic vehicle self-leveling, adjustable ride height, and the ability to withstand demanding off-road driving. The front and rear airspring modules include integral high-pressure twin-tube gas dampers.

**Kelsey-Hayes**, a subsidiary of **TRW Automotive**, is providing the stopping power for the 2005 **Ford** F-Super Duty trucks. The braking system includes four-wheel disc brakes, a rear hub assembly with drum-in-hat park brake, actuation, and advanced ABS. TRW engineers worked closely with Ford to deliver increased stopping power and enhanced pedal feel from a system with components 5% larger than its predecessor's.

Pickup trucks powered by the 6.6-L **GM** Duramax V8 diesel engine can now get an optional exhaust from **CORSA Performance**. The specially engineered system changes the sound and improves performance of the engine. The 4-in (100-mm) diameter 304L stainless steel exhaust uses CORSA's patented Reflective Sound Cancellation technology to enhance the engine sound while eliminating cabin resonances. The straight-through, non-restrictive design reduces backpressure and increases exhaust flow.

Seats developed by **Johnson Controls** for the second-generation European **Ford** Focus received awards for occupant protection under rear-end collision from the Swedish insurance company **Folksam** and the International Insurance Whiplash Prevention Group. The behavior of the seats also helped the new Focus receive 5 stars from **EuroNCAP** (the European New Car Assessment Program).

## A flexible interior to drive by wire

**Bertone** and **GM** have strong collaborative links (Stile Bertone built GM's drive-by-wire Hy-Wire fuel-cell concept) and the Italian company has come up with the CARosel concept interior based on a Hy-Wire configuration "skateboard" chassis. It is all about flexibility of interior design, "offering the driver the possibility of selectable driving positions and driving controls." Four seats are fixed to a rotating base and there is a choice of left- or right-hand drive—or even center drive.

There are no pedals; hand controls are used for braking and accelerating. Steering control offers a choice of a steering wheel, which can be folded and stowed under a seat, or joysticks positioned on the right and left armrests. "With the CARosel you can accelerate, brake, and steer with the right hand, with the left hand, or with both hands positioned on the steering wheel," said a Bertone spokesperson.

The Hy-Wire chassis allows a "virtually infinite" variety of bodywork to be attached, according to Bertone, with the chassis incorporating all vital functions of



*Not the ultimate in open-air motoring, but Stile Bertone's interior concept for GM.*

the vehicle. "CARosel represents the most advanced phase of the collaboration between Stile Bertone and GM, a collaboration in which *avant-garde* technologies provide opportunities for innovative design."

*Stuart Birch*

## Daewoo expands its role within GM

South Korea's third-largest automaker, **GM Daewoo** Auto & Technology—the Asian production base of parent **General Motors**—said it would bear more engineering and design responsibilities as it tries to expand its role within the GM family.

"GM Daewoo and other GM family companies in this Asia-Pacific region will be asked by GM to do more engineering work in the future when it is more effi-

cient to be done in this region," said Ki-Joon Yu, GM's Asia-Pacific Engineering Coordinator. "GM's strategy is to pursue "engineering globalization" and "regional engineering" to better link its units with the North America engineers."

Yu is also GM Daewoo's Vice President in charge of engineering. He said he will seek and consolidate "regional engineering" of GM units in Asia such as **Shanghai Automotive**, GM Daewoo, GM's Japanese alliance partners of **Suzuki** and **Fuji Heavy Industries**, GM's Australian arm **Holden**, and **GM-India** technical center.

"What I want to do for the regional engineering is to enhance the synergy effect of all GM engineers in the region," Yu said. "One GM, one [engineering] process is the slogan GM is pursuing now." Adding that GM Daewoo engineers will be called to do more engineering work for GM cars, Yu said GM's engineering technology could be shared through the "maximization" of GM's



*"GM's strategy is to pursue engineering globalization and regional engineering to better link its units with North America engineers," said Ki-Joon Yu, GM's Asia-Pacific Engineering Coordinator.*



GM facilities in India, Vietnam, and China are currently producing GM Daewoo's Lacetti compact cars on complete knockdown to sell the cars locally.



GM Daewoo President and CEO Nick Reilly is working with other GM Group members to devise advanced-technology solutions, including hybrid and fuel-cell propulsion systems.

Asia-Pacific resources. As the Asia-Pacific coordinator for China and Korea, Yu said he will attend GM's "global engineering leadership committee" meetings four times a year.

