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December 2008

2008 in review

Top technologies and products of the year

Setting the standards

Embracing protocols for CE devices

Prize-winning plastics

Lower cost, lighter weight solutions

Bodybuilding 101

Pumped up with performance-enhancing materials



Green victory?

Winning races with
smallest eco footprint

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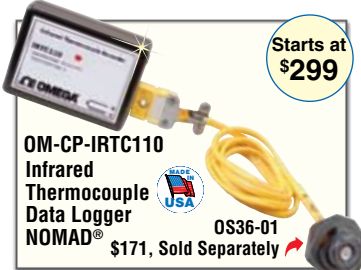
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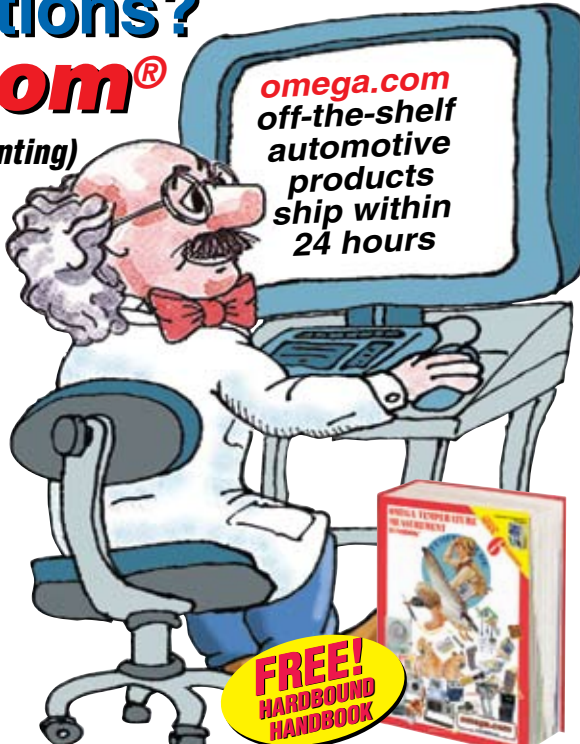
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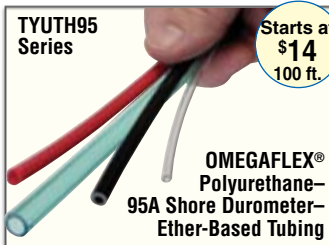
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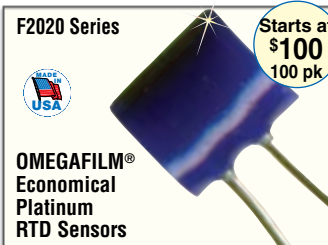
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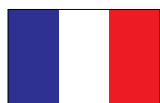
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A Chevrolet Corvette C6.R from the GT1 class won the inaugural ALMS Green Challenge competition at this year's Petit Le Mans race in Georgia.

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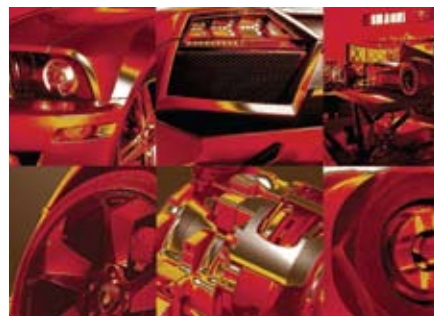
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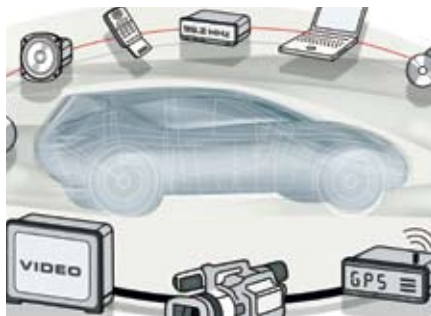
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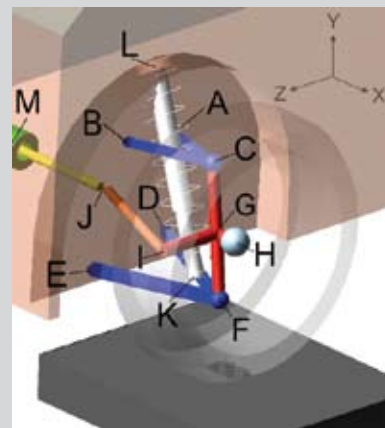
Top articles of the month

