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Future testing
Speeding up intro of active safety systems





Audi execs launch A6 hybrid in Detroit

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Racing for the green
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Preview
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Michael Dick, Member of the Board of Management for Technical Development, and Rupert Stadler, Chairman of the Board of Management of Audi AG, launch the Audi A6 hybrid at the NAIAS 2011 in Detroit. You can read about their hybrid strategy on p. 19.



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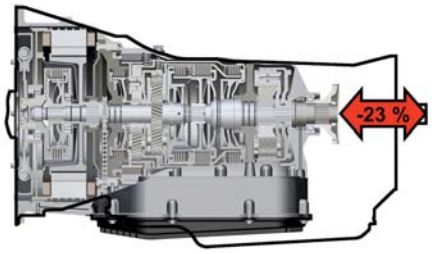
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TOP PRODUCTS

Featured are some of the products and technologies that will be exhibited at the SAE 2011 World Congress April 12-15 in Detroit. Visit www.aei-online.org for additional coverage.



Transmission synthesis program

IAV is introducing a computerized tool set for the selection of automatic transmission gearing arrangements. The program systematically searches through all power-flow permutations for a specific application and then selects the architecture with the highest mechanical efficiency and the lowest number of loaded components. More detail at www.sae.org/mags/aei/9394.

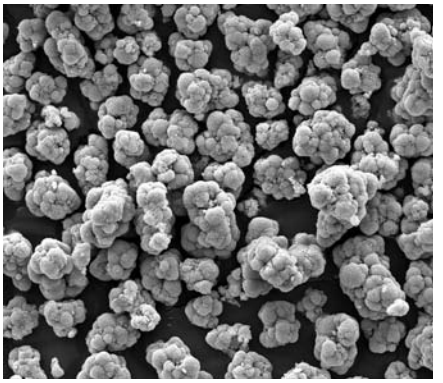
Insert design

Aluminum Tri-Step inserts from **PSM International** offer vehicle OEMs several advantages, including weight savings, over brass and steel inserts currently used in plastic-molded applications such as air intake manifolds. More detail at www.sae.org/mags/aei/9405.

Urea dosing system

Albonair's urea dosing system for passenger cars features a heat-resistant nozzle that has no electrical or mechanically moving parts. It allows for the finest possible spraying of the agent into the exhaust tract, even at low exhaust gas mass flows and low temperatures. More detail at www.sae.org/mags/aei/9403.

TOP NEWS



General Motors recently announced that it has invested $7 million to lead a $17 million equity investment round in **Envia Systems** and secured rights to use the latter's HCMR cathode material. Concurrent with that announcement, Envia announced that its High Capacity Manganese Rich material for advanced batteries is available in limited quantities for pilot vehicle programs. More detail at www.sae.org/mags/aei/9389.

In early February officials of the **Euro NCAP**, the European car-safety assessment organization, announced the five best performing cars of 2010 including the **BMW** 5 Series, in the Executive category (see video), **Alfa Romeo** Giulietta, **Honda** CR-Z, **Toyota** Verso, and **Kia** Sportage. More detail, including video, at www.sae.org/mags/aei/9424.

The **BMW** Group and **PSA Peugeot Citroën** have entered a new phase of their collaboration by signing an agreement to set up a 50-50 equity joint venture named **BMW Peugeot Citroën Electrification** to develop and produce hybrid components including battery packs, generators, power electronics, and chargers. More detail at www.sae.org/mags/aei/9390.

General Motors has named Mary Barra Senior Vice President, Global Product Development, and Thomas Stephens Global Chief Technology Officer (CTO), a newly created position. More detail at www.sae.org/mags/aei/9354.

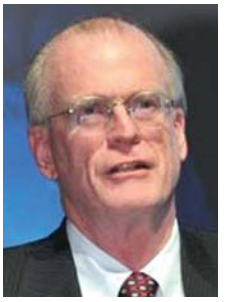
Webcasts

Better product development decisions

A new webcast, titled "The Automotive Industry: Making Better Product Development Decisions," will present the latest research on the challenges facing the makers of tomorrow's cars. Participants will review how vehicles are evolving and will discuss ways automotive engineers can improve their product development decision-making. The free webcast will be held April 7. Speakers will be Philip Gott, Managing Director of Automotive Consulting at **IHS** Inc., and Paul Brown, Senior Marketing Director at **Siemens PLM Software**. The one-hour program includes an audience Q&A session. For more information or to register, visit www.sae.org/webcasts.



Paul Brown



Phil Gott

High-fidelity system modeling

"Efficient High-Fidelity System Modeling for HIL and Control Applications for Commercial Vehicles" is a new webcast scheduled for April 20. The one-hour program will introduce new modeling techniques to accelerate model development and increase model fidelity and simulation performance. The free webcast will also include technique demonstrations and case studies to allow you to gain practical knowledge on improving or implementing model-based design techniques. Speakers will be Dr. Tom Lee, Vice President, Application Engineering, and Dr. Orang Vahid, Modeling Engineer, both of **Maplesoft**. For more information or to register, visit www.sae.org/webcasts.

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Features of the charging systems may include, but are not limited to, Level 1, 2, or 3 charging capabilities; third-party safety certifications such as UL Listing; standardized connector interfaces such as SAE J1772; standardized telematics and diagnostics provisions such as those identified in SAE J2836|1; service assistance and replacement parts, and universal chargers to vehicle connectivity for all vehicle make and models.

Acquisition of these systems and products are possible through the GSA Multiple Award Schedule (MAS) program, specifically under Schedule 23V — GSA's Automotive Superstore.

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Lightening up with partners

As vehicle fuel economy and emissions legislative rules tighten around the world, automakers are leaving no stone unturned in the development of efficient and clean vehicles that also meet consumer demands for form and function. While more efficient and sustainable powertrains are important, so are advanced material solutions that reduce efficiency-sapping mass. The makers of the traditional auto body materials are constantly reinventing their products to compete with the increasing number of material alternatives.

Lawrence W. Kavanagh, President of the **Steel Market Development Institute**, stressed the importance of advanced high-strength steel (AHSS) in reducing vehicle consumption and emissions in a panel discussion at the **American Metal Market**'s Automotive Metals Conference late last year. According to Kavanagh, the use of AHSS in vehicles allows engineers to meet important strength and safety performance targets, with mass reductions of 25% or more. He added that third-generation AHSS could add another 10 to 15% in mass reduction, yielding total improvements of 35-45%.

However, the makers of alternative materials are not resting on their lightweight laurels.

One of aluminum's biggest proponents for body materials is **Audi**. Its latest car, the 2011 A8, arguably represents the state of the art. The car's ASF (Audi Space Frame), composed of 13 different aluminum alloys, helps reduce body weight and increase strength and stiffness. Compared to the previous model, body stiffness is up by 25% and weight reduced 20% at 509 lb (231 kg).

The relative newcomers in the body materials arena are composites, with many recent developments and announcements of note centering on partnerships to aid the commercialization of less costly manufacturing processes.

The Sesto Elemento (Italian for Sixth Element) shown by **Lamborghini** at the 2010 Paris Motor Show (http://www.sae.org/mags/AEI/9196) is a technology demonstrator aimed at furthering the use of carbon-fiber construction methods at the Audi-owned brand. The result of the advanced material application is an overall vehicle curb mass of just 999 kg (2200 lb), even though the car has a V10 engine and all-wheel drive. Lamborghini is developing its materials technologies at two research centers, the new ACRC (Advanced Composite Research Center) and the **University of Washington**'s ACSL (Advanced Composite Structures Laboratory) in collaboration with others such as **Boeing**.

Lightweight composites play a huge role in the **Volkswagen** XL1 diesel/electric hybrid concept (see this issue's center Big Picture), revealed at the Qatar Motor Show in January, achieving combined fuel consumption of 0.9 L/100 km. The car's lightweight construction includes a monocoque and add-on parts made of carbon fiber. With supplier help, Volkswagen claims to have achieved significant reductions in XL1 production costs—important in making a limited-production run viable.

Also in January, **Daimler** AG and **Toray Industries** announced a joint venture for carbon-fiber reinforced plastics (CFRP) based automobile parts. The new production and joining processes are said to enable large-scale production with significantly shorter molding cycles. The partners plan to start supplying the mass-produced CFRP parts using Short Cycle Resin Transfer Molding, a process technology developed by Toray, for **Mercedes-Benz** passenger vehicles launching in 2012.

Research has shown that vehicle fuel economy can be improved by about 5% for every 10% reduction in mass, with a greater benefit coming in transient urban rather than steady-state highway conditions. However, the weight reduction must be accomplished without reducing performance, safety, and comfort for consumers while reining in manufacturing costs and cycle times if the industry is to succeed.

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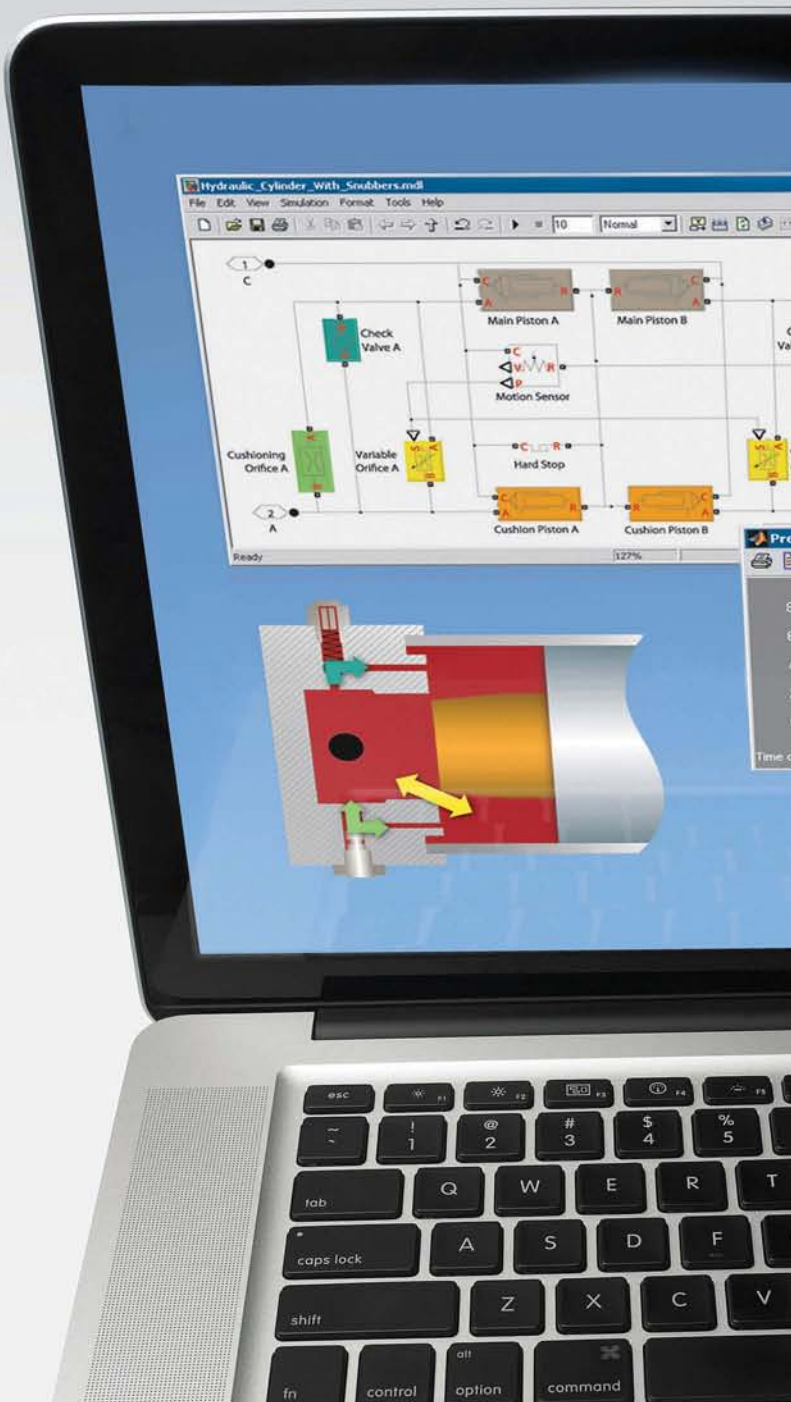
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Social media and the technology associated with it are reshaping and revolutionizing the way people put forth and accept information. Status pages are updated instantly and bits of information are shared for the world to see.

It's no different here at **SAE International**. With pages on Facebook, Twitter, and LinkedIn, SAE International is embracing this ever-changing communication technology. Team members from customer service, marketing, and corporate communications are regularly posting updates and information about all of SAE International's programs, products, and services.

But, it goes beyond that. Last year, SAE International launched its new "EngineerXchange" website. EngineerXchange, http://engineerxchange.sae.org, is an online professional network for SAE International members. The site gives members exclusive access to powerful networking tools, career counseling and management tools, and advance access to SAE International's vast repository of technical content.

EngineerXchange, along with the social media pages that SAE International has developed and populates, is just one part of our overall commitment to the new way of information delivery.

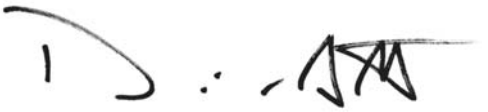
In addition to the digital versions of SAE International's award-winning magazines—*Automotive Engineering International*, *Aerospace Engineering*, and *SAE Off-Highway Engineering*—that launched last year, our publications team now offers all books in e-book format, allowing customers to purchase individual chapters as well as the entire title. SAE International's existing library of titles is being transferred over to the e-book format, as well.

The electronic initiative continues with our vast repository of technical papers. In the past 12 months, we have converted more than 20,000 technical papers written between 1906 and 1979 to downloadable, PDF documents. That means that SAE International's entire library of 88,000 documents is now available electronically.

More recently, we began implementing a new content management system that will give more options to customers in how and when they get and access information. New subscription-based product packages are being created for both SAE International's technical papers and standards; the result is more options, more flexibility, and more ways to access relevant information.

These programs and initiatives are just the beginning of SAE International's commitment to embracing new technology. Whether it is social media or a new electronic content delivery method, we will continue SAE International's tradition of not just staying ahead of the curve of innovation, but helping to define that curve.

SAE International has a long and storied history. Many of the tried-and-true practices that helped build this organization will continue to work into the future. But staying on top of what is new, what is yet to be discovered, is key to success—and SAE International always will strive to be a leader.



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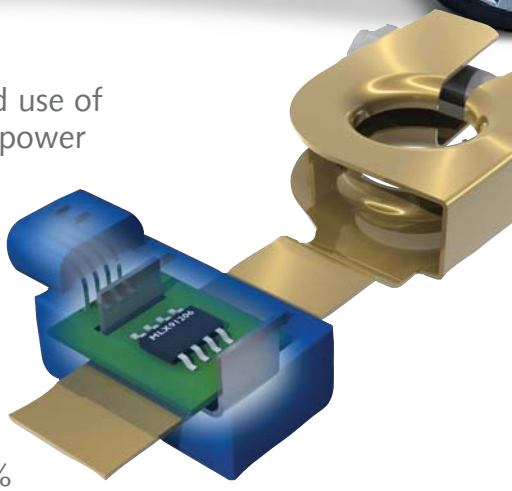
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Interiors

Johnson Controls stretches the interior look

Johnson Controls' ie3 demonstration concept shows how stretch fabric, a headliner with integrated audio, as well as other interior and electronic technologies can radically alter future production vehicles.

"We're showcasing 32 patent-protected innovations that are ready for production application in model year 2015," Michael Warsaw, Vice President of Design and Marketing, North America for Johnson Controls Automotive Experience, told *AEI* after the world debut of the ie3 at Detroit's 2011 North American International Auto Show.