GM Daewoo, which will jointly develop cars for both Asia and North America, is now developing part of the redesigned **Saturn** Vue that will be produced in 2007 in North America. The current Vue had been developed by GM and Suzuki engineers. The relatively high cost of engineers in Detroit, coupled with fast computer links, would prompt GM to use more of GM Daewoo's engineering capability.

In a sign of such regional cooperation, GM, through its arms in India, Vietnam, and China, is currently producing GM Daewoo's Lacetti compact cars on complete knockdown (CKD) to sell the cars in the Asian countries.

Currently, there are 1900 engineers in GM Daewoo's technical center, up from 1450 engineers when GM took over Daewoo three years ago. GM Daewoo will hire 150 more engineers this year, according to Yu.

On the design front, David Lyon is the Executive Director of Design for GM Daewoo. He is responsible for GM's Asia-Pacific Region. Lyon has been with GM since 1990 and was lead interior designer on the **Cadillac** CTS. He has been the chief designer on numerous concept vehicles, and has had overall responsibility for Truck and SUV interiors with GM before coming to GM Daewoo.

To handle more GM engineering work, GM Daewoo President and CEO Nick Reilly said his company will build a new R&D facility in Incheon, which is near Seoul. The facility will include a comprehensive test track.

Noting that this year will mark the

beginning of the new GM Daewoo's first major product offensive, supported by stronger engineering and design efforts, Reilly said his company will begin with the launch of the all new Matiz, followed quickly by the launch of the Statesman, and a new SUV sometime in early 2006.

"In all, we will launch five new products this year and over the course of the next 15 months, nine new products," Reilly said. "With the exception of the Statesman, which will be an import, the products have been designed inside and out by our GM Daewoo design team in our new Design Center." The design center opened in late 2003.

As an example of his company's in-house engineering expertise, Reilly explained about the new SUV. "An interesting story is that when we were deciding on the overall design direction of the new SUV, we asked for submissions from several design houses, including a renowned Italian design house," Reilly said. "We then put the designs through an [anonymous] visual appeal test, and to no surprise to us, the GM Daewoo design won hands down. We gave the job of designing the new vehicle to them."

Reilly said his design team's expertise extends beyond the skin of the vehicles, as its interior design skill is a core expertise and is recognized as among the best in the industry. The successors to the new Kalos and the new Magnus are good examples.

"Our investment in engine and transmission development is also showing real results," Reilly said, adding that the Boryeong transmission plant in South Korea has been fully integrated into GM Daewoo and its engineers are working hard on developing the next generation of small six-speed automatic transmissions.

"Our engine development effort has been as extensive as our vehicle development," he said. "We broke ground on a new diesel engine plant facility last June, [and] we expect to have the new plant up and running in a couple of months. Much work has gone into the development of our new diesel engine."

To the press, Reilly has briefly opened the automaker's design center near Seoul. "Typically an automobile company's design center is off limits to all but a few people within the company," he said. "In some cases the designs are experimental to test new concepts. In other cases they are intended to eventually become a part of a production vehicle."

"We are working with other GM Group members to devise advanced-technology solutions, including hybrid and fuel-cell propulsion systems," said Reilly. "Our aim is to reduce emissions, improve efficiency, and lessen Korea's dependence on imported oil."

Reilly said GM Daewoo is leveraging GM's advanced technology to implement leading-edge solutions and bring alternative-propulsion vehicles to market faster than it could on its own.

GM Daewoo recently unveiled its S3X SUV show car, which has a hybrid propulsion system. The actual production version will be the first diesel-powered vehicle manufactured and distributed by GM Daewoo. On top of local production, GM Daewoo products also are assembled at GM facilities in China, Thailand, India and Colombia. In 2004, GM Daewoo sold more than 900,000 vehicles. Imported GM products from the Cadillac and Saab premium brands are sold in Korea through GM AutoWorld retailers.

Peter Chang

## BMW + PSA = new gasoline engines

As technology and environmental needs converge and R&D investment soars, joint venture projects to offset development and manufacturing costs are increasingly attractive propositions for companies that are not head-on market rivals. That is why **BMW Group** and **PSA Peugeot Citroën** are cooperating on the development of a new range of inline four-cylinder gasoline engines with designs that will include natural aspiration with variable valve technology, and turbocharged plus direct injection.