1. Axelon aids RUF with electric 911 | Energy
2. Plastics seek problem-solver role | Materials
3. Autocoding, AUTOSAR move forward | Electronics
4. Corvette Racing laps up E85 | Motorsports
5. Shear plate reduces diesel noise | Powertrain
6. Autonomous braking from WABCO | Electronics
7. Volt benefits from tech transfer | Prod Management
8. BASF focus on commercial vehicles | Materials
9. VW tackles pickup segment, Euro 5 | Vehicles
10. Michelin re-invents the wheel | Chassis

Webcasts

Taking the weight off

New cost and weight savings via metal-to-plastic replacement are examined in the free 60-minute on-demand webcast, "Where Are Tomorrow's Vehicles Headed?" The webcast includes interviews with experts from Howarth Development Associates, Ticona Engineering Polymers, and Magna Powertrain, as well as a Q&A.



Modeling and simulation steps into the future

"Physical Modeling: Next-Generation Modeling and Simulation," a new webcast available for on-demand viewing at aei-online.org, discusses better ways to develop virtual models and explores new techniques that capture the complex details of next-generation systems. Watch presentations by experts from Maplesoft, Toyota Technical Center, and MotionPro and see examples of physical modeling taken from real-world applications.

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Navigation for the masses

Before the Global Positioning Satellite system was available for general consumption, **Honda** and **Alpine** in the early 1980s developed what many believe to be the first OEM navigation system, called the Electro Gyrocat. Navigation in automobiles has come a long way from those humble, analog beginnings, and to a great extent the Japanese are still leading the effort due to the great need for such systems in their home market.

In late October, **J.D. Power and Associates** reported that the navigation system in the 2008 **Mitsubishi** Lancer, supplied by **Mitsubishi Electric**, ranks highest in customer satisfaction for factory-installed systems, according to its 2008 Navigation Usage and Satisfaction Study. It is the first non-premium model to top the charts. The rest of the systems in the top ten were sourced from Japanese suppliers, from **Mitsubishi Electric** to **Xanavi**, **Alpine**, and **Denso**.

According to the study, the six most important factors that contribute to overall customer satisfaction are ease of use, routing, appearance, voice directions, navigation display screen, and speed. The study also measured quality by problems per 100 (PP100).

Compared with 2007, more consumers indicated problems with the accuracy of their systems' address information and routes, but loyalty among owners is still very high. And so is customer demand for more advanced functionality; among the most desired features are the ability to automatically avoid traffic congestion, provide speed-limit information, and supply speed and stoplight camera alerts.

Navigation represents a potentially lucrative revenue stream for automotive OEMs and suppliers, but the industry faces many challenges. It must provide a compelling alternative to personal navigation devices from the likes of **TomTom**, **Garmin**, and **Nokia**.

Mass-market adoption of automotive navigation systems will require creative thinking.

Quicker implementation of predictive and real-time traffic data could bring much needed value to the navigation consumer. Up-to-the-minute traffic information transmitted wirelessly to a vehicle's onboard navigation system can add information about road construction, traffic speed, and accidents to make smarter routing and re-routing decisions.

Real-time traffic information, which began as a luxury feature in 2004 for only the most expensive cars, is now available in a wider range of models. **NAVTEQ** says that, with the new model year introductions, nearly 70 North American vehicle models now offer its service, **NAVTEQ Traffic**, almost doubling the number available just a year ago. Today, 24% of all vehicle models in North America offer real-time traffic systems.

In addition to the convenience of real-time navigation, there is the potential for fuel-consumption improvements. In mid-November at the World Congress on Intelligent Transportation Systems, **Volkswagen** demonstrated the cutting-edge emissions reduction technology from its **Audi** Clean Air initiative.

A part of that program is to create connected, intelligent vehicles that are capable of collaborating with their users and with other vehicles to aid the environment. Elements include environmentally friendly navigation that lets drivers choose the most energy-efficient route. Smart engines use traffic information and advanced topography to consume less fuel. Onboard cameras allow vehicles to act as smart moving-traffic nodes and share traffic information with other nodes and data sources.