Stow spots on door panels, seatbacks, and the upper instrument panel (IP) are dressed in a lightweight woven material stretched over a frame. LEDs illuminate the area underneath this mesh fabric.

"We're doing lab tests for all of the various safety concerns because it is a new material application that we envision being used in conjunction with airbag deployment. Johnson Controls is working with textile manufacturers to find appropriate coatings for the fabric that are robust enough for automotive usage," Warsaw said.

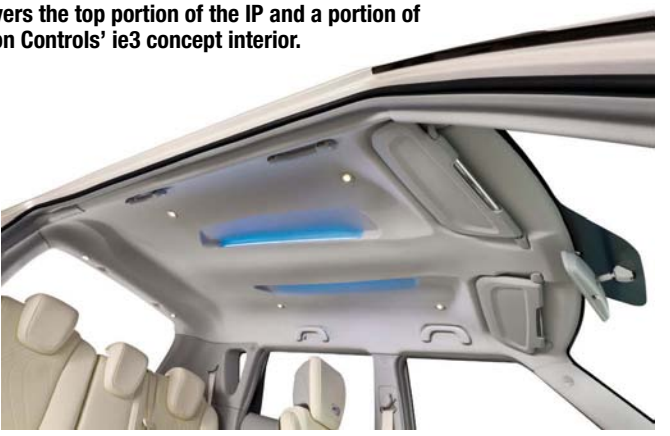
Door panel inners are void of audio speakers because the ie3's headliner and trim panels double as a soundboard. "Transducers are integrated within the headliner," Warsaw noted, adding that the vehicle's audio performance is optimized by digital signal processing technology.

When sunlight hits the 6.5-in "transflective" instrument cluster display, "it doesn't lose its color or its contrast so it's unnecessary to have a hood over the display or sink the display into a cave-like position," Warsaw said. The cluster display moves up and down with the adjustment of the steering column.

A display screen positioned off the center dashboard is used for the operation of navigation, radio, and HVAC. "This transflective 'floating' display screen features a resistive touch panel that incorporates a row of fixed buttons for the HVAC controls that visually appears as one seamless display panel," he said.



Door panels, interior trim, and the IP are made from natural-fiber materials. Mesh fabric covers the top portion of the IP and a portion of the door panels on Johnson Controls' ie3 concept interior.



The overhead system with integrated audio speakers enables increased storage opportunities in the ie3's doors.

The driver also can interface with the 8.8-in dashboard display by using the capacitive-touch controller/gear shifter unit located in the top deck of a dual-level center floor console. Sliding tracks enable forward and backward movement of the multicontroller, cupholders, and an e-bin for wireless recharging of handheld mobile devices.

A steering wheel stock switch engages a transparent head-up display (HUD).

"Instead of a traditional HUD that uses the windshield to display information, this HUD uses a separate piece of optical glass that stows within the IP until it's activated into an upright position," Warsaw explained. A similar Johnson Controls-supplied HUD is on select **Peugeot** vehicles in Europe, but the ie3 vehicle's HUD differs from the production offering by showing turn-by-turn navigation and other information in full-color graphics.

The ie3's rear seats adjust to a lounge position via a manually controlled mechanism. "We're able to get a 45° recline, and the cushion has extra tilt because it also moves backward," said Warsaw.

Next-generation battery packs—stowed under the floor—supply power to the all-electric demonstrator vehicle. According to Alex Molinaroli, President for Johnson Controls Power Solutions, the ie3 uses 216 prismatic lithium-ion cells.

"This is a real step-up from a standpoint of how well we're able to package the batteries," said Molinaroli.

Kami Buchholz



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Interiors/Manufacturing

Frimo flaunts new plastics production facility

Automakers and the supply chain are checking out the latest machinery for assembling instrument panels, door trim, headliners, and other interior plastics at a new technical center in Michigan.

"No other tooling and equipment supplier in North America has a facility that serves as a one-stop shop for the prototyping and production of interior plastic components," Jeff Daily, President and CEO of **Frimo North America**, said about the company's new $5 million technical center in Wixom.

The 15,000-ft² (1400-m²) center features tooling and equipment for forming vehicle interior skins, producing and joining the substrates behind the touch surfaces, scoring airbags, and completing other tasks.

"Before a company goes through the risk and cost of building a tool and/or machine based on an idea, Frimo's engineering and technical experts can work to build a low-cost prototype and do testing to see if the proposed solution validates the original concept. We can then take the next step, which is building that new tool and/or new machine," Daily said.

In addition to customized equipment, the company offers a range of standard solutions, including an infrared (IR) welding machine for joining thermoplastics.



Frimo's IR welding machine is the newest member of the company's equipment portfolio for processing plastics. Other machines perform thermoforming, joining/gluing, pressing/forming, trimming, and polyurethane processing.

While specific European-sold **Audi** and **BMW** vehicle interiors have been assembled using contact-free IR welding technology, the first vehicles with instrument panels assembled via IR welding for the North American market will arrive in the 2012 model year.

Said Lee Hodson, the tech center's Manager and the Director of Advanced Development, "IR welding is a much greener joining process than techniques that require solvent-based adhesives."

The airtight, particle-free IR welding machine, operated via intelligent drive and control systems, enables complex 3-D contours as well as the ability to mate different material combinations.

U.S.-based customers initially evaluated IR-welded part samples at Frimo's tech center in Germany. But with the



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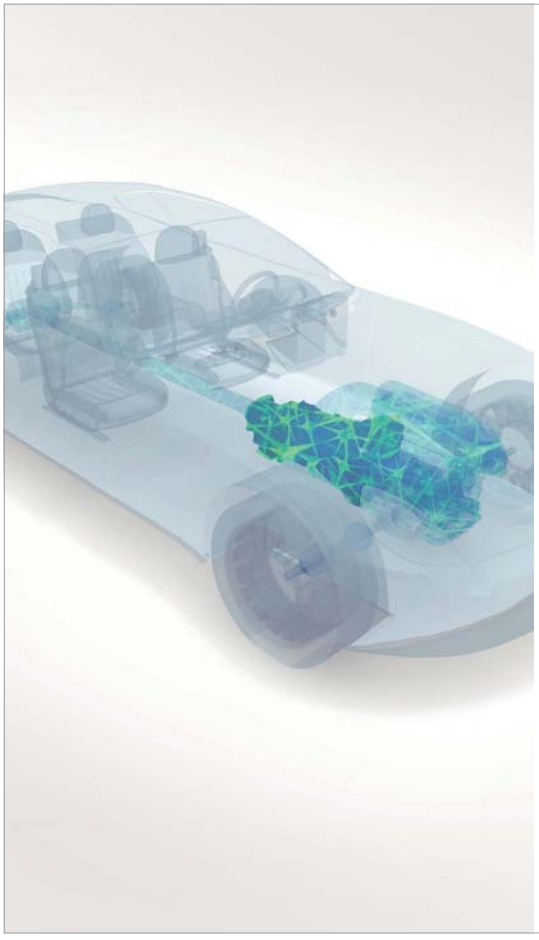
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With a heating time of approximately 12 s, the IR welding machine can be paired with optional thermal imaging to compare heat profiles.



Frimo workers have been busy updating factory floor equipment, including this refurbished foam tool carrier machine.



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Wixom facility's grand opening in October 2010, Michigan also serves as a comprehensive equipment showplace.

Frimo's Shanghai tech center is on a fast track to put its capabilities on par with facilities in the U.S. and Germany under the guidance of Hans Scholko, who served as the company's U.S. technical director for the past 10 years.

Business has been booming in the U.S., where the company's sales volume increased 52% from 2006 through 2009, in part the result of renovating customers' existing plastics processing equipment.

"With credit hard to get during the economic downturn, many Tier 1 suppliers needed to optimize their working capital. That's why a strong part of our business the last three to four years has been tied to upgrading machines—both Frimo and competitor machines—as well as upgrading computer controls to improve manufacturing efficiency," Daily said.

Although processing plastics for vehicle interiors is Frimo's automotive application stronghold, the ever-increasing use of plastics under the hood has not gone unnoticed.

Said Hodson: "We're working on new programs for engine compartment covers with grades and textures that rival interior surfaces. Our range of products is not limited to one industry or one application, which is why the engine compartment is a possible new growth area for us."

Frimo's Wixom tech center, which includes two secured test bays, provides a framework for automakers, Tier 1s, and material suppliers to optimize production processes.

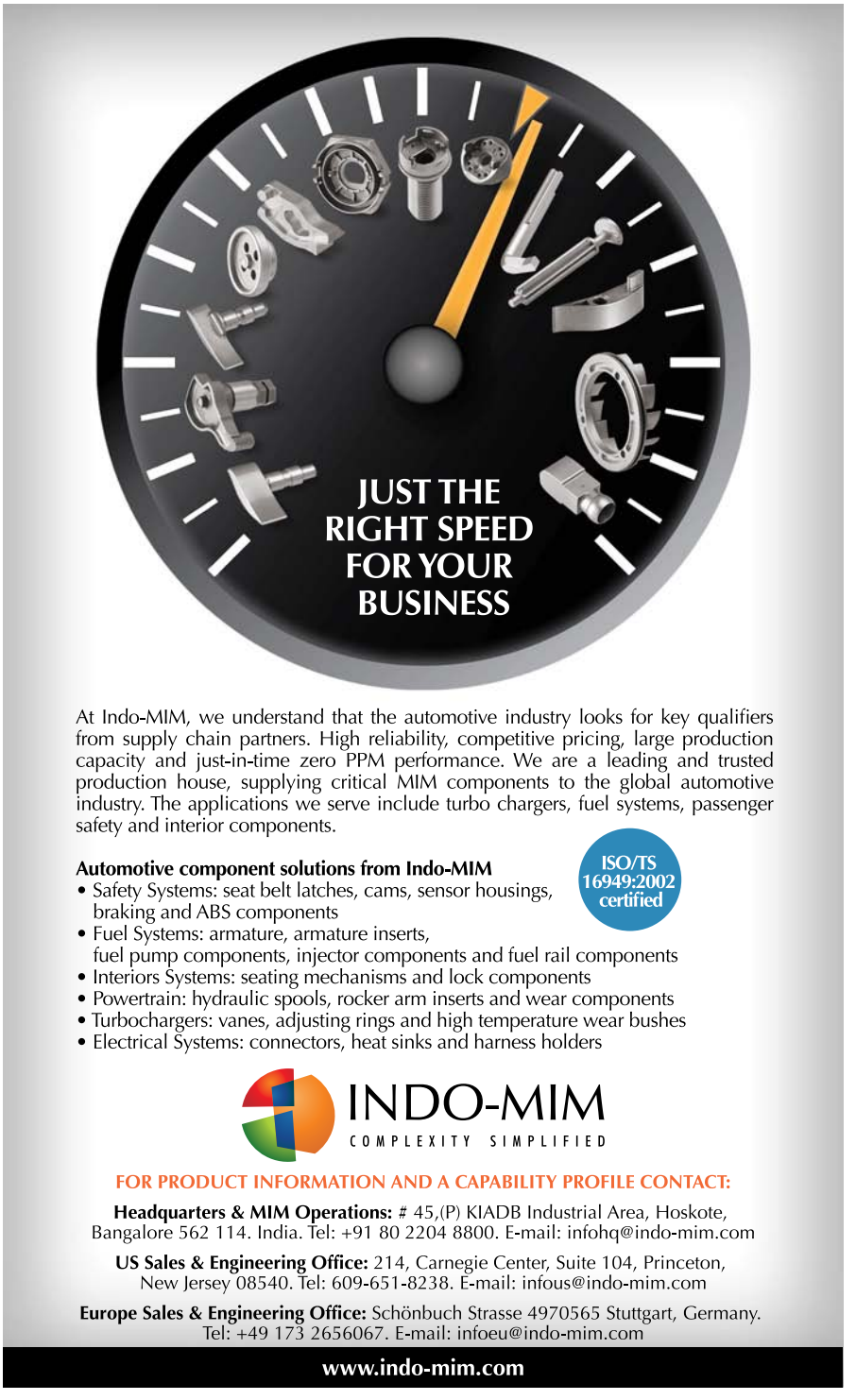
"We're trying to bring OEMs, suppliers, and material providers together in a collaborative and productive way to drive innovation and manufacturing efficiency so that we can be on the cutting edge of developing the technologies they want to sustain our business," Daily said.

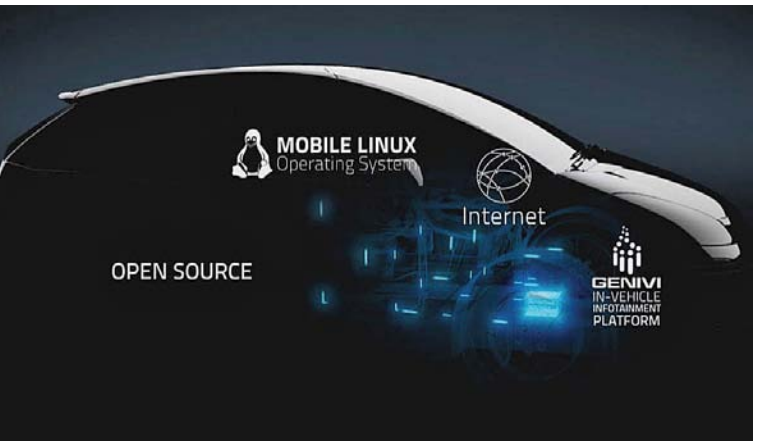
Kami Buchholz

Interiors/Electronics

Vegas show of support for GENIVI

Throughout the auto industry, industry players are scrambling to link consumer electronics to vehicles. At the recent Consumer Electronics Show put on by the **Consumer Electronic Association** (CEA) in Las Vegas, a number of suppliers teamed up to support GENIVI, a standard that many hope will become





At CES, Visteon showed its latest developments in scalable platform solutions for next-generation infotainment, fully compliant with requirements of the GENIVI open source software alliance.

the target environment for infotainment developers.

The **GENIVI Alliance** made the first live demonstration of its multi-architecture middleware platform, the Apollo baseline, at CES. The Apollo software, shown in **Visteon**'s booth on some of its systems, was augmented by a number of demonstrations made in a private room.

Renesas Electronics displayed a high-end infotainment/dashboard controller based on an **ARM** Cortex-A9 dual-core processor. **Intel** showed automotive-targeted applications running on an Atom-based infotainment system, while **Texas Instruments** demonstrated an OMAP3-based reference platform. **Nokia** showed a Terminal Mode client running on the head unit connected to a phone. **Rohm**, **Oki**, and **Sophia Systems** teamed up on what they call the Black Creek Development Platform. A reference platform from **IAV** displayed the designer's capability. Other vendors such as **Neusoft**, **Cinemo**, **Intrinsyc**, and **Luxoft** also joined in the action.

The GENIVI Alliance is creating software that it hopes will become the standard for many infotainment systems and application programs. That will make it simpler for developers and programmers, who will be able to design to common specifications and requirements. Proponents note that membership more than doubled during 2010, with **Robert Bosch**, **Tata Consulting**, and **TomTom** joining early this year.

"The fact that our membership has grown to 101 demonstrates the auto industry is starving for solutions like this," said Joel Hoffman, Chair of the GENIVI Alliance Marketing Committee. "We are focusing on compliance so GENIVI members can plug their programs into other people's software. That ensures that map suppliers, for example, can provide data for everyone."

The standard, like most, should help cut costs. That will be important in infotainment since consumer products and owner expectations are constantly shifting.

"One pain in the side of the infotainment industry is that development never stops, so you have a lot of nonrecoverable costs. GENIVI won't eliminate those nonrecoverable costs, but it will reduce them," said Hoffman, who's also Strategic Marketing Development Manager for Intel's Embedded Computing Group.