The new engines will be suitable for future models in each company's range, including the **Mini**. The need to enhance emissions technology to meet the self-commitment target of members of the European carmakers association (**ACEA**), which includes CO<sub>2</sub> levels of 140 g/km by 2008, is a major reason for the collaboration. The companies say their joint project will demonstrate that it is wholly practical to manufacture "fuel-efficient engines with innovative technologies" for small and compact cars.

The outcome of the collaboration will initially involve two engines. The companies claim: "While increasing driveability and performance and without making the slightest concession in terms of refinement, the naturally aspirated power



*The naturally aspirated BMW/PSA engine with fully variable valvetrain will produce 85 kW (114 hp) at 5700 rpm.*

unit with fully variable valve drive as well as the turbocharged direct-injection engine will set new standards in their displacement category."

That displacement is 1.6 L, and the engines will include various features found on BMW's current engines—not

only variable valve control but also a volume-flow-controlled oil pump, single-belt drive of ancillaries, individual coils and composite camshafts, direct gasoline injection, twin-scroll design turbocharger, on-demand mechanical coolant pump, and a new tightening unit for the poly-V belt drive.

"In terms of stiffness and acoustic features, the engine's aluminum crankcase with its bedplate construction is absolutely unique and unparalleled, and optimization of the crankdrive bearings and conversion of all mechanical valve drive transmission units to anti-friction rollers serve to provide the lowest level of friction losses in this class," claim the companies. The two-piece bedplate construction of the aluminum crankcase made up of the cylinder block and the bearing housing is a design adapted from motorsport.

The use of an on-demand oil supply is regarded by PSA Peugeot Citroën and BMW as being particularly significant, bringing a 1% fuel-consumption improvement: "Together with the oil/water heat exchanger, an on-demand water pump serves to further reduce fuel consumption and emissions." Fully variable valve control, with no requirement for a throttle butterfly, also contributes to reduced fuel consumption and emissions.



*BMW/PSA's 1.6-L gasoline engine with direct injection and turbocharger will be suitable for future models in each company's range.*

Variable valve drive technology may cut fuel consumption (depending on route and traffic conditions) by up to 10% and up to 15% with a turbocharged direct-injection engine, say the companies “with a saving in the EU test cycle of approximately 9%.”

The lower-output, naturally aspirated engine will produce 85 kW (114 hp) at 5700 rpm and a maximum torque of 160 N·m (118 lb·ft) at 4250 rpm. With 140 N·m (103 lb·ft) available at 2000 rpm, the engine will have a commendably flat torque curve. The turbocharged, intercooled direct-injection engine will produce 105 kW (141 hp) at 5500 rpm and maximum torque of 240 N·m (177 lb·ft) from 1400 to almost 4000 rpm. The twin overhead camshaft configuration has conventional valve actuation, but there is fully variable adjustment of the intake camshaft. The engine is claimed as the first in its class to use a twin-scroll turbocharger for improved low-speed response, generating torque “virtually just as fast” as in a compressor engine, say BMW and PSA. Common-rail



*BMW's Valvetronic fully variable valvetrain technology will be featured on a new range of small engines jointly developed with PSA.*

technology is used for the direct-gasoline-injection system. The 1.6-L engines will be some 20% smaller overall than most comparable power units and about 15 kg

(33 lb) lighter.

PSA and BMW say they are developing a “complete family” of engines with power outputs spanning 55 to 125 kW (74 to 168 hp). The companies expect long-term engine development generally to be very costly and say they will not incorporate any technologies that do not bring a good direct cost-benefit ratio in terms of performance, fuel consumption, emissions, manufacturing costs—and the overall expectations of the end user. It was partly for the latter reason that cylinder cutoff was rejected.

Major groups have been set up within the collaborative project to look after engine development (with BMW the lead partner), preparation for production, and purchasing (PSA leading both). More than 20 different car variants are expected to be fitted with the engines. Production is expected to begin late this year at PSA's facility in Douvrin, France.

*Stuart Birch*

## A breath of fresh air in engine design

**NESTA** (National Endowment for Science, Technology and the Arts), the organization that supports UK innovation, has invested in the Bruntel Environmental Engine (BEE) project that aims to match diesel-engine fuel efficiency with a low-emissions spark-ignition engine. Central feature of the Bruntel is the use of return stroke induction—the engine aspirating on the piston's return stroke. “It is a two-stroke engine with the problems of that technology removed—notably oil contamination of the catalyst,” said its designer, Keith Hall, who previously has worked for major automobile companies including **Ford**, **Jaguar**, and **Audi**.