The benefits of navigation systems are obvious. The challenge for the industry is to educate consumers on their value and to develop useful new features to make them must-have options.



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A complete listing, along with their respective officers, can be found at www.sae.org/sections/sectlist.htm.

Additional information regarding a particular section or group is available from SAE Headquarters, Membership and Section Programs, by contacting Sections@sae.org.

Just imagine what we will do

On a recent Thursday evening, I had the privilege of participating in a celebration of the 250th anniversary of the naming of Pittsburgh, PA.

The room was filled with business executives and community leaders of Pittsburgh as well as Pennsylvania's Governor and other state government officials. The purpose of the evening was to celebrate and recapitulate what the City of Pittsburgh had accomplished over the last 14 months throughout the year-long celebration.

It was an impressive list of accomplishments. An aggressive set of goals had been established and a strategic plan had been put in place to ensure that the myriad activities, the thousands of volunteers, and the time and financial commitments of all involved were focused. The awe-inspiring success of the effort reflected the outstanding leadership capabilities of the Chair, Vice Chair, and the Board of Directors.

What intrigued me most, though, was the slogan that inspired thousands of volunteers, shaped their activities, and provided a future-oriented purpose for the entire celebration. The slogan: "Imagine what you can do here."

As I drove home that evening and to work the next day, the words of that slogan resonated with the optimism that Jim Press, Vice Chairman of **Chrysler**, used at a recent gathering of engineers during Convergence 2008 in Detroit.

Imagination truly is a historical cornerstone of the mobility industry.

Imagine a vehicle that propels itself. Imagine a network of autonomous heavy-equipment vehicles working together in an open-pit mine. Imagine an airplane that travels at supersonic speed. Imagine

a combine that uses satellite navigation to guide it through the fields.

At one point in time, these were just crazy fantasies. Today, they are very much a part of our reality.

And what are the vehicles and products that are being imagined today? Where will today's dreams take us?

How about a self-navigating, emissions-free automobile; or a convoy of trucks that is led by a single driver while the other trucks follow autonomously behind via sensing technology; or perhaps even hypersonic aircraft that can safely transport passengers from New York to Tokyo in two hours?

These dreams and these imaginations are what propel us as a society into the future.

Also, they help transcend and overcome challenging times like we face today. While such times can strike paralyzing fear into many, an unbridled imagination can lift us out of such doldrums and help to create a new economy.

We can wish for the days when things were better and when economic times had a rosier tint. Or, we can meet these challenges head on; we can imagine what is possible and then make it happen. That is what engineers do—we make the future happen.

Emily Dickinson once wrote, "The possible's slow fuse is lit by the imagination." Those words are evermore true today when describing the mobility engineering profession.

As always, I welcome your feedback and constructive input to this topic and any other issues on your mind. Please feel free to e-mail me at focus@sae.org.