Though GENIVI has a lot of support, it still has a fair way to go before it's ready for use in vehicles. The second release of Alliance-developed software was just completed, and the hardware and software were only recently separated so the code could run on a range of processors.

A compliance statement won't be finished until later this year. Once it's finished, programs will be developed to go along with it. They must then be validated by automakers and moved into production.

Though that might sound daunting, proponents feel it will be simpler to port applications packages to the GENIVI platform than to alter them for every new product variant that emerges. They also contend that the pieces will be in place by the time the industry is truly ready to use them.

"I don't think the applications field will be settled before GENIVI is out there," Hoffman said.

Terry Costlow

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Powertrain

ZF's new nine-speed automatic to replace CVTs in 2013 Chryslers

ZF has escalated the raging transmission-ratio war with its January announcement of a new nine-speed transaxle in development for front-drive passenger cars.

Production of the all-new nine-speed unit, development of which began in early 2009, is scheduled for 2012, according to the company's Executive Vice President, Dr. Michael Paul, who confirmed earlier reports that some MY2013 **Chrysler** models will be the first vehicle applications. In mid-2010, Chrysler and **Fiat** Chairman Sergio Marchionne noted Chrysler's interest in a nine-speed automatic.

It is expected to initially replace all of **JATCO**'s continuously variable transmission business in Chrysler's North American C/D segment vehicles, according to powertrain industry analysts.

"The number of transmission ratios is not stopping in the industry," observed Casey Selecman, Transportation Project Manager at **The Martec Group**. He said OEMs' move to a greater number of gears "is not a marketing game. Traditionally lower gear ratios are getting taller; it's a trend which offers improved launch torque, stronger tip-in feel to the driver, and greater value."

Selecman believes the extremely stringent fuel-economy regulations expected in 2016-2025 will cause average engine power outputs to level off across the industry, after years of growth. This will increase OEMs' adoption of transmissions with more than the six forward ratios that are becoming typical.

According to reports in mid-2010, **Mercedes-Benz** is also developing a nine-speed automatic for large-displacement engines in rear-drive applications.

The new ZF transmission will be built for "global customers" at the company's new Greenville, SC, plant, Paul said. He did not reveal many specifics about the new unit, including its model designation, during a media briefing at the North American International Auto Show.

Paul did say that compared with typical six-speed planetary-type, fwd automatics, ZF's new nine-speed is "the optimum design for front-wheel-drive transverse-engine applications" and is capable of delivering "two-digit" improvement in vehicle fuel efficiency. The transaxle's overall package dimensions and weight are expected to be very similar to current six-speed fwd units, Paul said. Input-torque capacity will be 400 N·m (295 lb·ft).

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The new nine-speed fwd automatic's overall packaging and mass will be similar to competitive six-speed units, said ZF executives. Its ratio spread is expected to be 6.4; input torque capability is 400 N·m.

Rapid, "imperceptible" ratio changes will be a hallmark of the new nine-speed, Paul promised. While he would only admit to the new automatic having "a few clutches" and a ratio spread of "more than 6" during media questioning, a veteran powertrain industry engineer familiar with ZF's plans told *AEI* the new nine-speed's ratio spread will be "about 6.4."

He noted that because "only two of the eight forward gears will have dragging clutches," its internal efficiency will be vastly superior to incumbent six-speed units.

According to analysts, Chrysler's move away from CVTs points to their classic limitations—limited input torque capability, high internal parasitics, peculiar shift quality and NVH (the "slipping-clutch" feel under acceleration), and ratio spreads typically in the 4.2-6 range—compared with the latest planetary-type step-ratio automatics.

The Chrysler deal is expected to dramatically increase ZF's already growing business with the Italian-American automaker. Last year Chrysler announced plans to license ZF's 8-HP eight-speed automatic for RWD applications. Those transmissions will be built at the Kokomo, IN, transmission plant.

Lindsay Brooke



Audi broadens its focus on hybrids

Multitasking is the norm for many high-level engineers, a situation compounded by the necessity for OEMs to find successful multiple solutions to meet global environmental challenges. The salient aspect of this work involves alternative powertrains, with hybrid and pure EV issues towering above all else.

Until recently, it could be argued that hybrids (mainly gasoline but also diesels) were just a stepping stone toward the all-electric vehicle (EV), but with the convincing advance of plug-in systems, which offer a flexible solution in terms of performance, economy, cost, and particularly range, there are indications that the EV star, with its downside of battery cost and limited range, may be waning for some.

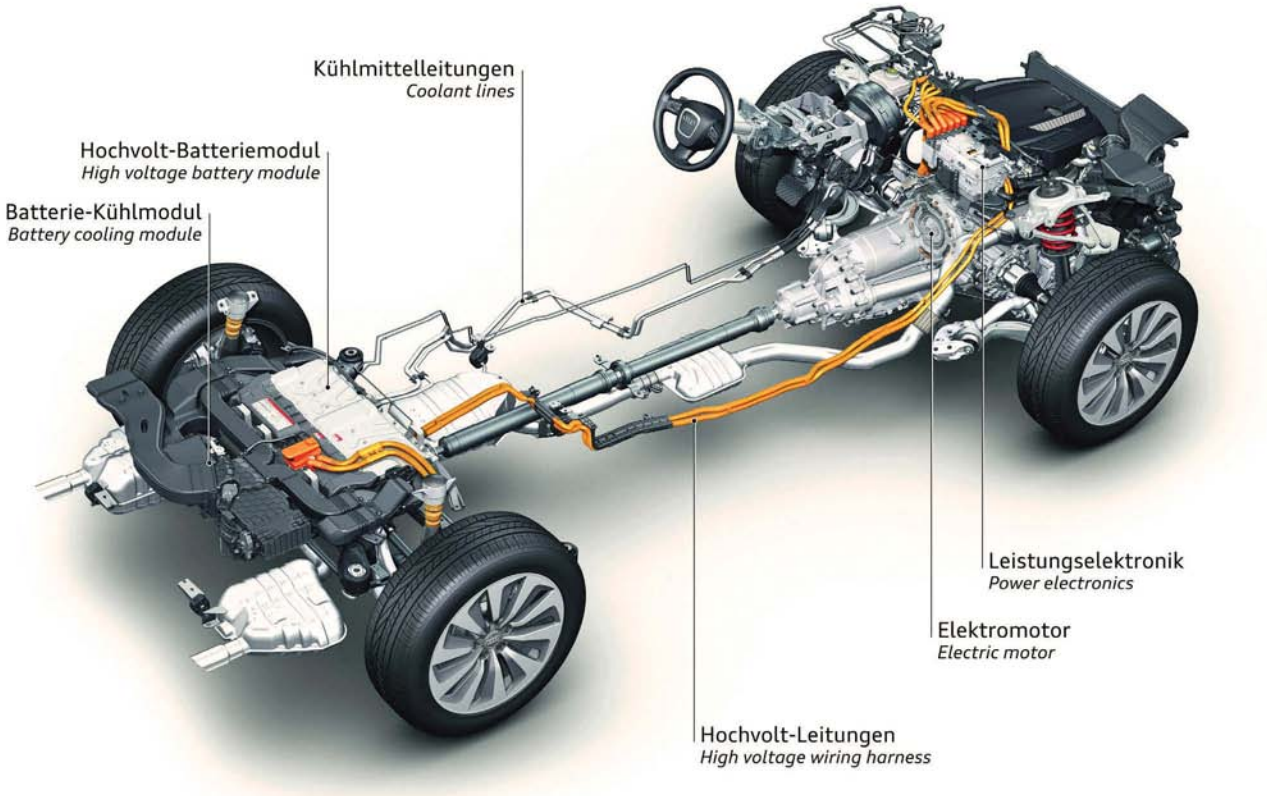
"A hybrid vehicle is of great interest to some markets such as the U.S. and China," said Michael Dick, **Audi**'s technology development boss. "This is why a [hybrid] electric vehicle based on an A6 is being developed within the scope of a partnership between Audi and the prestigious **Tongji University** in China. As far as introducing a pure electric vehicle is concerned, however, we consider only urban small-car concepts such as the A1 e-tron and a pure-electric sports car concept based on the R8 e-tron to be viable."

A major reason for this is the cost of batteries, but particularly the lack of range they provide, notably in inclement conditions. The note of caution from Dick echoes a reference in a speech by current Audi CEO Rupert Stadler some four years ago in which he referred to the need for caution in the context of "sustainability."

It is significant that parent company **Volkswagen**'s highly futuristic XL1 concept uses a plug-in hybrid solution powered by half a 1.6-L TDI engine with a light-alloy cylinder block producing 35 kW (48 hp) and a 20-kW motor with a 5-kW·h lithium-ion battery. Volkswagen is planning both a pure electric and a hybrid version of the Golf.

Some companies, the **Renault-Nissan** Alliance among them, are investing very heavily in pure EVs, demonstrating the continuing dichotomy of views on what route will be taken by alternative powertrain solutions. Renault has four EVs in development, and its specialist teams are working toward models achieving 400 km (249 mi) between recharging by 2020.

The Audi A1 e-tron concept is not pure electric in the fullest sense because it uses a small Wankel range-extender engine. Because it runs at constant speed, the technology does not exhibit the disadvantages of such an engine: relatively poor fuel consumption and emissions. The A1 e-tron is slated for (probably limited) production, although Audi has not confirmed the time frame.



Audi's upcoming Q5 hybrid quattro incorporates a 33-kW synchronous electric motor.



Only the badges distinguish the new hybrid Audi A6 from versions with conventional powertrains.

With its emphasis on hybrids across the broader model range, Audi will introduce the Q5 quattro hybrid this summer, and at the recent European launch of the new conventional A6, the company took along the hybrid version of that model, too. Its appearance was significant and emphasized the importance of hybrid technology to Audi, which is also to be extended to the A8 in 2012.

All three hybrids will share similar technology—a 2.0-L gasoline direct injection turbocharged TFSI power unit allied to a 33-kW synchronous electric motor with a combined system output of 180 kW (241 hp) and 480 N·m (354 lb·ft). Fitted to the Q5, the combined-cycle NEDC fuel consumption figure is less than 7.0 L/100 km.

Such is the efficiency of Audi's diesel TDI engine range, however, that the A6 hybrid will not quite match the fuel consumption or CO_2 levels of the 155-kW (208-hp) diesel 2.0-L, said David Ingram, Audi U.K.'s Product and Technology Manager. "As a pure electric vehicle, the A6 hybrid will cover 3 to 4 km and speeds up to 100 km/h in that mode. With our expanding hybrid range, we are responding to market needs. As for fuel-cell technology, we do not at present see it providing a full, everyday cost-effective solution for an only car, which hybrid technology does. We continue to see pure EVs as having limitations that are too severe and that would in general compromise a car's functions—the exceptions being A1 e-tron, our city/small car, and the first e-tron sports car that we showed at Frankfurt in 2009, which will go into limited production in 2012."



Audi's Michael Dick at present sees only urban small cars and sports cars as ripe for pure electric powertrains.

Audi has put its diesel hybrid technology on hold until markets that do not have diesel fuel acceptability (notably the U.S.) change direction. "At present we feel our TDI powertrains provide the best economical solution," said Ingram.

Bernd Huber, Technical Project Manager for the Q5, said the hybrid version of the car would have an eight-speed (with widely spaced ratios) Tiptronic transmission without a torque converter. "Its place is taken by the disk-shaped electric motor, combined with a multiplate clutch operating in an oil bath; it couples and decouples the electric motor and TFSI. The fast-shifting hybrid gear unit contributes significantly to efficiency of the vehicle."

A pulse-controlled inverter is fitted in the plenum chamber of the engine compartment. A separate low-temperature water-filled circuit cools the power electronics. A dc/dc converter couples the electric consumers in the 12-V electrical system with the high-voltage network.

Each Audi hybrid uses a lithium-ion battery system weighing 38 kg (84 lb) and positioned in a crash-safe area beneath the loading floor. The battery reduces luggage space in the A6's trunk by around 20%. Cooling is via a fan drawing temperate air from the vehicle interior or at high temperatures, a refrigerant circuit.

In place of an engine rev counter, hybrids get a power meter (marked 0-100%) that also incorporates multi-colored segments showing how the vehicle is being powered. The instrument display also includes charge level of the battery. An MMI (multimedia interface) screen also shows operating states and power flows.

Ingram said quiet hybrid technology is proving very effective in the A8, due to be launched in 2012, particularly for city chauffeur work. The 3.0-L diesel has a combined CO_2 emissions figure of 159 g/km, but the hybrid beats that to return 144 g/km.

"We are researching all powertrain options," said Ingram. "Application of battery-only technology depends on space and capacity—both need to improve significantly before there is a great uptake of EVs, and that improvement is proving slow."

Stuart Birch

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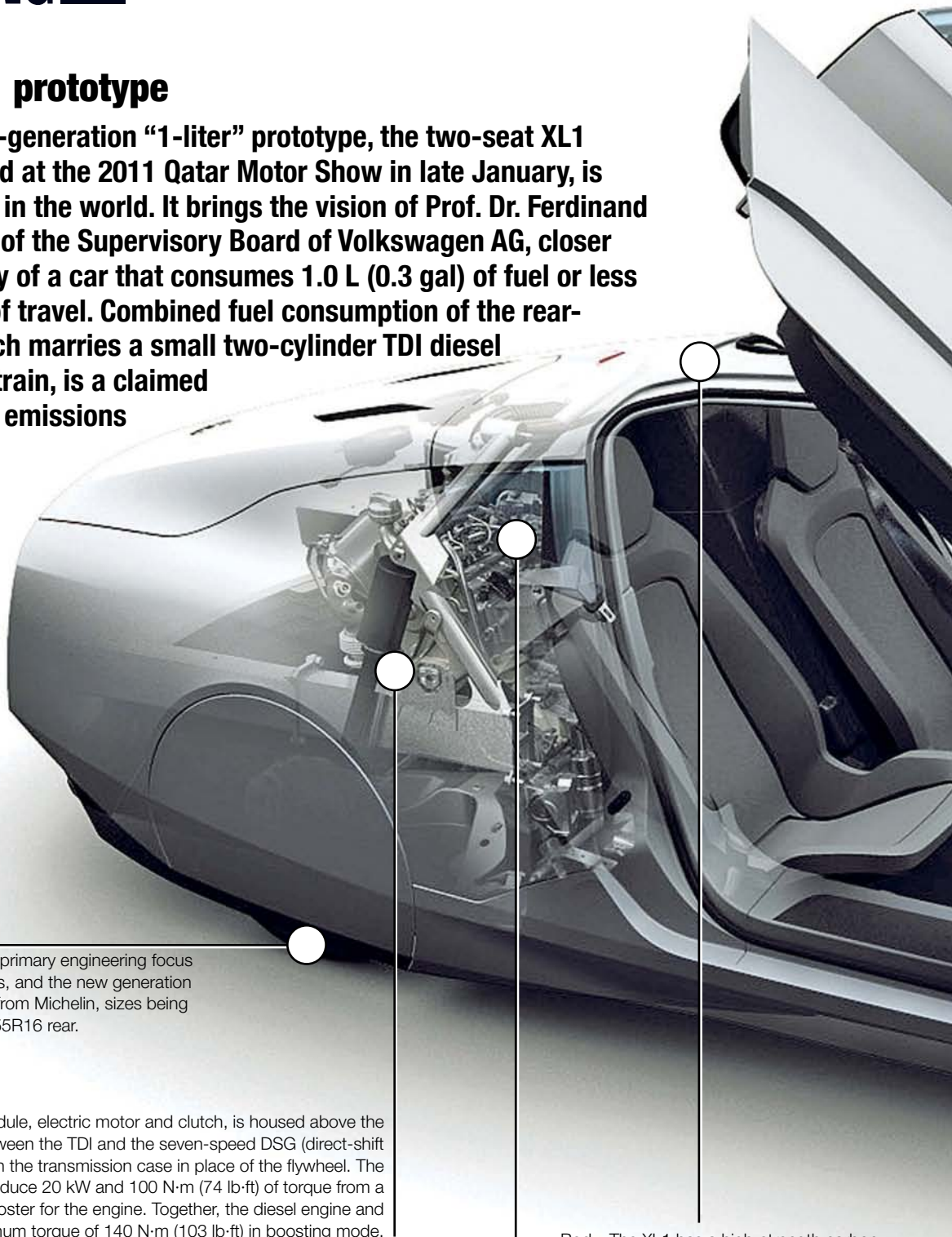
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P101540

Volkswagen XL1 prototype

VW says that its third-generation "1-liter" prototype, the two-seat XL1 prototype that debuted at the 2011 Qatar Motor Show in late January, is the most efficient car in the world. It brings the vision of Prof. Dr. Ferdinand Piëch, now Chairman of the Supervisory Board of Volkswagen AG, closer to production maturity of a car that consumes 1.0 L (0.3 gal) of fuel or less over 100 km (62 mi) of travel. Combined fuel consumption of the rear-wheel-drive XL1, which marries a small two-cylinder TDI diesel with an electric drivetrain, is a claimed 0.9 L/100 km and CO_2 emissions are 24 g/km for the plug-in hybrid, both by NEDC measurements.