“Part of the funding will go towards a simulation study of Keith Hall's theories,” said NESTA in a statement. The aim of the engine's design is to achieve fuel consumption of 3.0 L/100 km or better, with associated low emissions. The engine has been designed to offer torque and power output similar to a comparable conventional engine.

“Cost of unit manufacture of a production engine would be half that of a current conventional engine, with size

and weight also halved,” said Hall.

He describes the engine as a low-pressure/low-temperature spark-ignition unit “that virtually eliminates NOx and particulates at source in lean-burn mode; it offers diesel economy without the particulates.” The engine combines a high expansion ratio to increase thermal efficiency with a low compression ratio to increase mechanical efficiency. Engine speed is halved because a patented induction process creates an engine cycle each revolution whilst breathing via a conventional four-valve cylinder head. A low-energy electropneumatic valve actuator (patent granted) facilitates variable valve timing for optimization of engine efficiency at each speed, and a planetary-motion disc replaces the connecting rod in order to achieve dynamic symmetry and balance in a 90° vee configuration.

Hall hopes to see the project reach fruition in time to meet 2009 EU emission control requirements. “With energy consumption outstripping resources, it is important to come up with a solution that is economical and causes less pollution,” he said. “Fuel consumption of conventional



*The Bruntel concept engine replaces connecting rods with planetary motion discs.*

engines is unacceptably inefficient. I found throttling at part load particularly unpalatable; the excuse that this was simply due to the thermodynamic limitation of physics was not convincing.” Hall said use of a planetary disc not only reduces engine vibration but “greatly simplifies” engine construction.

*Stuart Birch*

## Power-saving pump

Designing power-saving engine accessories is now an essential element of automotive engineering, bringing worthwhile fuel consumption and emissions reductions. With this aim, **Concentric** has developed a new infinitely variable-flow oil pump (VFP) for automotive engines which is said to use significantly less power than fixed-flow types. The pump was originally developed for heavy-duty diesel engines but can now be applied to medium- and light-duty diesels and passenger-car gasoline engines.

The company explained that unlike many other variable-flow pumps, which offer a choice of only two fixed rates of flow, its infinitely variable model, designed to provide fuel savings of about 1%, reduces parasitic losses by adapting to the differing requirements for each point in the operating cycle.

"In a typical light-duty cycle, many engines do not reach a stable 80°C (176°F) for long periods, and the regulating valve can operate prematurely, providing the opportunity for further energy savings. Additional benefits can be achieved if the oil system is optimized, enabling the pump to provide only the pressure necessary at any point in the operating range. Aligning flow to de-



A CAD drawing of Concentric's variable-flow oil pump shows the split rotor and rack and pinion actuation. The pump is suitable for passenger car gasoline engines as well as diesels, ranging from light to heavy-duty.

mand limits power requirements and reduces fuel consumption," said Paul Evans, the company's Director of Technology.

The system uses two inner rotors within a single outer to control flow output. The driving rotor operates via a traditional fixed configuration, while the offset position and resultant flow of the second, eccentrically mounted rotor can be controlled mechanically by a rack and pinion

system or via electronic management.

Concentric made extensive use of CFD to refine the internal geometry of the VFP pump. Low pulsing and high efficiency have been achieved by optimizing the port design. Internal loadings have been reduced to obviate the need for special materials or heat treatment.

Concentric's range includes oil, water, and fuel-transfer pumps.

Stuart Birch

## Japanese hybrids gather momentum

Thanks to the success of the new Prius, **Toyota** is adding more capacity to the Prius production line. Toyota has four ICE (internal-combustion engine)/electric hybrid types: the Prius THS-II, the minivan Alphard/Estima TH-C (Toyota Hybrid-CVT), the Crown mild hybrid, and the Coaster small bus series hybrid. The Alphard/Estima is equipped with an electric rear-wheel-drive system, a hybrid drivetrain in the front, and sophisticated electronic brake control.