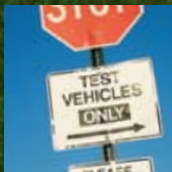


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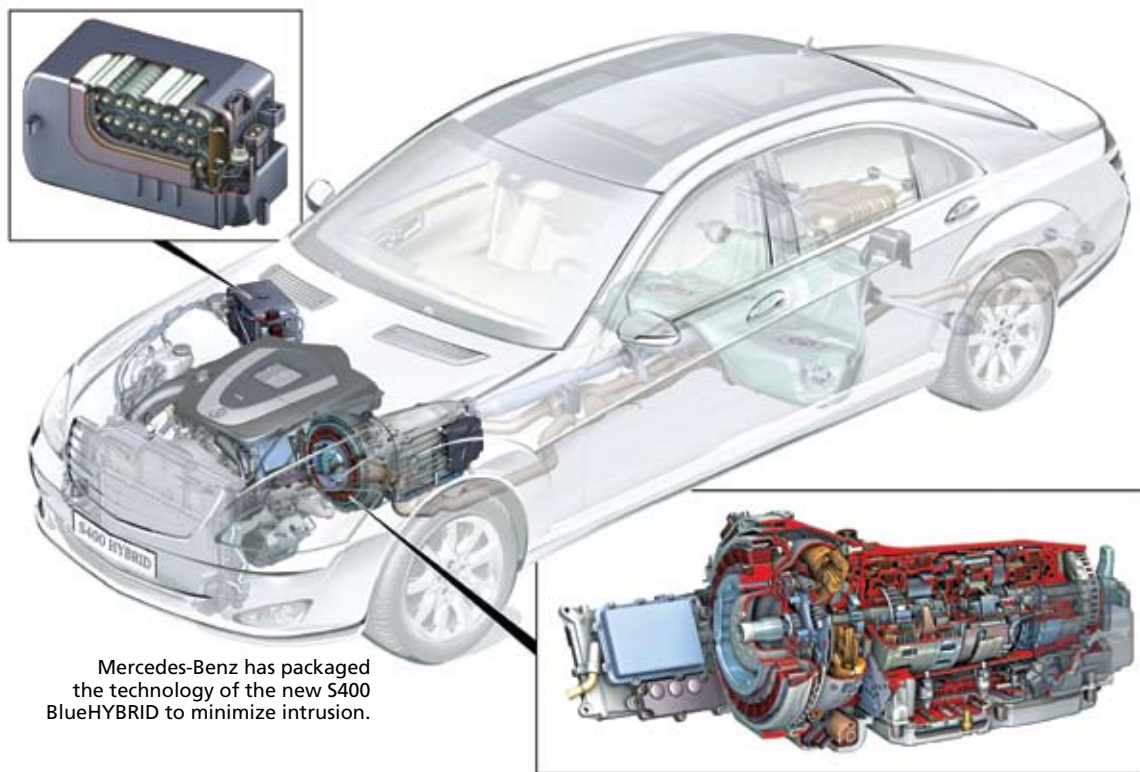
Edited by Kevin Jost

Lithium-ion for first Mercedes-Benz hybrid

Mercedes-Benz gave its S400 BlueHYBRID its first public airing at the Paris Motor Show. Salient figures include a combined fuel consumption of 7.9 L/100 km, CO₂ of 190 g/km, an updated 3.5-L V6 gasoline engine producing 205 kW (275 hp), and an electric motor generating 15 kW with stepoff torque of 160 N·m (118 lb·ft) to give a combined torque of 385 N·m (284 lb·ft).

erator. A regenerative braking system is fitted.

Major advantages of lithium-ion technology compared to conventional nickel/metal-hydride batteries include a higher energy density and better electrical efficiency, together with more compact dimensions and a lower weight. A 12-V lead-acid battery is installed in the trunk to supply energy to the standard consum-



Mercedes-Benz has packaged the technology of the new S400 BlueHYBRID to minimize intrusion.

The company claims that the S400, its first production hybrid car, is also the first series-production model to be equipped with a lithium-ion battery specifically developed for automotive use. A start/stop function is fitted, and its transmission is Mercedes' established 7G-Tronic. The battery and hybrid control units are positioned in the engine compartment.

The hybrid module is a disc-shaped electric motor fitted in the torque-converter housing between engine and transmission. It also acts as a starter and gen-

ers and the monitoring system for the high-voltage components. It is smaller and lighter than most batteries of its type.

According to Mercedes, the lithium-ion battery not only stores energy for the electric motor but is also connected to the 12-V onboard network via the transformer to supply power to other standard consumers such as the headlamps and comfort features. The newly designed battery system consists of the cell block with its lithium-ion cells and the cell

monitoring system, the battery management function, the high-strength housing, cooling gel, cooling plate, coolant feed, and a high-voltage connector.

The gasoline engine has variable valve control and exploits the Atkinson principle—with the expansion phase longer than the compression phase. The intake valve is kept open slightly longer between the intake and compression phases, which improves the engine's thermal efficiency while reducing specific fuel consumption and untreated emissions.

A new cylinder head, different pistons, and a modified camshaft with specific control increase the output of the V6 by 5 kW (7 hp) and also help reduce fuel consumption.

The three-phase ac external-rotor magneto motor has an operating voltage of 120 V. The motor is said by Mercedes to "effectively" damp torsional vibrations in the drivetrain, reducing noise and vibrations in the interior.

The hybrid S-Class has a top speed electronically limited to 250 km/h (155 mph) and betters the NEDC fuel consumption of the conventionally powered S350 by up to 2.2 L/100 km. CO₂ emissions are reduced by 21%.