Tires: Reduced friction was a primary engineering focus for wheel bearings, driveshafts, and the new generation of low-rolling-resistance tires from Michelin, sizes being 115/80R15 in front and 145/55R16 rear.

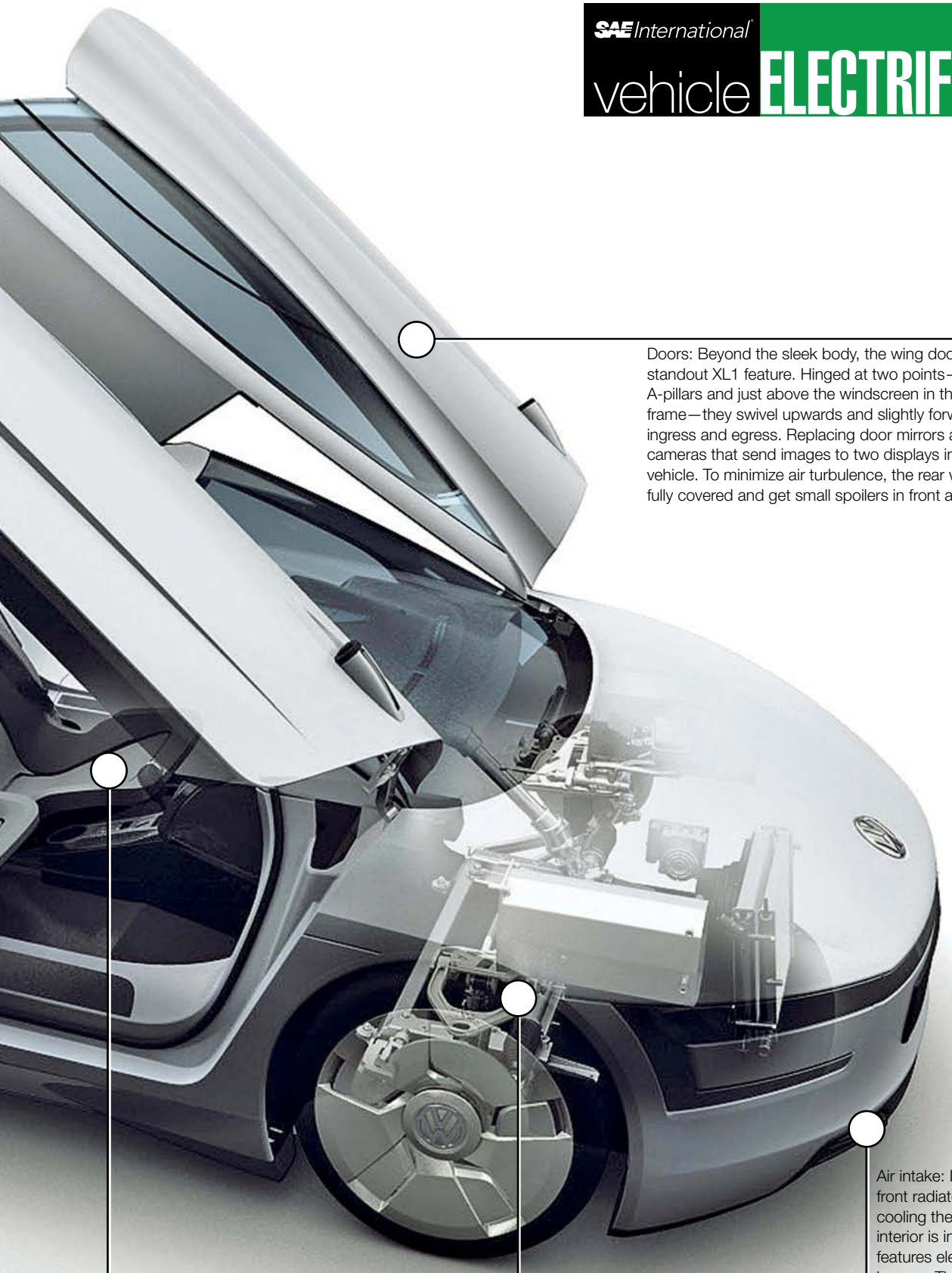
e-motor: The hybrid module, electric motor and clutch, is housed above the vehicle's driven rear axle between the TDI and the seven-speed DSG (direct-shift gearbox) and integrated in the transmission case in place of the flywheel. The electric motor can produce 20 kW and 100 N·m (74 lb·ft) of torque from a standstill and works as a booster for the engine. Together, the diesel engine and e-motor deliver a maximum torque of 140 N·m (103 lb·ft) in boosting mode.

Turbodiesel: The common-rail turbodiesel engine generates a maximum power of 35 kW (47 hp) and 120 N·m (89 lb·ft) from just 0.8 L displacement. The two-cylinder uses mass-production technology, being derived from the 1.6-L unit from the Golf and Passat. It uses the same 88-mm (3.46-in) cylinder spacing, 79.5-mm (3.13-in) cylinder bore, and 80.5-mm (3.17-in) stroke, as well as the special piston recesses for multiple injection and individual orientation of the individual injection jets. Combined with exhaust gas recirculation, an oxidation catalytic converter, and diesel particulate filter, the engine meets Euro 6 emissions standards.

Body: The XL1 has a high-strength carbon fiber reinforced plastic (CFRP) monocoque in the style of Formula One racecars, but it is enclosed on top for safety. The XL1's length and width are similar to those of a Polo, at 3888 mm (153.1 in) long and 1665 mm (65.6 in) wide, but it is significantly lower in height at 1156 mm (45.5 in), vs. 1462 mm (57.6 in) for the Polo and 1184 mm (46.6 in) for the Lamborghini Gallardo Spyder.

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Doors: Beyond the sleek body, the wing doors are a standout XL1 feature. Hinged at two points—low on the A-pillars and just above the windscreen in the roof frame—they swivel upwards and slightly forwards to ease ingress and egress. Replacing door mirrors are small cameras that send images to two displays inside the vehicle. To minimize air turbulence, the rear wheels are fully covered and get small spoilers in front and behind.

Seats: Unlike the tandem arrangement of both the first 1-L car in 2002 and the L1 presented in 2009, the XL1's body layout offers side-by-side seating.

Suspension: In front, a double wishbone suspension is used (a semi-trailing link setup is in the rear). Front and rear are both very compact and tuned for comfort. Weight was reduced by using aluminum for suspension components, brake calipers, dampers, and steering gear housing, CFRP for antiroll bars, ceramics for brake discs, and magnesium for wheels.

Air intake: Instead of a traditional front radiator grille, the air intake for cooling the TDI engine, battery, and interior is in the lower front end and features electrically controlled louvers. The XL1's 0.186 Cd and 1.50 m^2 (16.1 ft^2) frontal area combine for a total CdA aero value of 0.277 m^2 (2.98 ft^2)—some 2.5 times less than that of the Golf.



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Volvo's electrifying future may include 'platooning'

"**Volvo** [Cars] needs to return to its Swedish roots—not so much sporty but more functional. Simplicity is the key," said the company's CEO Stefan Jacoby.

That may sound as if Volvo, now owned by **Geely**, is going to ease up on high-tech projects, but that is not the situation; he insists that functional and high technology sit very comfortably together.



Volvo's V60 is on its way to become a PHEV, with production scheduled for 2012.

That combo will be the foundation of Volvo's electric vehicle (EV) program. It would fit comfortably within the futuristic—and optimistic—EU SARTRE (Safe Road Trains for the Environment) project, of which Volvo Cars is one of seven consortium members. Reducing road transport's negative effect on the environment and improving safety via the use of "road trains" (known colloquially as "platooning") are two of the project's aims, both also at the core of the company's technology and business philosophy. Volvo stresses the importance of the project also providing time for all vehicle occupants to read and work.

"We will introduce the C30 electric model into small fleets in 2011, and the V60 will be available as a plug-in hybrid (PHEV) with production starting in 2012," Jacoby said in detailing the present status of Volvo's commitment to electric vehicles. "It will have CO_2 emissions of 49 g/km. EVs are not yet competitive, but we will achieve economies of scale as the market builds. Battery prices are already coming down."

The V60 will be a D5-engined diesel PHEV. The IC (internal-combustion) engine will power the front wheels, an electric motor the rears; it can be operated in pure electric mode driven by the rear wheels, IC only powering the front, or as an all-wheel-drive vehicle.

Jacoby, who previously spent much of his career with **Volkswagen** (as President and CEO VW Group of America from 2007 to 2010), said that when he took over at Volvo in August 2010, he planned to set aside his initial 100 days for a "deep dive regime," visiting the company's R&D facilities, factories, and dealers. But the pressures of directing a modern auto company made that impossible: "I was totally wrong with that approach; you have to throw yourself straight into the cold water and start swimming!"

He wants Volvo to build 800,000 vehicles annually in 10 years' time (current capacity is about 500,000) and sees a significant part of that total comprising electric vehicles.

One of Jacoby's aims is to lower Volvo's platform count from the current three to two or possibly only one. Although no specific announcement has been made, because of the powertrain mix envisaged (IC, PHEV, pure EV), this indicates the creation of a multirole platform/architecture, although Volvo has yet to give details.

Jacoby said that design engineers are now working on solutions that would place batteries in the center tunnel through the cabin, would meet front-rear weight distribution targets, and also contribute to safety levels, while permitting the use of larger battery systems for increased range.

But Volvo, like **Mercedes-Benz**, is also looking at fuel-cell technology as a low/zero emissions solution. In Volvo's application, however, it would be just as a range extender and to support ancillaries. The **Swedish Energy Agency** is backing a program to have two prototypes using the technology undergoing real-life testing in 2012 (Volvo is also working with **Powercell Sweden** AB) based on the battery-powered C30 DRIVe (now called C30 Electric). Jacoby sees fuel cells—which still present significant cost challenges—as giving the sort of realistic ranges that end users are likely to demand.

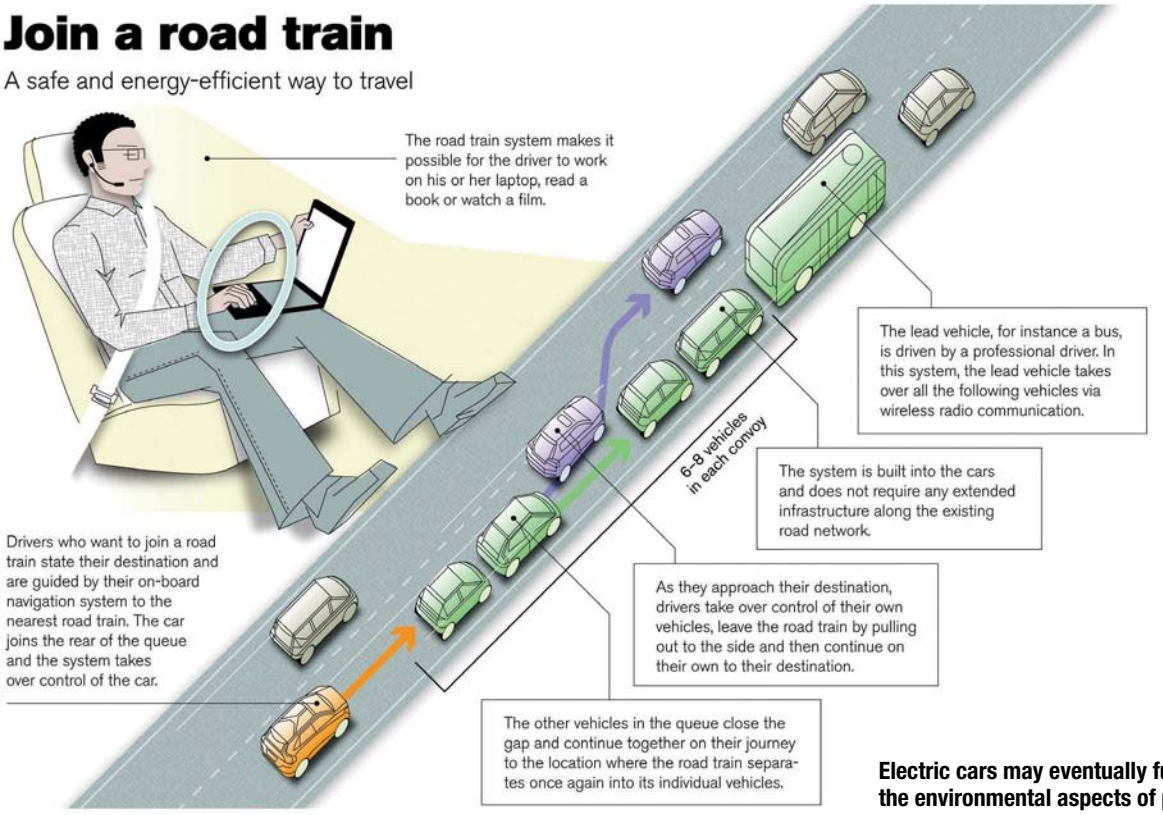


Volvo CEO Stefan Jacoby says of the company's extensive electric-vehicle program: "We will achieve economies of scale as the market builds."

The fuel cell would not use hydrogen but would incorporate a reformer and use gasoline as its fuel source to create hydrogen. Volvo sees a vehicle with a fuel-cell range-extender added to the battery pack possibly achieving an extra 250 km (155 mi) depending on fuel-tank size, taking the car's best operat-

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ing range to about 400 km (249 mi).

"It is too early to talk about market introduction of electric cars with range extenders," stated Jacoby. "The industrial decision will come when we have learned more about fuel cells and the opportunities they offer."

The Volvo C30 Electric uses a lithium-ion battery, and its 82-kW motor is placed under the hood. Top speed is 130 km/h (81 mph), and 0-100 km/h (0-62 mph) acceleration takes 10.5 s.

By 2020-25, Volvo estimates that electric cars will account for at least 3% and possibly 10% of EU-country market share.

With safety a central plank of Volvo's technology strategy, the company's approach to electric vehicles includes programs to develop advanced automatic battery monitoring of battery status and encapsulation of batteries. Component-level and real-life crash tests include not only the effect on batteries of a collision but also of harsh braking. Production, daily use, servicing, and recycling are also considered as elements of Volvo's safety design and development process, which is divided into five phases: normal driving, conflict, avoidance, collision, and post collision.