The company is now readying the **Lexus RX 400h**, combining a V6 engine, THS-II technology, and an Alphard/Estima-type electric rear-wheel drive for all-wheel-drive versions. Giorgetto Giugiaro's **Italdesign** saw huge performance potential in the RX 400h power pack, managed to get one, and built the concept sports car Volta. Actually, Toyota's own skunk works had built a running testbed car in the same configuration, although clothed



Toyota's Alphard large minivan series includes a sophisticated THS hybrid employing CVT and electric rear-wheel drive. An inline four-cylinder engine and THS-C motor/CVT drives the front wheels. A nickel metal hydride battery pack is located under the floor, and the "E-Four" motor drives the rear wheels when needed.

in a rather unsightly makeshift coachwork, with the RX 400h drivetrain relocated to behind the two-seat cockpit driving the rear wheels, and a coordinated electric front-wheel-drive system grafted on.

In the meantime, **Nissan** is working on a hybrid version of the Altima sedan, using Toyota's THS-II technology. A prototype combined the company's QR25 DOHC 2.5-L inline four-cylinder engine to the Toyota-supplied THS-II, which was



*Italdesign's concept sports car uses Toyota's RX 400h-type hybrid system located behind the cockpit. An Alphard-type E-Four motor drives the front wheels.*



*The Subaru B9 concept is Fuji Heavy Industries' idea of a high-efficiency hybrid.*



*The Honda Accord powertrain combines a V6 engine with cylinder deactivation, IMA, and an electronically controlled five-speed automatic transmission.*

believed to be the high-torque unit for the RX 400h. It has not been decided which engine type Nissan's hybrid will employ.

**Honda** launched the Accord Hybrid at the end of 2004. This is a U.S. Accord, not the Japanese/European one that is a size smaller than the American version and available only with inline four-cylinder engines. The Accord Hybrid is powered by a high-efficiency V6 engine equipped with cylinder deactivation (one bank of the V) that has already been adopted in two Japanese models, combined with IMA (integrated motor assist) as in the Insight and Civic Hybrid. The Accord Hybrid is fitted with an electronically controlled five-speed transmission, versus a CVT in the Insight and Civic. Honda cites a maximum combined power of 255 hp (190 kW).

**Subaru** showed an interesting permutation of the ICE/electric hybrid in the 2003 Tokyo Motor show concept B9 Scrambler. Called "sequential series

hybrid," it exploits the potential of Subaru's symmetrical drivetrain configuration, a horizontally opposed engine driving all wheels. Subaru's hybrid operates in four modes: electric motor only, engine-driven high-ratio, engine-driven low ratio, and parallel engine and electric operation. The system places emphasis on electric motor drive up to 80 km/h (50 mph), which covers most driving in Japan.

Electrical energy storage is the NLE manganese lithium-ion battery being developed by **NEC Lamillion Energy**, a joint company of **NEC** and **Fuji Heavy Industries**. Vice President Ichiro Kudo says that research and development are showing great promise for this battery type. Another concept car, the R1e, is an electric runabout using the same battery pack.

Nissan is also working on the battery type, in cooperation with NEC, and has fitted it as the secondary battery in its latest fuel-cell vehicle.

*Jack Yamaguchi*

## Bringing a glow to VW

The **Volkswagen** Group is believed to be the first European motor manufacturer to install ceramic glow plugs as original equipment. **NGK** is to supply the new-generation plugs which have the capability to reach high temperatures markedly more quickly than metal types. Called the New High Temperature Ceramic (NHTC) glow plug, it replaces a second-generation type in production since 1998. The first-generation Self-Regulating Ceramic (SRC) was introduced 20 years ago.

VW has selected two NGK NHTC glow plugs for installation on new engine developments for existing models: the thinner NGK M8 for the 2.0-L four-cylinder four-valve engine for the Passat, and the NGK M10 for the 1.9-/2.0-L four-cylinder two-valve engine and 5.0-L V10 engines

for models including the Phaeton and Touareg. "In the future, VW four cylinder and V10 engines with particle filters installed will only have ceramic glow plugs fitted as original equipment," said NGK.

The NHTC ceramic plugs have a long element with a small diameter that will heat up quickly, reaching 1000°C (1830°F) in under 2 s to achieve improved cold starting and lower emissions. "They also have a longer post-starting operation time of approximately 10 minutes and for the first time are able to assist in reducing emissions by their ability to operate intermittently during engine running—for example, when the throttle is eased back," said NGK. A high stabilized temperature of about 1300°C (2370°F) is said to ensure excellent startability from a lower



*Volkswagen is now fitting third-generation NGK ceramic glow plugs to several diesel engines as standard equipment.*

compression ratio. This also reduces noise, engine stress, and emissions, with improved mechanical resistance to reduce vibration. Both versions of the new NHTC glow plug offer lower power consumption, added the company.