The driver can monitor the status of the hybrid drive system visually; the instrument cluster has a separate, centrally positioned display showing the energy flow during boost and energy recuperation phases as well as the battery charge status.

The BlueHYBRID is produced at Mercedes' Sindelfingen plant alongside the other S-Class models. The gasoline engine, automatic transmission, and electric motor are first put together to form a hybrid module and then delivered to the production line as a unit.

The car's market launch in western Europe is planned for June, with China following in late summer, followed by the U.S. in September.

In keeping with the generally accepted industry view, Mercedes believes at present that no single technology will provide the ideal solution for sustainable mobility in the future. The approach taken by Mercedes-Benz envisages vehicle concepts with modular drive technologies, which ensure that customer benefits and environmental compatibility are always jointly emphasized.

Stuart Birch

Chevrolet launches Cruze

General Motors hopes its new **Chevrolet** Cruze sedan, given its first public viewing at the 2008 Paris Motor Show in September, will finally make it a respected contender in a hotly contested U.S. segment. The new car is fundamentally stronger than the model it replaces (in the U.S. that is the Cobalt), boasting 140% better torsional rigidity to give the Cruze a solid feel that is beyond the reach of the Cobalt.

equipment holder for outdoor gear.

Avoiding the excuses given in the past about cost or customer preference, Peter Mertens, Global Vehicle Line Executive for Compact Cars, boasted of the Cruze's features. "I'm convinced this interior is a step forward in materials," he said. "It will have state-of-the-art powertrains, and it is absolutely top-of-the-segment in body stiffness."

The Cruze will carry the same taut,



The 2009 Chevrolet Cruze will carry the same styling in all markets. Particular attention has been paid to reducing body gaps and eliminating excess trim for a premium appearance.



The "technical" nylon mesh fabric (blue) used for dash, door, and seat inserts carries the appearance of outdoor, active lifestyle equipment, an association manufacturers are keen to make for buyers of compact cars.

The Cobalt's hard, shiny cabin surfaces are gone. The Cruze, in contrast, has an abundance of soft-touch surfaces, with even hard surfaces bearing a textured, matte finish that looks more expensive than it is. This is supplemented with the use of a nylon mesh material in dash, seat, and door inserts that recalls a stretchy bungy net or other

sleek (0.31 Cd) styling in all its global iterations, with the goal of establishing Cruze's concave shoulder line as a brand design cue, but there will be variation under that flowing skin. Not only will there be different powertrains in different markets, but the chassis itself will vary depending upon local crash-protection requirements to ensure a maximum score

in each country's test, Mertens explained.

In particular, there will be reinforcements to the B-pillars and the rocker panel area of cars for some markets, but not for others. "We will add or delete those as local safety standards require," Mertens said.

The Cruze debuts in European markets in March, powered by one of two gasoline I4 engines, a 112-hp (84-kW) 1.6-L and a 140-hp (104-kW) 1.8-L, plus a new 150-hp (112-kW) 2.0-L turbodiesel I4, all backed with standard five-speed manual gearboxes. An available six-speed manual gearbox will debut as a segment-first offering for Chevrolet.

Future engines include a detuned 125-hp (93-kW) version of the diesel engine, and in the U.S. there will be a 1.4-L turbo gasoline engine, according to Mertens.

The Delta platform that underpins the new Cruze is meant to be extremely flexible, serving as the foundation for other models such as the next-generation **Opel Astra**, which is about a year away. It can also be stretched larger, as demonstrated by the Chevrolet Orlando concept vehicle, which targets the popular MPV segment in Europe. Although not yet announced, the Orlando is certain for production there. U.S. availability remains a topic of discussion within the company, according to Mertens.

Dan Carney

Front-mid V8 for latest Ferrari

Ferrari is a sportscar maker, and that does not mean four-door cars, emphasized its President, Luca di Montezemolo, at the Paris Motor Show unveiling of the new folding hardtop (two-door) California. His words sounded almost like an admonishment for the likes of **Lamborghini**, **Porsche**, and **Aston Martin**, companies that make no secret of their enthusiasm for the potential of four-door models.



Ferrari's folding hardtop California is powered by a front mid-mounted direct-injection V8 engine.