If a battery (protected and positioned outside the main deformation zone) is damaged, resulting in gas leakage, ducts carry any resultant gas beneath the car; power supply is automatically shut off in the event of a collision, and encapsulation shields occupants from any extreme heat generated.

Volvo's electric-car expertise may be of significance in subsequent developments based on the SARTRE. Although the consortium does not specifically include an electric-car aspect, the potential importance of the technology (particularly in relation to Volvo's range targets achievable within a decade) may be significant. The aim of the current program is to develop, test, and validate technology for vehicles that can drive themselves in long road trains or platoons on motorways and also to help gain customer acceptance.

Such a possibility has been considered by companies for many years, but it is only now that processing systems are in place that make it possible to meet the stringent standards required, including vehicle-to-vehicle communications. An essential element of SARTRE is to assess and understand what legislation and standards would need to be changed if platooning becomes a reality.

Ricardo is the lead partner, working with **Volvo Technology** Corp. and Volvo Car Corp.; **Robotiker-Tecnalia** Technology Center; **SP Technical Research Institute**, Sweden; **Applus** and **IDIADA**; and the **Institut für Kraftfahrzeuge** of the **RWTH Aachen University**, (ika), Germany.

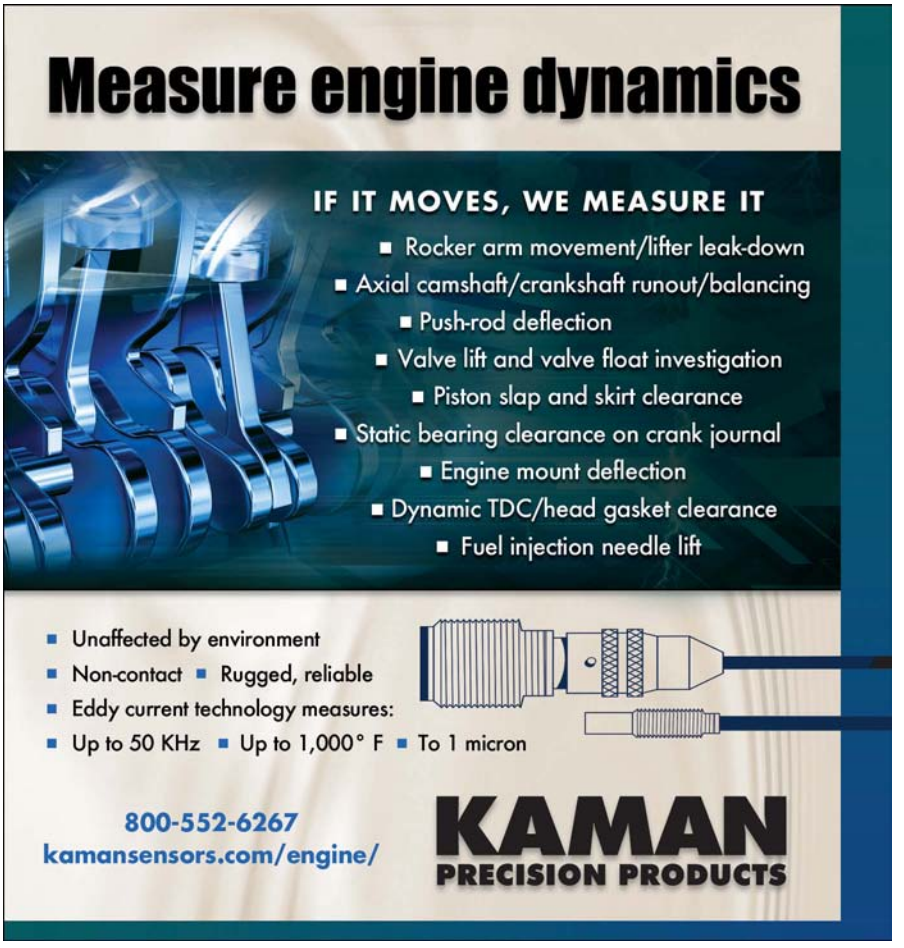
The initial phase of the project has seen the partners considering the basic principles of a platooning system, with issues investigated including usage, human factors, behavior associated with platooning, core system parameters, and specification of prototype architectures and applications.

Real testing is following the implementation phase, which has seen installation of hardware in two vehicles for lead and following roles. The technology will include the vital vehicle-to-vehicle communications, integration of sensors, and low-level actuators for lateral and longitudinal control of the following vehicle. Software integration for automated driving has started. By 2012 it is anticipated that a five-vehicle road train will be under test.

Human-factor simulator testing is being carried out at Tecnalia, Bilbao, Spain. The simulator has a 120° forward view via LCD screens and a virtual 18 km (11 mi) of motorway. The simulator has a steering wheel with force feedback, manual and auto transmission controls, and haptic seat capability.

SARTRE's main target is to achieve a step-change in personal transport usage via platoons, which it hopes will lead to environmental, safety, and congestion improvements, together with enhancing people's free time during travel. The development of electric vehicles with sufficient range could help play a significant role in achieving these aims.

Stuart Birch



Future testing of active safety systems



TNO Automotive's indoor hardware-in-the-loop (HIL) test facility with vehicle under test (VUT) and two moving bases.

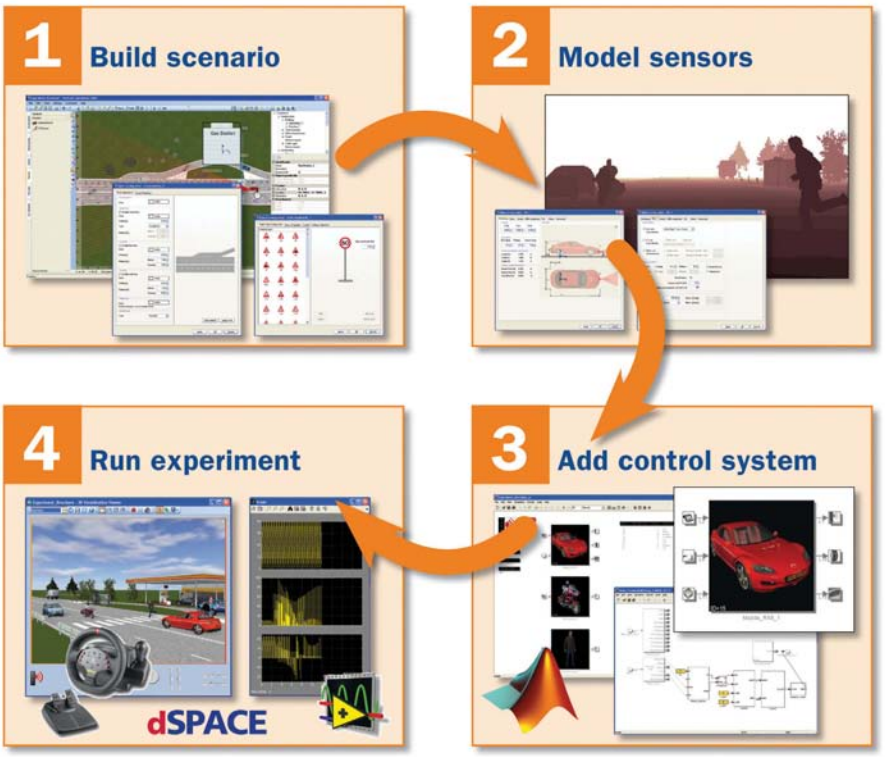
To speed up the introduction of active safety systems, efficient standardized test programs are needed, including alternatives to test-track testing.

Advanced driver assistance (ADA) systems are increasingly becoming available in trucks and passenger vehicles. In recent years, developments in the field of ADA have shifted from increasing driver comfort toward increasing occupant safety. Moreover, safety functions are being added to comfort-oriented ADA systems, rather than adding new safety systems to the vehicle. Comfort systems such as cruise control are extended via adaptive cruise control (ACC) to pre-crash braking systems, and will be extended to collision avoidance systems in the future. Furthermore, car-to-car (C2C) and car-to-infrastructure (C2I) communication are being integrated in intelligent vehicle safety (IVS) systems.

Although strong efforts in increasing the passive safety of vehicles have resulted in a decreasing number of fatalities in Europe, the current developments in IVS systems are needed to reduce the number of fatalities even further. However, a large penetration of IVS systems and C2C or C2I communication in the vehicle fleet is not to be expected in the next 10 years.

In the meantime, developments in IVS systems will be focused on safety by collision mitigation and even collision avoidance. The effectiveness of IVS systems will be increased by the use of communication. Furthermore, safety of vulnerable road users (VRUs) and non-connected road users must be considered.

The development of IVS systems should go hand-in-hand with the development of test procedures for these systems. Without a procedure to test functionality, performance, and robustness, it will not be possible to implement systems at large scale in production cars. Development and subsequent acceptance of the test procedures will require strong involvement from OEMs. The test procedures should be adapted to the type of IVS system that is assessed. Development of collision mitigation and avoidance systems calls for test methods that enable testing with small time-to-collision (TTC), whereas development of IVS systems to protect VRUs calls for the development of appropriate test objects. Furthermore, to ensure efficient testing of IVS systems that comprise different functions such as comfort and safety, test programs are needed that allow for testing of those various functions.



PreScan consists of four stages. In the first stage, the traffic scenario is built using a database of road sections, infrastructure components, and road users. In the second stage, the environmental sensors of the system are modeled (or a standard sensor from the PreScan library can be used). In the third stage, a Matlab/Simulink interface can be used to design and verify algorithms for data processing, sensor fusion, decision making, and control. Finally, in the fourth stage, the experiment is run with ControlDesk and LabView.

Testing of IVS systems

Whereas passive safety systems are assessed by standardized test programs that have been accepted by OEMs, customers, and governments for several decades all over the world, no widely accepted standard test program is available for active safety systems.

Standardized test programs for passive safety systems typically consist of only a handful of scenarios. In contrast, standardized test programs for IVS systems should consist of hundreds or thousands of scenarios. This is because IVS systems should function well in many different situations and under many different conditions. However, as this is a very large number of tests, the standardized test programs should be an incentive for OEMs to consider all these situations and conditions during the IVS system's development process, in an efficient way.

It will be infeasible to assess the IVS system's performance in all these scenarios by means of test-track testing. Not only because test-track testing is expensive and time-consuming, but also because it is potentially unsafe. This is especially true when testing pre-crash systems. Furthermore, the reproducibility of the test scenarios in test-track testing is somewhat limited, which makes it difficult to compare different IVS systems in an objective way. Therefore, some alternatives to reduce the amount and complexity of tests to be performed are needed.

TNO Automotive has developed a simulation and a testing environment that can be used for standardized test programs for IVS systems: PreScan and VeHIL. PreScan is a software-in-the-loop (SIL) environment and VeHIL is its hardware-in-the-loop (HIL) counterpart.

A four-pronged approach

PreScan consists of four stages and allows for development and testing IVS systems on a desktop PC. In the first stage, the traffic scenario is built using a database of road sections, infrastructure components, and road users. This can be based on "ideal" scenario parameters, but also on logged differential GPS (dGPS) data from test-track driving. Weather conditions and light circumstances also can be incorporated. In the second stage, the environmental sensors of the system are modeled (or a standard sensor from the PreScan library can be used). In the third stage, a **MathWorks** Matlab/Simulink interface can be used to design and verify algorithms for data processing, sensor fusion, decision making, and control. Alternatively, existing Simulink models from **Mechanical Simulation**'s CarSim or MathWorks' veDYNA can be used. Finally, in the fourth stage, the experiment is run with **dSpace** ControlDesk and **National Instruments** LabView. Typically, 1000 scenarios can be run within a couple of hours, and this process can be automated.

Once a system passes in PreScan, a subset of those 1000 scenarios can be uploaded to VeHIL where the complete IVS system is tested in a realistic hardware environment. The subset can be randomly chosen, but to increase the efficiency of the test program, a smart subset can be chosen, containing the most important or most challenging scenarios. The VeHIL tests are used to validate the PreScan simulations and thereby to validate the conclusion about the IVS system's performance.

VeHIL allows for evaluation of various IVS systems on a technical as well as on a functional level in a realistic and controlled environment that is partly simulated and partly real.

VeHIL constitutes a traffic simulation in which one vehicle is the vehicle under test (VUT) and the motions of selected other simulated vehicles are represented by wheeled mobile robots to provide environment sensor input for the VUT.

Best of both worlds

Once the system has shown its good performance in VeHIL, it can be tested on a test track to evaluate the performance in all kinds of environmental conditions (such as weather, road, and light conditions). Again, the test to be performed on the test track can be based on the results of the evaluation in PreScan. Comparing results between VeHIL and test-track testing can be used to validate the VeHIL test results.

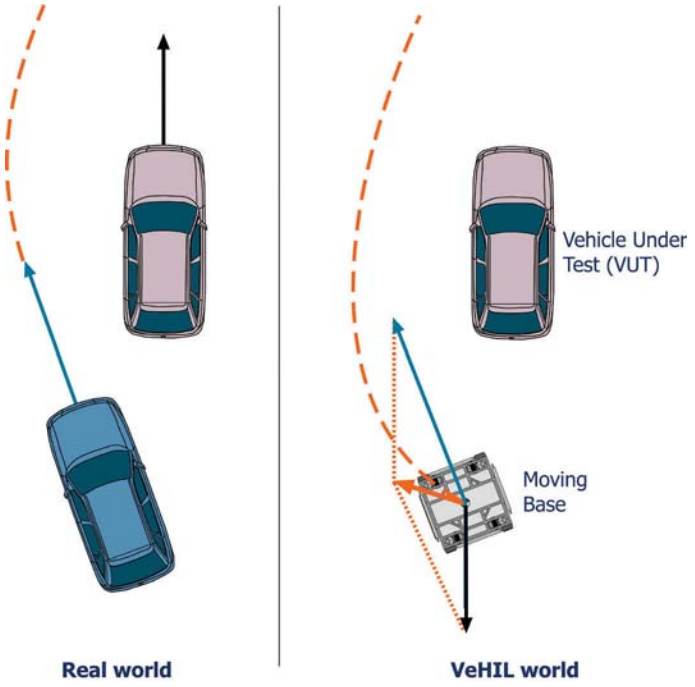
In addition to the increased efficiency (in time and cost) that can be gained by the use of simulation and HIL simulation, a second improvement compared to test-track testing only is to "translate" a set of scenarios that are usually performed on test tracks to VeHIL scenarios. This results not only in higher efficiency but also enables testing paths that are dangerous for the test driver and testing the ideal test path that is difficult for human test drivers. Position and speed of the test vehicles on the test track is often measured by a dGPS system or even controlled by a steering robot connected to a dGPS system.

Due to restrictions in space of VeHIL and maximum speed of the moving bases, not all scenarios performed on a test track can currently be performed in VeHIL. VeHIL is not designed to replace test-track testing. It is designed as an addition to test-track testing and to enable highly reproducible testing in a safe and efficient way, especially in cases where reproducibility and safety in test-track testing is difficult to achieve. One of the advantages of VeHIL is that it allows very reproducible testing with respect to driven paths (which is difficult using human test drivers) and environmental conditions (such as weather and light). This makes it easy to tune the control algorithm or to benchmark various IVS systems. It is also easier in VeHIL to perform the "ideal test path" (desired speeds, lateral offsets, braking actions, etc.) than on a test track. Furthermore, testing in VeHIL is less time consuming and safe for man and material.

Acceptance and standardization

Although most drivers are aware of the benefits of passive safety systems, their acceptance and awareness of the safety benefits of active safety systems should be increased. Standardized test programs such as EuroNCAP make it easy for drivers to understand the benefit of passive safety systems. For active safety systems, however, such test programs are hardly available yet. Furthermore, most drivers are not likely to pay for systems that keep other traffic participants safe or for systems for which a high penetration rate is needed to become effective (such as cooperative systems).