*Stuart Birch*

## Servicing gets boost with new bearing design

A new bearing unit for the wheel hub uses a detachable braking system cable, which essentially makes the SKF-designed unit a more service-friendly product. "With traditional designs, the cable and sensor were one-piece systems—making servicing of the cable, sensor, or bearing separately a challenge," said Gregg Rasmussen, Vice President of **SKF** Car Business in North America. "What gets damaged during servicing is normally the sensor wire connection or the sealing between the sensor and the bearing. This sealing is what keeps the water and other contaminants out of the critical internal bearing surfaces," added Cengiz Shevket, Director of Technical Sales for SKF.

SKF's new wheel hub bearing also employs an integrated ABS sensor. The product debuted in North America on the 2005 model year **Ford** Crown Victoria, **Lincoln** Town Car, and **Mercury** Grand Marquis. Compared to the 2004 model year wheel-hub bearing unit, the 2005 application has a number of modifications.

"There has been a change in the ball size and number of balls in each ball row to attain optimized bearing-carrying capacity," said Shevket, adding, "We have added a fully integrated non-serviceable



*SKF wheel hub bearing units with integrated sensors are being provided to Ford for brake systems on the Crown Victoria, Lincoln Town Car, and Mercury Grand Marquis.*

multi-pole ABS sensor into the bearing assembly and have included a plated steel sleeve to the outer diameter of the bearing to provide a unique [barrier] method of anti-galvanic corrosion between the aluminum knuckle and the steel bearing."

The result of the changes, according to Shevket, is a bearing with greater load capacity, improved system stiffness, and an improved cost-to-capacity ratio. "This is the first time Ford in North America will

use this type of non-serviceable integrated sensor with serviceable cable," said Shevket. "SKF has been providing this type of ABS sensor technology to vehicles in Europe—including European Ford vehicles—for some time."

The SKF bearing is a self-retained, pre-greased, pre-sealed, and pre-set third-generation hub unit. "The unit is made of three forged steel parts that are hardened and mirror-finished to provide the anti-friction ball raceways," said Shevket. "The forged rings are then assembled with balls, nylon cages that separate the balls, an SKF-designed and produced seal to keep contaminants out and grease in, studs to attach the car's wheel, a toothed target wheel for the speed sensor, a one-piece sensor, and a detachable cable for the sensor."

As for the sensor, it is permanently pressed onto the inboard side of the outer ring, which is bolted by its flange to the knuckle of the vehicle suspension. The sensor does not rotate. "The hub unit, therefore, acts as the link between the wheel and the vehicle. It provides low-friction wheel rotation, helps reduce brake roughness, and provides a speed signal to the ABS system for safe braking as well as traction control," said Shevket.

*Kami Buchholz*

## GM's new airbag technology

Two 2006 model year full-size **GM** sedans will be the vehicles to feature industry-first airbag technology. Unlike a conventional front passenger airbag that inflates to one shape with different pressures, the new airbag is not limited to a single size.

"This GM-patented technology deploys in two different sizes and at different pressures, depending on occupant seating position, safety belt usage, and crash severity," said Jim Taylor, **Cadillac** General Manager, during the DTS product reveal at the Chicago Auto Show. The **Buick** Lucerne, sharing the debut spotlight at the show, also will feature GM's exclusive dual-depth airbag.

The technology enables one airbag to inflate to different shapes. "The additional functionality provided by the dual-depth front passenger airbag provides

more ability to adjust the airbag's deployed profile and pressure outputs. It essentially can adapt its functionality and profile to varying occupant sizes and shapes to help provide the necessary restraint for passengers," said Scott Thomas, Engineering Specialist – Technology, GM Interior Center.

Specific components include one airbag with releasable/extendable tethers, a single-level inflator, a module housing with a housing vent, and a pyrotechnic mechanism that holds onto the tethers and leaves the housing vent open when not deployed and releases the tethers and closes the housing vent when deployed.

GM and **Delphi** are co-owners of the base patent. The automaker and supplier also have specific patents for specific designs. Patents, in general terms, address the airbag module mechanism that re-

leases the cushion tethers and closes the airbag module housing vent as well as the releasable/extendable tethers.