"We will never do a four-door," stressed di Montezemolo. And Ferrari will not be doing any more manual gearbox cars after the California either. The California comes with a seven-speed dual-clutch system or a six-speed manual; di Montezemolo's preference is clear.

Any Ferrari is inevitably a transport of technology, and the California is no exception, with a new direct-injection V8 engine, a new suspension system, carbon ceramic brakes as standard, and a further evolution of F1-Trac traction control, plus the aluminum retractable hardtop that puts the California in the

coupe-cabriolet category.

But as with every Ferrari, it's the engine that is the star. It is the first V8 to be front mid-mounted in a road-going production Ferrari. An all-aluminum 4.3-L, its use of direct fuel injection marks a first application of the technology for Ferrari, and variable valve timing for intake and exhaust help it meet Euro V and LEV2 requirements. CO₂ emissions are 306

g/km, and fuel consumption 13.1 L/100 km—both ECE combined figures.

Power output of the 90° V8 is 338 kW (453 hp) at 7750 rpm, and maximum torque is 485 N·m (358 lb·ft) at 5000 rpm, aided by a 12.2:1 compression ratio. Performance figures include a 0-100 km/h (0-62 mph) time of 3.9 s and a 310-km/h (193-mph) top speed. Ferrari emphasized its focus on achieving the requisite aural signature, particularly in the cabin with the roof raised or lowered.

Shell, a long-time technical partner of Ferrari (it started with Enzo Ferrari in the 1930s and powered the first Ferrari out of the factory gates at Maranello in 1947), was involved for two years in the development of the direct-fuel-injection system for the California. As the first Ferrari to feature such a system, the California is a major step toward the future for the manufacturer, which has pledged to improve fuel efficiency by 2012. Shell provided technical expertise, fuel mapping information for use in computer modeling, and the supply of V-Power fuel and Helix Ultra oil.

The California's engine drives through either a six-speed manual or a new rear-mounted, seven-speed, dual-clutch gearbox offering automatic and manual paddle control. The paddles are fixed in position and do not rotate with the steering wheel. The engine front/gearbox rear



Heart of the matter: the California's 4.3-L naturally aspirated V8 engine gets direct injection—a Ferrari first.

Testing limits.



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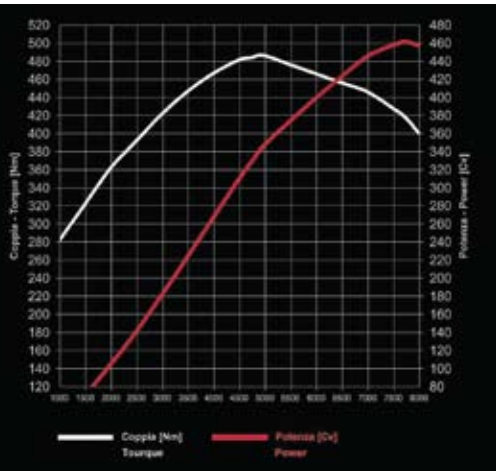
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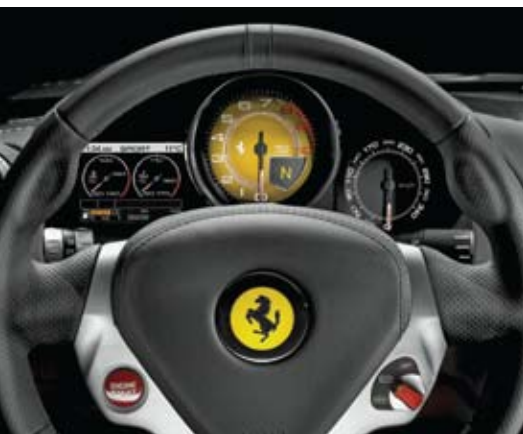
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The Ferrari California's V8 engine produces 338 kW (453 hp) and 485 N·m (358 lb·ft).



Center of operations: the rev counter is the dominant instrument in the Ferrari California.

configuration makes for a front:rear weight bias of 47:53.