To increase the amount of IVS systems on the road, OEMs can be encouraged to introduce those systems in a larger amount of car models by legislation or EuroNCAP-like qualifications (e.g., higher rating for good performance with IVS systems). Driver's awareness of the safety benefits can also be increased by such qualifications. Finally, governments need support to define minimal standards and new legislation.



The left side of this figure depicts an overtaking maneuver; the gray vehicle is the VUT and the blue vehicle the overtaking vehicle. Expressing the velocity vectors in the VUT coordinate frame results in the VUT standing still (with respect to its own coordinate frame) as shown on the right side. The resulting velocity vector of the other vehicle indicates a crabwise movement at relatively low velocity. Obviously, this crabwise movement cannot be driven by a common vehicle, which is why moving bases are used to represent other road users.

Several initiatives are working on developing standards describing system requirements and standard test programs. Some examples are the **ISO** standards on intelligent transport systems, the Crash Avoidance Metrics Partnership initiative (CAMP), and the National Highway Traffic Safety Administration (**NHTSA**) describing confirmation test requirements for lane departure warning and forward collision warning systems. In Europe, for example, the Beyond NCAP group from EuroNCAP and European projects such as PReVENT, ASSESS, and interactIVe are working on standard test programs.

Despite all initiatives, so far no test program is accepted widely among car manufacturers or known to the public. Furthermore, the standards do not always provide sufficient information for standardized testing, nor are they applicable to future IVS systems. Therefore, effort is needed to make the standards suitable for standardized testing including rating of available IVS systems and to let them evaluate along with the developments in the IVS systems. Development and acceptance of standardized test programs also needs definition of generally accepted test scenarios and test targets (such as pedestrians and cars) as well as requirements for accurate, reproducible, and efficient testing facilities.

Based on the developed test program, TNO will offer a complete test program for IVS systems. This program will most likely consist of (PreScan) simulations, HIL testing in VeHIL, crash-testing, and test-track testing, for which a partnership will be developed. AEI

This article is based on SAE technical paper 2010-01-2334 by **Falke Hendriks**, **Riné Pelders**, and **Martijn Tideman** of TNO Automotive.

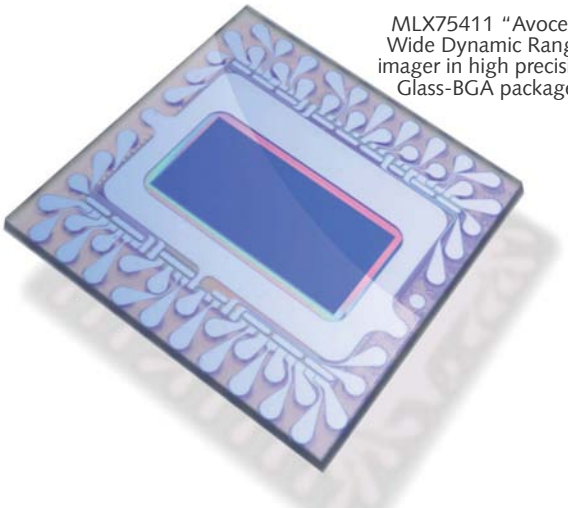


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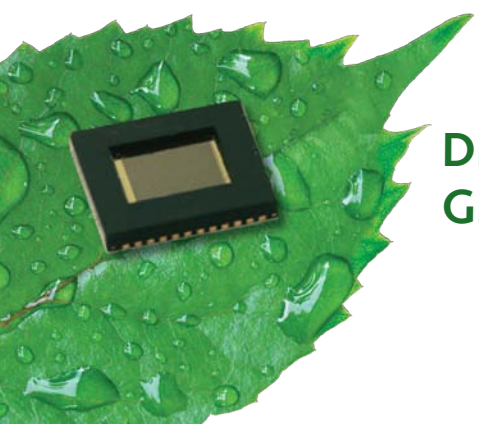


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Engine management on a budget



Tata Motors product developers had no obvious benchmarks for its low-cost Nano, which was targeted at the average Indian family of four that used a two-wheeled vehicle for commuting.

Tata Technologies engineers at the recent SAE Convergence event provided an inside look at how they developed the Nano's low-cost EMS and reduced development time and cost with extensive use of modern tools.

When the groundbreaking Nano was first conceived by **Tata Motors** product developers, existing low-cost cars available in India were not affordable to common people. The new car was targeted at the average Indian family of four, which at the time was using a two-wheeled vehicle for commuting, irrespective of season.

Vehicle goals included a fuel economy target set at 20-40% below that of the existing lowest-cost car. While fuel economy was critical, launch performance and driveability could not be compromised, particularly for acceleration from traffic signals. It was decided to optimize the car mainly for city and urban driving, so the top-speed target was set at 105 km/h (65 mph). In an Indian city, around 90% of the time the average speed on roads is about 50 km/h (31 mph), and the top speeds achieved range from 60 to 80 km/h (37 to 50 mph).

For engineers, early vehicle and powertrain benchmarking was difficult because there was no competition anywhere near the low cost target. It was decided that the Nano's engine would be developed in-house to keep costs low. The challenge was to develop an engine that would not only fit into limited space, but also deliver the desired power and torque in natural aspirated form. All components for the 625-cm^3 two-cylinder engine had to be designed and developed from scratch. Indian pollution regulations could not be met without an engine management system (EMS), and the focus centered on a low-cost unit.

To reduce development time and cost, modern simulation tools were used extensively.

EMS development phases

Due to time and cost constraints, it was clear that a different approach was required to meet EMS design & development requirements. With basic requirements evolving continually, and considering the criticality of timeline, it was decided that EMS development would be in two phases. The initial alpha phase employed Tata's in-house model-based design process including HIL (hardware-in-the-loop) testing. Tata used **dSpace** tools to develop its own EMS ECU (electronic control unit) and tested several strategies and functions on the dSpace platform, which convinced developers of the merits of the project. In the second phase of the **Bosch**-supplied production EMS, Tata did functional HIL testing of the released production software, participating in functional design, review, and calibration.

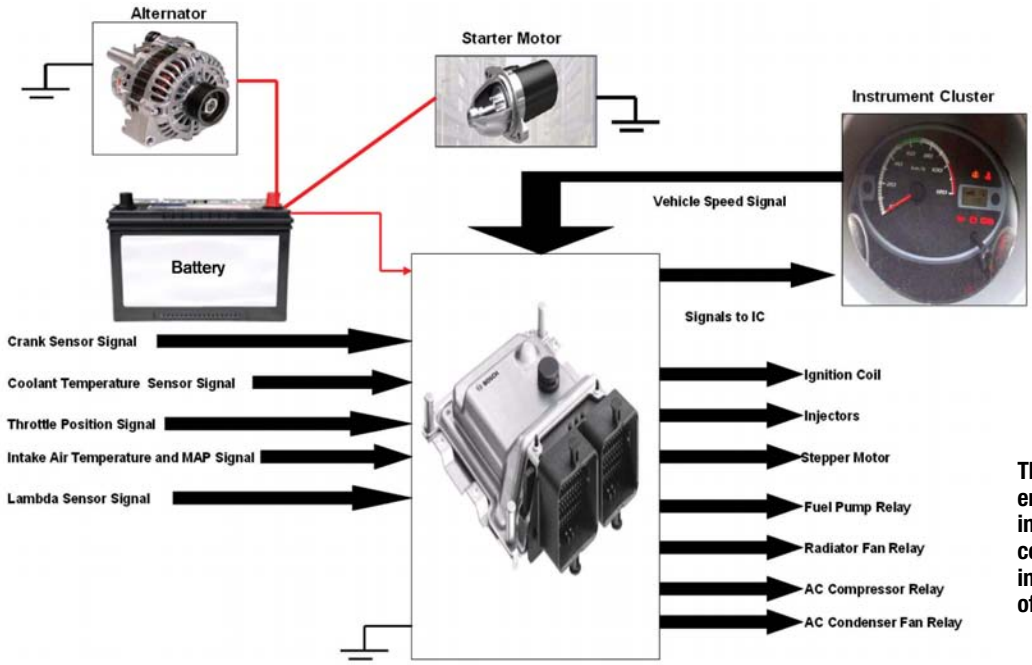
In the first phase, the focus was on building and running an alpha prototype engine economically and quickly. The in-house EMS was used so that all engine- and vehicle-level data could be acquired and then demonstrated to the company's marketing and management for approval. This gave management additional input and time to bring down EMS cost estimates from vendors without sacrificing development time.

In the second phase, the production EMS was further developed to meet safety, emissions, comfort, and driveability requirements without escalating cost. The EMS also needed to fit well with the vehicle E&E (electrical & electronics) architecture. Suitable ECU, sensors, actuators, high-tension leads, and ignition coils were required to fulfill Indian EMI (electromagnetic interference) and EMC (electromagnetic compatibility) requirements. Special diagnostic systems rich in features but easy to operate in remote areas and roadside without any computer or external tool had to be developed.

Running alpha Nanos

For quick feedback on engine power and vehicle driveability, **Pi Shurlock**'s OpenECU tool was chosen for rapid prototyping of the engine ECU because it was already available within Tata. Most EMS components—crank, temperature, manifold air pressure, and lambda sensors—were taken from existing Tata car projects, but a few new components—ignition coil and high-tension lead—had to be developed.

Engine-control algorithms were developed and modified in **The MathWorks**' MATLAB and Simulink using code generation by Tata engineers to meet the two-cylinder engine's wasted-spark configuration. The ECU, flashed with the executable software, was tested in the HIL setup running an engine and vehicle model to verify functionality both in normal and abnormal conditions.



The Nano's E&E architecture relevant to engine management system was divided into 5 parts: EMS including the ECU (engine control unit), battery, alternator, starter, and instrument cluster. EMS hardware consists of sensors, actuators, and engine ECU.

Use of an already established tool chain helped in reducing the cycle time for software development and testing. It also shortened the calibration time in the engine testbed.

Eight alpha Nanos were built and run, each using a rapid prototype ECU. The cars were track-tested for driveability, engine power, braking performance, suspension, and NVH. Apart from design optimizations of engine capacity, brake, and suspension, reduction in development time in this crucial first phase was achieved. It also helped management decide on various parameters such as vehicle layout, cooling design, and engine capacity upgrade—and early in the development process.

The in-house prototyping team's acquisition of the necessary EMS knowledge and skills helped Tata negotiate and collaborate more effectively with suppliers. The activity also helped answer many questions that the project team had at the start of the Nano project such as the adequacy of engine capacity, configuration, and torque curve; idle NVH; and electrical architecture that met customer and target cost expectations—all especially important since there was no benchmark vehicle available.

The Nano's E&E architecture relevant to engine management system was divided into five parts: EMS including the ECU, battery, alternator, starter, and **Delphi**-developed instrument cluster. EMS hardware consists of sensors, actuators, and engine ECU. Performance, reliability, and cost targets were the main criteria for selecting the hardware.

Since vehicle-speed information is required by the instrument cluster for display purposes, it was decided to integrate the vehicle-speed sensor into the instrument cluster, where the speed signal is processed in the cluster's control unit. The signal is hardwired into the engine ECU. To reduce E&E system complexity and cost, the instrument cluster was not designed with a CAN (controller area network) interface.

EMS development for production

Based on experience gathered during alpha development, requirements for EMS quotation were prepared and enquiries were floated. For production, the **Bosch** Value Motronic system was chosen. This ECU has a two-layer PCB and can meet Euro IV pollution regulations with European Onboard Diagnostics.

Instead of a cam sensor, phase detection software was introduced on the platform. To meet the tight timeline for vehicle start-of-production, Tata and Bosch worked jointly to calibrate the software in the testbed and vehicle.

The Nano EMS team modified the Value Motronic platform through software and calibration to reduce the higher vibration levels inherent in a two-cylinder engine. To reduce complexity, only one software and calibration was used for all engines and vehicles regardless of emissions standards (Bharat Stage II, Bharat Stage III, etc.) and A/C (air-conditioning) fitment.

A Nano-specific diagnostics tool with powerful capabilities was developed for workshop use. Real-time engine operating parameters, online monitoring, and recording of data facilities are provided by the diagnostics tool. Customers can get a printout of the average fuel consumption and average vehicle speed for the last 10 drive cycles, helping to educate them about fuel-efficient drive cycles.

Software emulation

Much of the software and hardware development was done in India to reduce development cost and time. EMS components such as ignition coil, throttle position sensor, and crank sensor were specifically designed and developed to meet cost targets. Other sensors were taken from existing platforms to create a proven-in-field and reliable EMS, but the number of sensors was kept to a minimum.

The starter motor and alternator were designed and developed specifically for the Nano. The alternator does not provide load feedback to the engine ECU, so software strategies were developed to estimate load. For example, parasitic loads during idling are taken into consideration by increasing target idle speed before engaging the air-conditioning compressor clutch, resulting in a lower idle NVH and better battery charge balance.

The Tata EMS control algorithm structure was different from Bosch's typical torque-based control structure. To reduce

costs arising out of complexity of the software strategies, a torque structure was activated only in regions where it was an absolute must. Software complexity was reduced so that it takes less memory and calibration time.

The EMS team worked to downsize a considerable number of the two-dimensional maps of the default software functions in the Bosch-provided engine ECU software. Bosch also trimmed the functions not required for the Nano to reduce software size and increase availability of microcontroller computing resources. Using one software and calibration set for all varieties of engines reduced the cost of part handling in plant and in the service field.

Hardware elimination

An entirely new engine ECU was developed to meet Tata's cost demands. Bosch combined a number of previously separate ASICs (application-specific integrated circuits) into a single ASIC. Expensive EEPROM was replaced by emulated ROM.

Bosch developed a two-layer (vs. a conventional four-layer) PCB (printed circuit board) for the engine ECU that met all Indian EMI/EMC standards and Tata internal requirements. The number of engine ECU pins was based on functional requirements without keeping many spares.

The ambient-pressure-sensing chip was removed from the existing PCB layout to save cost. All related calculations were handled by an ambient-pressure-sensor estimator in the embedded software. Deletion of the cam sensor signal detection ECU circuit and software processing functionalities helped reduce cost. The knock sensor processing circuitry was not populated.

These were innovative ideas considering that Bosch came up with them in 2005, but they have become industry-standard practices since then.

Other hardware components were deleted to save cost. It was decided that a wasted mode ignition system would be used, so there was no need to go for the two individual ignition coils that are usually required in a nonwasted spark mode operation. The cam sensor was removed from the bill of material, and in its place software was used to determine engine phase. Knock sensing was not considered for cost reasons; instead calibration was done carefully. Costs associated with the wiring harness, connectors, clamps associated with these sensors, and actuators were saved. Almost all of the indicator lamps in the instrument cluster are LEDs, which reduced cost.

Other examples of hardware cost reduction include a combination switch and battery developed in India and a more cost-effective small-capacity fuel pump was developed. Charge-balance trials were conducted on rainy nights and during busy road conditions to confirm that the battery was not depleting even during frequent idling when the current demand from headlamp and wiper motor were high.

This feature is based on SAE technical paper 2010-01-2324 by **Prasanta Sarkar** and **Debarsish Hazarika** of Tata Technologies Ltd.