The airbag module mechanism, when un-deployed, "holds onto airbag tethers and leaves a module housing vent open near some of the inflator outlet ports to vent some of the inflator gas outside the module, so that a shallow lower-output airbag is deployed," said William Barnes, Lead Engineer for GM Frontal and Side Airbags. "The mechanism, when deployed, releases/extends the airbag tethers and closes the module housing vent near the inflator outlet ports to direct the inflator gas inside the airbag. The timing on when the mechanism is deployed determines how much inflator gas is directed into the deep airbag."

While slightly larger than a conventional airbag in terms of package size, the



■ Shallow Deployment — Forward Seat Position  
 ■ Deep Deployment — Rearward Seat Position

The new dual-depth airbag, co-developed by GM and Delphi, is one of six standard airbags on the 2006 Cadillac DTS and Buick Lucerne.

dual-depth airbag has more content, “thus more space is needed in the instrument panel to package the larger module,” said Barnes. “Although the dual-depth airbag uses only two deployment loops—one for the inflator and one for the mechanism—just like a conventional airbag with a dual-level inflator with two deployment loops, changes are needed to the airbag electronics to account for sensor inputs and the specific delay times needed to deploy the different dual-depth airbag states.”

The prompter for the development of a dual-depth front airbag centered on meeting “future safety challenges and [to] enable more stylish and roomy vehicles while maintaining top safety performance,” said Stephane Vitet, GM Performance Engineer.

Kami Buchholz

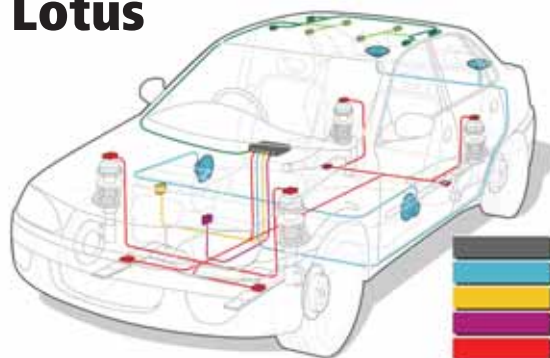
## Sound advice from Lotus

Cabin noise levels in some compact and supermini cars can be a problem. As the challenges of engine and aerodynamic noise have been tackled, so other noise sources come to the fore. To help tackle this issue, the consultancy **Lotus Engineering** has developed In-Car Active Acoustic Tailoring (ICAAT). Lotus has been involved in research and development into active noise systems since the 1980s, and at one time demonstrated software that could make a humble **Citroën AX** sound (to its occupants) like a powerful motorcycle or a sports car with a V8 engine.

The introduction of active noise reduction for cars has been treated with caution by OEMs, but Lotus feels that as weight saving again becomes a major factor in new model design, it could provide a major asset, and its ability to generate the “right” sound, albeit not as extreme as the above example, is an added plus.

“ICAAT works by reducing unwanted noise in the relevant frequency range from both road and engine,” said Steve Swift, Lotus’s Head of Vehicle Engineering. “Through complex algorithms, the technology then generates sound of an opposing phase through the car’s standard speakers, suppressing the perceived level of noise for passengers.”

He added that while eliminating unwanted noise, ICAAT also features a



Lotus Engineering’s active noise quality system can be used to customize cabin sound.

sound-generation mode. “It is capable of producing engine sound cues as well as suppressing unwanted noise. Manufacturers could therefore tune the engine tone characteristics between different models in a product range. Alternatively, there is the option of leaving the decision to individual drivers, allowing them to choose the engine tone, dependent on their mood or driving experience.”

Swift said that a surprising fact is that interior noise levels of a majority of cars have worsened over the past 10 years. “As the number of clients requesting our help in this area has increased, we have been working to refine our active noise solution.”

Among the causes of increased interior noise, he cited larger wheels made of alloy

instead of steel, and the use of low-profile, wider tires, increasingly with run-flat capability. “The suspension configuration of modern cars also compounds the issue. A decade ago, most European and Asian hatchbacks had standard beam axle suspension, but now many feature multilink systems, setups which offer multiple paths for vibration and noise to enter the car. According to Swedish researchers, the presence of low-frequency monotonous noise can make drivers feel drowsy, which is widely believed to be a factor in some accidents.” Low-frequency noise, he added, cannot be effectively treated with conventional NVH tools without compromising vehicle dynamics performance.

Stuart Birch

## More performance automatically

Both the **Mini Cooper S** and the Cooper S Convertible are now offered with a six-speed automatic transmission that includes Steptronic mode and Steptronic shifting paddles on the steering wheel. Unlike the automatic version of the Mini Cooper that is a CVT (continuously variable transmission), this new automatic transmission has fixed gear ratios that result in 0.25-s gear changes tuned specifically for the MINI Cooper S. The new transmission is built by **Aisin**.