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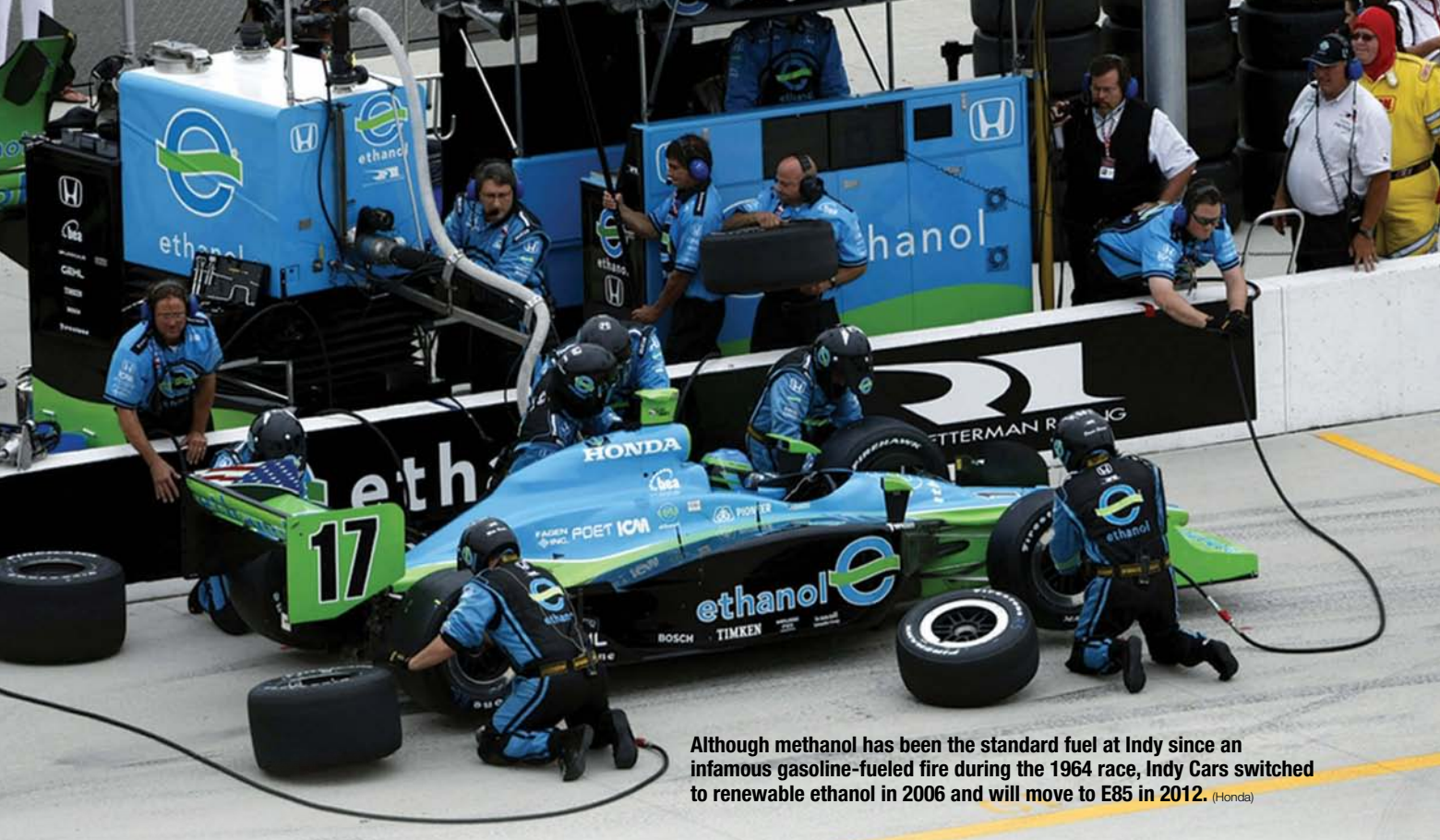
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Although methanol has been the standard fuel at Indy since an infamous gasoline-fueled fire during the 1964 race, Indy Cars switched to renewable ethanol in 2006 and will move to E85 in 2012. (Honda)

Racing for the green

Changes are coming to Indy Car and Formula One to focus on green technology that applies to production vehicles.

by **Dan Carney**

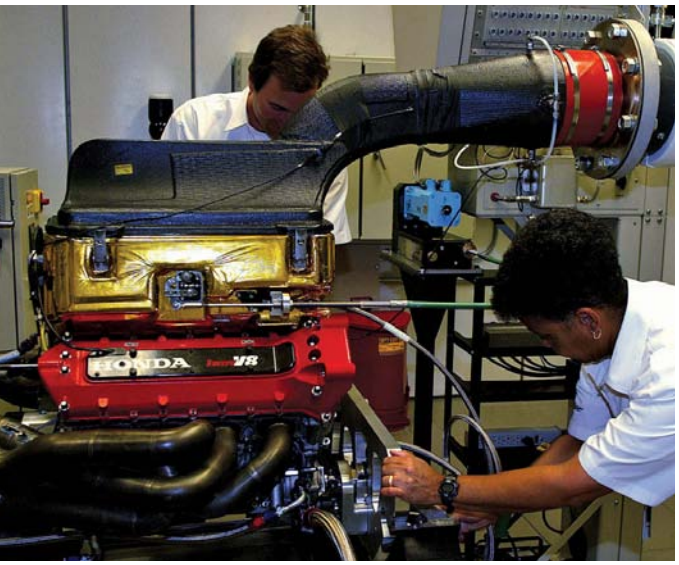
In a tight financial environment and with relentless focus on environmental impact, automakers have shown understandable interest in production-derived racing series, as technology developed for racing can be applied to products for sale. Now thoroughbred top-level open-wheel racing series aim to apply some of these practical plow-horse attributes as **Indy Car** and **Formula One** each adopt specifications that appeal to manufacturers seeking to feature road-car technology in racecars.

New Indy Car rules for the 2012 season take American open-wheelers back to the future, with normally aspirated V8 engines being replaced by small-displacement, direct-injected turbo motors—the kind companies expect will soon power the bulk of their production fleets. Additionally, the series and its flagship Indy 500 Memorial Day event, which recently switched from methanol fuel to ethanol, will convert to the E85 ethanol that flex-fuel production cars burn.

Formula One launched its kinetic energy recovery system (KERS) hybrid drivetrain system in 2009, a season during which some teams used the technology, some did not, and some used it only on tracks where their computer models predicted it would be advantageous. Such ambiguous results were not doing much to promote the image of hybrid technology, so the series put KERS on hiatus for the 2010 season.

For 2011, KERS returns but without new rules to permit more powerful systems as some teams had hoped. Instead, the new, improved 2011 KERS systems rely on technical advances to make them more effective and therefore appealing to teams.

Racing for the green



This year will be the last for V8 engines such as this Honda in Indy Car racing as the series moves to smaller, turbocharged engines that more closely reflect the engines in production models.



Turbocharged, small-displacement, inline four-cylinder engines have been used in Indy Cars before, as the Offenhauser engine dominated the series for decades. Johnny Rutherford's 1976 Indy 500 victory was the engine's last win at the track. (Indianapolis Motor Speedway)

Will Offy return?

Indy Car is also seemingly returning to old rules with the specification of 2.4-L turbo engines, echoing the 2.65-L turbo formula featured until the **Championship Auto Racing Teams/Indy Racing League** split of the 1990s. The turbocharged, alcohol-burning four-cylinder Offenhauser racing engine dominated Indy Car racing for decades, with its last victory coming in 1976 when the venerable motor propelled "Lone Star JR" Johnny Rutherford to the second of his three Indy 500 wins.

While the Offy was finally displaced by the V8 Cosworth engine, the new Indy Car rules dictate that the next generation of engines will be either inline-fours or V6s. The goal is for the race engines to mirror the engines in manufacturers' production models, though they will not be production-based engines.

General Motors has announced its return to Indy Car racing with a V6 provided by race engine specialist **Ilmor Engineering** Inc. and wearing the **Chevrolet** brand. **Honda**, which has been the sole engine supplier to the series with engines provided by Ilmor, will compete in the new engine formula with twin-turbo V6s developed by Honda Performance Development (HPD).

This new engine's season-long lease will be 40% less expensive than that of the 2011 V8 engine, reflecting the success of the new rules in containing cost for racing teams, according to Erik Berkman, President of HPD. The appeal of the formula is also illustrated by the fact that GM, Honda, and **Lotus** have announced plans to supply engines to the series, and those companies say that **Volkswagen** has also participated in rules discussions with an interest toward participating with an I4 turbo engine similar to those in its production models.

The increased relevance of the series to Honda and to other automakers drove Honda's interest in renewing its participation in Indy Car racing, said Berkman: "We are delighted to take a role in that promising future."

"These new engines are going to be much more relevant to what we are making," said Mark Kent, Director of GM Racing. "All of the things that we are working on as an auto manufacturer are exactly the things that are going into the new engine, so we have a lot of opportunity for learnings in the new engine."

E85 education

The key areas of interest are in the use of direct injection and turbocharging with E85 fuel, Kent said. "Although we currently have an enormous fleet of E85 vehicles, this is a whole new opportunity for us to apply it to small-displacement, direct-injected turbo motors."

Additionally, because of limits on displacement, turbo boost, and rpm, the potential for a power advantage comes from areas such as reduction of internal friction, which would also help the fuel efficiency of production engines.

Potentially even more importantly, GM and Ilmor will involve the company's production suppliers in development of the engine, creating a direct pipeline of know-how from racing to the street.

"We have already contacted that supplier base to take what we already know on our production engines and help Ilmor progress rapidly with the race engine," Kent said. "Then we'll take back what we learn in racing to production with these same suppliers."

GM selected the V6 engine configuration because with the engine serving as a stressed member in the racecar, its



Magnetti Marelli illustrates the connection between the track and the street with its KERS hybrid components in the foreground and prototype road components derived from KERS experience in the background.



Race team owner Roger Penske and GM Vice Chairman Tom Stephens announce their collaboration to reunite Penske, GM, and Ilmor in Indy Car racing. Penske and GM contributed to Ilmor's foundation as the company's first customers.

wider structure has better torsional rigidity, according to Paul Ray, President of Ilmor Engineering.

The biggest challenge for engine builders will be refining the fuel injection and turbocharger management systems, Kent added. "There are no commercially available injectors that will meet that [performance] envelope," he said. The rules permit a single direct injector per cylinder and one port injector, "but at 12,000 rpm you have very little time."

The external injector helps with that problem and it also serves to chill the incoming air charge. The extreme pressure required for the direct injector to work at such rpm levels with the correspondingly short injection opportunity means that the fuel pump must provide fuel at 300 bar (4350 psi), which is twice the pressure of production direct-injection systems, said Ray.

At the other end of the spectrum, the turbochargers will run at as little as 35 to 38 inches of boost on fast superspeedways (higher boost of about 46 inches of mercury will be permitted on road race circuits). At such low boost levels it is difficult to maintain even boost, according to Ray, so the turbo management will be tricky.

Additionally, penalties for excessive boost will be administered immediately, so there is the ability to reduce boost further. At slower tracks, higher boost will be allowed, and the expectation is that a "press-to-pass" overboost feature will be supported, so the engines must be extremely adjustable while maintaining performance that stays within 1% of factory-fresh levels.

Electrifying formula

In Formula One the focus is on hybrid drive, which participating manufacturers hope to infuse with a sporty image, especially among European consumers who have so far remained skeptical of the value of hybrid drive. The decidedly mixed performance of KERS in 2009 did not help their cause, but the 2011 system is substantially improved, according to Roberto Dalla, Managing Director of **Magnetti Marelli** Motorsport, which supplies the **Ferrari** team with its KERS technology.

"After two years of experience we can say that the 2011 KERS will be much, much better than the solution we saw in 2009," Dalla said. The new system will be between 30 and 40% lighter than the old system, he said.

This was the reason Magnetti Marelli pursued a battery-electric hybrid drive rather than a flywheel like that used by **Williams Hybrid Power**. "The weight of a flywheel is defined by physics," Dalla pointed out. "The weight of a battery is subject to evolution." Most of the weight savings in the new KERS comes from advances in battery technology, he said.

Further, the old system was only able to propel the car for about 30 to 40% of the duty cycle, while improved efficiency means that the 2011 system could run nearly continuously if the rules permitted a larger battery. "Now it could work for a fully electric race," he said.

Magnetti Marelli engineers improved the electric motor's heat rejection by selecting a different magnetic material and carefully shaping it to improve heat dissipation. The company's simulation tools were critical in this development, said Dalla.

While many participants hope that motorsports will aid production know-how, Magnetti Marelli points to production hybrid-electric components offered to automakers as the results of its KERS program. This connection, along with the increasing performance benefit of KERS, will make hybrid systems irresistible to other racing series, Dalla predicted: "If [in 2011] Formula One will again demonstrate that this kind of device is a useful device, then we will see it everywhere in racing." AEI

Taking strides **together**



SAE 2011 World Congress host company General Motors touts teamwork as a way to expand industry knowledge and encourage energy efficiency.

by Matthew Monaghan

Karl-Friedrich Stracke, General Motors' Vice President of Global Vehicle Engineering and SAE 2011 World Congress General Chairman, believes the time is right to talk more about electrification. He is shown speaking at the GM-hosted Electrification–Plugging into the Future Forum in Shanghai.

AT **GENERAL MOTORS**, 2011 will largely be remembered as the year of the Volt. With a host of 2011 Car of the Year awards already in hand and **Chevrolet** Volt deliveries expected in all 50 states by year's end, GM has taken a huge step forward this year in its effort to "redefine the DNA of the automobile."

"We are right now in a very significant time phase where we are reinventing the automobile; the DNA of the automobile is basically being redefined," said Karl-Friedrich Stracke, GM's Vice President of Global Vehicle Engineering and **SAE** 2011 World Congress General Chairman.

GM acknowledges that switching from an automotive landscape that is mechanically driven, energized by petroleum, and powered by internal-combustion engines to one that is electrically driven, energized by electricity and hydrogen, and powered by electric motors is not something the automaker can do on its own and will require a great deal of cooperation. Under the theme "Charging Forward Together," the GM-hosted SAE 2011 World Congress, to be held April 12-14 at Detroit's Cobo Center, serves as an excellent opportunity for the automotive community to come together and share strategies and perspectives on the automotive landscape moving forward.

"'Charging' creates automatically a relationship to electric cars, and I think it's the right time to talk more about electrification in the society," Stracke said. "But then with 'Charging Together,' it's really a society effort. It's a team effort—everybody: the utility companies, different suppliers, the automotive in-

dustry—so a big industry effort is required to get the right solutions out to the road to the customer."

Steps toward solutions

The collaborative atmosphere and many networking opportunities provided by the SAE World Congress can go a long way toward finding those right solutions and sparking creativity for future developments.

"There are a lot of reasons why the World Congress makes a lot of sense," Stracke said. "You discuss and share technical solutions, you share your strategies, you share your perspective on the automobile going forward. I am seeing this Congress defining a lot about the automobile. The SAE conference is a perfect platform actually to discuss and debate it."

While stressing the importance of collaboration to future technology development, Stracke understands the concern some in the industry may have about being too collaborative.

"The challenge is, we are competitors, but at the same time, we need to work together to provide the right technical solutions to the customers," Stracke said. "At the end of the day, I think we are dependent on each other to develop the right solution. It's a big society issue, getting away from fuel-dependent propulsion systems. It's a unique industry challenge, and the better we work together on those challenges, the better solutions we get. But there are some standardized solutions you can work together.

"That's the opportunity to discuss those things at the SAE Congress. Those days will be a huge benefit for the society, for the automotive industry, and for the suppliers to provide some clear guidance. Also, the supplier who needs to be invested in the business wants to have some clear direction going forward and wants to understand that and anticipate what direction the automotive industry is heading. It's a unique platform, to standardize, to discuss, and then go from there."

As an example of successful collaboration, Stracke points to the relationship between GM and the SAE 2011 World Congress Tier One Strategic Partner **LG Chem**, which is supplying the battery cells for the Volt.



Ray Lane, Managing Partner, Kleiner Perkins Caulfield & Byers, and Non-Executive Chairman, Hewlett-Packard Co., will speak at the Grand Opening on April 12.



The show floor at the World Congress will again feature only the most innovative technologies, as exhibiting companies had to submit an application detailing the technologies to be displayed and then have that application reviewed by a panel of OEM engineers and executives.

"We have an excellent relationship with LG that we have developed over the last few years. I remember three years ago when we decided [to proceed with] the Volt, there was no battery cell, there was no chemistry, there was nothing, whatsoever. So we received cells around that time from LG Chem, we tested them, and we found that the biggest opportunity was to go with LG Chem. We have developed an excellent battery performance-wise and have not seen any big hiccups during the development phase. They have supported us all the way through in an excellent way. We are very fortunate to have them here with us."

The SAE World Congress is nothing new to Patil Prabhakar, CEO, LG Chem Power Inc. His involvement with the conference dates back many years, and he is a strong believer in the unique opportunities it provides.

"I've been involved in all different facets, in terms of attending as a participant and getting to know the different technologies and different tools," Prabhakar said. "This is the one place where a lot of things come together, where you would have to travel all over the world to find. In addition to that, it's been participating on the panels, participating in the technical papers, so many different facets and elements, and I think that's really the value of this in one place; in a concentrated dose you get to meet different people, get new ideas, and see new exhibits."

Innovation in mind

The conference itself will carry over many of the changes instituted last year, maintaining a three-day format as opposed to the traditional four and only featuring the most innovative technologies on the show floor.

"We want to focus this year again on having the right tech-

Taking strides **together**



Electrification and batteries will be one of the main topics of discussion at the World Congress. Tier One Strategic Partner LG Chem is supplying the battery cells for the Chevrolet Volt.

nology out there on the floor," Stracke said.

Once again, to participate in the event as an exhibitor, companies had to submit an application detailing the noteworthy technologies to be displayed and then have that application reviewed by a panel of OEM engineers and executives, who then selected only the most innovative technologies to be present on the show floor. A total of 74 companies had received approval for exhibition at time of publication.

The access to technology and innovation on the show floor and the opportunity to directly talk to the suppliers in one convenient place is a unique benefit of the SAE World Congress, and one that Stracke stressed to his employees and colleagues.

"We said we want to have staff meetings here. I agreed with Bob Socia on the Purchasing side that we have staff meetings on the floor. We will have a very interactive activity over that time frame. We will interact more with the suppliers," Stracke said. "When you are a supplier and put money into your booth, you want to see something in return. Therefore, I committed with the other OEMs that we are on the floor with them, that we share ideas. It should be a win-win for everybody."

Strategy sessions

In addition to the value to be gained browsing the exhibition, attendees will have the opportunity to hear industry experts and leaders discuss automotive technology trends during presentations and panel discussions held at the **AVL** Technology Leadership Center and the **FEV** Powertrain Innovation Forum.

The World Congress begins April 12 with the Grand Opening at the AVL Technology Leadership Center featuring keynote speaker Ray Lane, Managing Partner, **Kleiner Perkins Caulfield & Byers** (KPCB), and Non-Executive Chairman, **Hewlett-Packard** Co.

At KPCB, Lane is focused on helping entrepreneurs with technological and market insight, organizational development, team building, selling, and managing growth. In his time with the firm, Lane has sponsored several investments in clean and alternative energy, including vehicle manufacturers **Fisker Automotive** (plug-in hybrid) and **Th!nk NA** (electric).

Additionally, Helmut List, Chairman and CEO, AVL Powertrain Engineering Inc., and Mircea Gradu, Director Transmission and Driveline Engineering, Head Virtual Analysis, **Chrysler** Group LLC and SAE Automotive Vice President, will be part of the ceremony.

Keynote addresses at the AVL Technology Leadership Center on April 13 and 14 will feature Cathy Zoi, Acting Under Secretary for Energy, **U.S. Department of Energy**, and Rodney O'Neal, CEO and President, **Delphi**, respectively.

Panel discussions in the two theaters will be centered on the topics: future powertrain strategies, petroleum alternatives, global collaboration, electrification for personal mobility, ensuring safety, compressed natural gas, and transmission, electrification, and off-roading technologies.

Touting technology

The technical program at the World Congress will feature more than 175 sessions. The sessions will feature nearly 1300 technical papers, presented by engineers, which showcase applied technology, innovation, and product leadership. Technical sessions, which will each begin with a keynote address, are grouped in seven technology topics: Electronics, Emissions/Environment/Sustainability, Integrated Design and Manufacturing, Management and Marketplace, Materials, Propulsion/Powertrain, and Safety/Testing.

Nearly half of the papers have come from outside North America, including 305 from Asia and 270 from Europe, both increases from 2010. Papers submitted by OEMs have increased by 82%, to 398, compared to 2010.

In addition to using the time between technical sessions to discuss challenges and ideas, attendees can also take part in the many designated networking opportunities offered at the SAE World Congress.

Several annual events held in conjunction with the World Congress will offer pre- or post-event receptions, including the SAE Awards Ceremony on April 12 and the SAE Detroit Section meeting on April 13, which will feature a presentation by the Chevrolet Volt development team. The World Congress Annual Banquet will be held April 14 and feature an address by Daniel F. Akerson, Chief Executive Officer, General Motors.

The popular Chats with the Experts sessions, introduced at the SAE 2010 World Congress, will return this year, discussing topics such as recyclability, diesel emissions, composites, motorsports, and supply chain. Technology-focused lounges will also be open to all attendees throughout the day located near the session rooms.

Whether engaging the World Congress through the management program, technical sessions, exhibition, or any of the special events, Stracke believes attendees will come away from the event with valuable experience that they can apply to their specific field.

"The benefit of this event is to show the future technology, to show what's coming next, and how all the partners can be engaged here to have greater success for the industry at the end of the day," Stracke said. **AEI**

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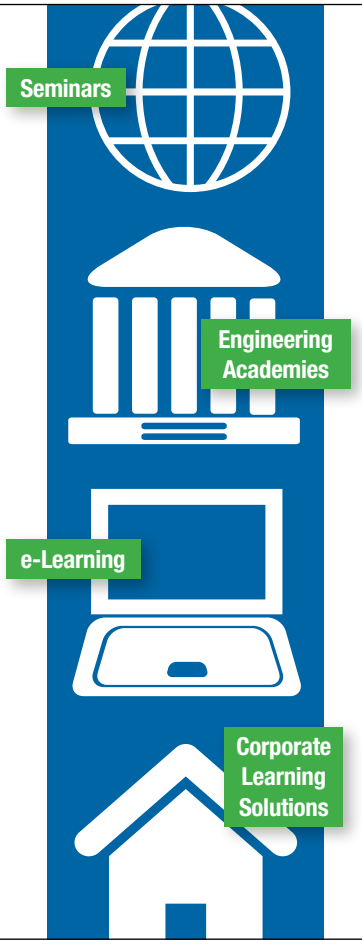
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Ethanol not what it's pumped up to be?

The article "Major sugarcane ethanol refinery coming to U.S." (Dec. 7, 2010, page 10 and www.sae.org/mags/aei/9096) states, "The ethanol will meet California's low-carbon fuel standard." How can this be?

Use published data for the lb/gal of CO_2 for gasoline (19.6), and for ethanol (12.57), and the energy content of each of those fuels. You can show that for a trip that would require 100 gal of pure gasoline, the same trip with E10 would have tailpipe emissions of 6 lb less CO_2 if the loss in mpg were that predicted by the energy content per gal. The loss in mpg on this basis would be 3.4%.

However, most motorists report a loss in mpg of between 5 and 10% when E10 is used. My own careful speed-corrected mileage measurements over the past two years show that E10 costs me about 7.5% loss of mpg. At an mpg loss of 7.5%, the trip would generate about 75 lb more CO_2 with E10 than with E0. This is over and above the carbon dioxide generated in the farming and production of ethanol, whether from sugarcane or corn.

Even Al Gore admits that ethanol harms the environment.

It's time that SAE International takes a stand on the ethanol scam that is costing our nation $7 billion annually and benefits only the recipients of the taxpayer largesse. We engineers know better.

Harry Wertheimer
Retired engineer and 55-year SAE member
Salem, SC

Untold pluses for Toyota's PHEV

Regarding the online article "Prius plug-in hybrid put to the test" (www.sae.org/mags/aei/9326), I was surprised how it played down the value of the PHEV Prius. Toyota is always conservative about its vehicles' impacts, but I think it will be significant.

I think there are a couple of missing upsides, one of which is a 5.2-kW·h pack that will get a battery tax credit of about $3000. Also, the CAFE and CARB ZEV value to Toyota of this model should be powerful.

Jeff Ronning
Indianapolis, IN
Company affiliation withheld at writer's request

Measuring true mileage vs. EPA mileage

I applaud the Clemson students on the Deep Orange car (www.sae.org/mags/aei/9301). It sounds like they have some good ideas.

However, I would like to see articles like this tell the true mileage equivalent and not just the EPA way to calculate it. I calculated the Chevrolet Volt mileage equivalent by going all the way back to the energy necessary at the power house. That changed the mileage number from 238 equivalent per the EPA to actual of 48 equivalent at the power house.

I think that is a better way to represent the mileage since that much energy will have to be put in the power house to charge the batteries. In this case, they would also have to include the fuel used by the engine to charge the battery and/or propel the car when the battery is down.

Food for thought.

Marvin "Mickey" Christensen,
PE, retired
Owner and President
TQM Systems, Inc.
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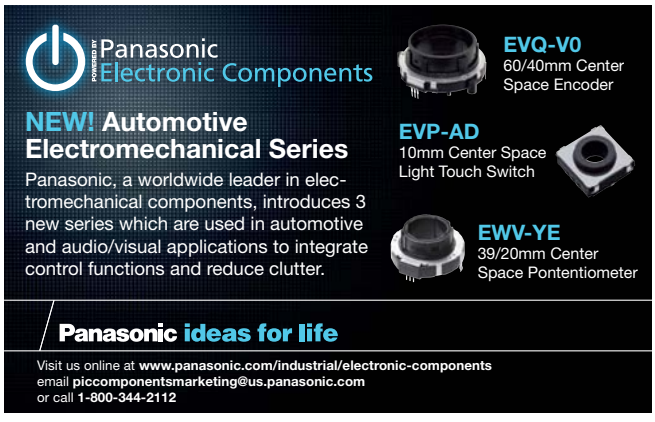
Appreciation for a Smartphones app

The article "Should there be an app for that?" (Jan. 18, 2011, page 6, and www.sae.org/mags/aei/9340) was interesting. I've long thought that there was a great opportunity to use a Palm Pilot to beam the address of your destination to the navigation system, since entering the address is still clunky. With the new smartphones, that should be even easier since you don't need the infrared connection.

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In celebration of AEI's 100th anniversary in 2011, the Future Look series provides a forum for what the future holds for automotive engineering from the top technical minds in the industry. Join in the conversation by contacting ***aei@sae.org****, and look for more articles in digital and print AEIs and online at* ***www.aei-online.org.***

From mind to motion

A novel approach.

The rapid evolution of automotive engineering in the last 10 years has largely been driven by the introduction of integrated systems coupling electronic functions with mechanical ones. Electronic fuel injection, electric throttle control or "drive-by-wire," electric power steering, active brake systems, and adaptive cruise control are just some of many examples. The need for improved comfort, safety, and environmental compatibility has led the latest generation of engineers to dedicate its minds to this sort of mechatronic integration and the electronic controls to attain levels of stability, control, positional accuracy, and architectural simplicity that just weren't possible before.

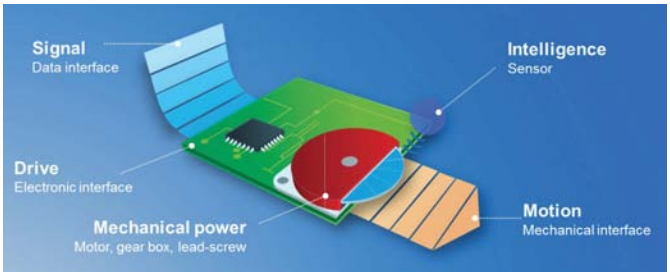
Fascinating mission

At **Sonceboz**, as at most of the automotive Tier 1 and OEM laboratories, engineers are creating new solutions inspired by the rubric "from mind to motion," meaning that a signal—from a sensor or a transducer, for example—will be interpreted, amplified, and transformed into a closed-loop mechanical motion. In the case of haptic applications such as force feedback, steering, or gearshift applications, a human motion input will generate an amplified mechanical output motion.

So, today's mechatronic engineers are on a most fascinating mission to develop:

- Future applications related to CO_2 reduction toward a target of less than 95 g/km via mechatronic solutions such as air grille shutters, variable cam phasing, and variable valve lift control,
- Future applications related to Euro 6+ or U.S. Tier II Bin2 exhaust emissions limits such as low-pressure EGR, SCR, and exhaust back pressure valves,
- Future safety-related applications like adaptive lighting, assisted electric steering, and electric braking systems.

It is a great and satisfying thing to know that our brains are contributing to better, safer, and cleaner conventional cars in preparation for the consequential shift to one of the major developing technology shifts such as hybrid and fully-electric vehicles.



Mechatronics integrate hardware and software electronics, sensors, motors, and actuators.



Pierre Gandel, CEO of Sonceboz, wrote this article for *AEI*'s 100th anniversary.

Mechatronics: a reliable discipline

All these current and forthcoming developments can rely on a confirmed discipline: mechatronics, which is, with a kind of anthropomorphism aspect, mainly based on five core activities:

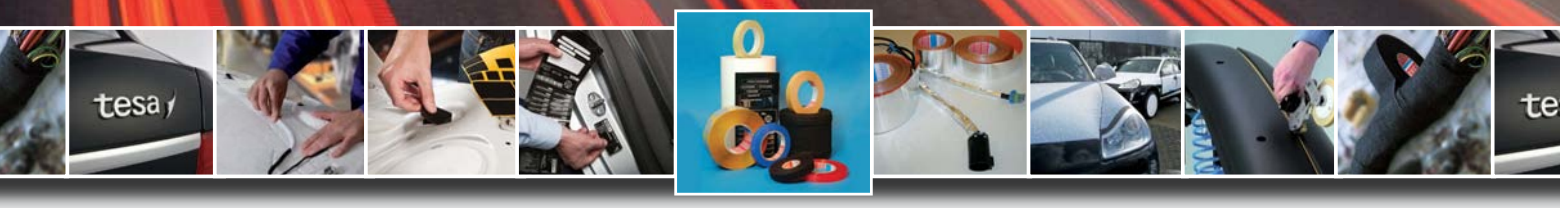
- Hardware electronics, which can be considered as the nerves driving a muscle
- Software electronics, which are like the brain commanding the nerves
- Gearboxes, like the muscles creating a powerful motion
- Sensors, which we can liken to the sensitivity in your fingers
- Motors and actuators, which can be thought of as the heart of the motion.

Today, it is our responsibility as part of the mechatronics community to organize the best practices by setting up worldwide standards that will give robust, consistent structure to this discipline. Tomorrow, the shift from fossil to electric energy will more than fortify the need to link "mind" and "motion," which sounds like such a rewarding activity that we at Sonceboz would not be surprised to see an increasing number of automotive engineers focusing on this booming mechatronics trend. This is all to the general good, as end users will gain a faster access to enhanced applications that consider public health, fuel economy, safety, and comfort.

The automotive engineering community is steadily transforming itself into a novel "mechatronic" engineering community, and it is a great chance to be part of this evolution. 100

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