A hydraulic torque converter ensures a smooth gearshift, while the converter lock-up clutch—closing at 1800 rpm—provides an equally smooth flow of power and good fuel economy. Despite its six gears, this new transmission requires a smaller number of gearshift elements than a typical five-speed, making it light and compact. The transmission concept is based on the Lepelletier principle. While a conventional five-speed automatic transmission has eight clutch elements and four free-wheels, the new transmission needs only five clutches and one free-wheel to shift the six forward gears and reverse. The only free-wheel is on first gear, serving to take the load off the drivetrain in overrun. Whenever Steptronic is active, the free-wheel remains neutral in order to capitalize on engine braking when shifting down.

The unit also features Adaptive Transmission Control (ATC) to allow the transmission to adapt to driving style. For example, the transmission will build the revs longer between gear changes if it “knows” the driver enjoys taking the car to its limits. Since the ATC communicates with other control units via the bus system, it is able to adjust gearshift programs individually to both driving conditions and technique.

One of the major benefits of the new automatic transmission is its versatility. The driver has the choice of four different gearshift modes, shifting gears either in a more comfortable style in the interest of superior fuel economy or with a more sporting and dynamic technique, whatever is preferred. A display in the central instrument shows the driver at all times which driving program and which gear are currently in use. The driver decides whether to leave things to the automatic transmission or whether to activate Steptronic and manually shift gears by



*The Mini Cooper S is now available with a six-speed automatic transmission that delivers a top speed of 220 km/h (137 mph).*

briefly touching the gearshift paddles at the back of the steering wheel. In the process, both hands stay on the steering wheel, shifting gears via the paddles like a Formula 1 driver. During the gearshift process the foot can stay on the accelerator since the electronic control unit prevents any mistakes and shifts to the correct gear.

In the S-mode—activated by moving the selector lever to the right—the transmission control unit chooses a special sporting automatic gearshift with extremely short gearshift times in the interest of maximum agility. Here again, the driver can change directly from this program to the Steptronic mode, subsequently shifting gears manually as long as required. The only function of the electronic control unit in this case is to prevent the engine from over-revving.

The top speed of the Mini Cooper S is 216 km/h (134 mph) with the 6-speed manual transmission and 220 km/h (137 mph) with the new automatic transmission. Acceleration from 0 to 100 km/h (0 to 62 mph) comes in 7.7 s for the fixed-roof vehicle and 7.9 s for the convertible.

The Cooper S can now be optioned with a new limited slip differential (LSD). The mechanically controlled LSD, manufactured by **GKN Driveline**, is integrated in the manual gearbox and helps to divert more torque to the drive wheel with better traction, ensuring power is transmitted to the road more effectively. This feature helps to increase traction under acceleration or during cornering, resulting in improved handling and increased stability. Without limiting engine power, it prevents the front wheels from spinning.

The LSD unit is a torque-sensitive dif-



*The John Cooper Works tuning kit for the Mini Cooper S increases the engine output to 154 kW (210 hp).*

ferential that manages torque output under acceleration and deceleration and offers a 30% slip rate, which means that there is no loss of torque if the difference in grip between the two wheels is 30% or less. The system also allows the threshold for Dynamic Stability Control (DSC) to be increased without impeding the system's safe intervention in slippery situations. All of this benefits the enthusiastic driver of a Cooper S. The LSD is only available with the manual six-speed **Getrag** transmission.

The new **John Cooper Works** Tuning Kit is also now available in the U.S., producing 154 kW (210 hp) and 245 N·m (181 lb·ft). Acceleration to 100 km/h (62 mph) comes in 6.6 s, and top speed is increased to 230 km/h (143 mph). Among other features, the tuning kit comprises a more powerful compressor, a cylinder head modified to cope with higher thermal loads, and a state-of-the-art exhaust system with a special rear silencer.

The new “heart” of the system is the air filter specially developed by John Cooper Works. At higher engine speeds, the electronically controlled valve opens an additional duct in the air filter housing, and via a special filter element, provides an extra supply of fresh air to the engine. To handle higher forces, both the fuel injection nozzles and the spark plugs have been modified. Engine management has also been adapted to the greater demands, serving at the same time to give the engine an even better response to the accelerator.

*David Alexander*