Aluminum is the chosen material for chassis and body shell. Both extrusions and shell casts are used. Torsional and flexional rigidity are described by Ferrari as being "better than average" for a Spider body design. Curb mass is 1735 kg (3825 lb). The car is 4563 mm (179.6 in) long, 1902 mm (74.9 in) wide, and 1308 mm (51.5 in) high—on a wheelbase of 2670 mm (105.1 in).

Suspension systems include double wishbones at the front, and there is a new multilink system at the rear. A magnetorheological suspension damping control system called SCM is optional.

The California also gets Ferrari's established GT Manettino, with steering-wheel-mounted control to integrate gearbox, stability, and traction control systems (CST and F1-Trac), with Comfort, Sport, and CST-Off settings, the last turning off all electronic chassis support systems except ABS. F1-Trac's capabilities include

providing maximum grip on corner exit. According to Ferrari, F1-Trac offers a 20% improvement in acceleration coming out of corners with respect to a traditional traction and control system.

Brembo carbon-ceramic brakes measure 390 x 34 mm (15.4 x 1.33 in) front and 360 x 32 mm (14.2 x 1.26) rear. Tires are 245/40ZR19 front, 285/40ZR19 rear. A tire pressure and temperature monitoring system is fitted.

With its racing expertise, Ferrari has massive aerodynamic engineering capability to achieve the required C_d (0.32 with roof raised) and downforce. The company claims a desire to achieve "perfect balance" between vertical load and drag, influencing the shape of the rear diffuser and the spoiler integrated into the front bumper. Drag is some 10% less than that of other Ferrari models.

To help keep the center of gravity as low as possible, the folding hardtop uses aluminum panels and has a cast-aluminum weight-bearing structure. Cycle time for opening or closing is 14 s. Trunk capacity is 340 L (12.0 ft³) with the roof up and 240 L (8.5 ft³) with it retracted. Fuel tank capacity is 78 L (20.6 gal).

Safety systems include pop-up rollover bars behind the backrests of the rear seats that deploy in 190 ms if needed. Airbags include door-mounted systems, and adaptive headlights are optional. The car comes as either a two-seater or a 2+2, with the rear bench having seating for one or two passengers and a fold-down capability. With the pursuit of weight savings a Ferrari constant, magnesium framed front seats are fitted.

Analogue and digital instruments are fitted, with the round analogue rev counter dominant and a secondary multidisplay screen.

Although the California is set to become a sales success, di Montezemolo said at Paris that the company would keep production below 7000 next year. As for new developments, he did not rule out turbocharging and said Ferrari was exploring a spread of technologies that might be used in future road cars, including energy recuperation technology depending on results from F1 development.

"We are always looking to see how we can transfer our technology from racing to road cars—as we have in the last 10 years," he said.

Stuart Birch

VW shows new eco-models

At the 2008 Paris Motor Show, **Volkswagen** demonstrated its abilities to reduce environmental impact with the Passat BlueMotion II, Passat Blue TDI, and Passat BlueMotion 2. Looking ahead to U.S. Bin 5 and Euro VI emissions limits, VW will introduce the Passat Blue TDI in European markets during 2009. VW is not the first to introduce selective catalytic reduction (SCR) technology. It is already established in Europe for reducing heavy-truck emissions, while **Daimler** has previously shown the technology for passenger-car use.

By using a urea-based additive, AdBlue, injected into the exhaust stream, it is possible to reduce the nitrogen oxides in the exhaust gases to nitrogen and water, greatly reducing NOx emissions. AdBlue dosage is metered by mass flow rate monitoring of the exhaust gases. A NOx sensor downstream of the SCR catalytic converter controls the process via the engine management system.

In addition, the Passat Blue TDI is fitted with an oxidation catalytic converter and a diesel particulate filter to further reduce emissions. VW expects AdBlue consumption to work out at around 0.1 L/100 km. Stored in an auxiliary tank, the AdBlue would only require top-ups during regular servicing.

The engine for this model is based on the 2.0-L 140-PS (103-kW) common-rail diesel widely used in European VW Group products. Power output has been raised to 143 PS (105 kW). For the Passat Wagon, VW quotes an EU combined-cycle fuel consumption figure of 5.5 L/100 km and 144 g/km of CO₂ emissions. Equivalent figures for the sedan are 5.2 L/100 km and 137 g/km. This represents a reduction in fuel consumption of around 7% compared with the current Passat diesel, which uses enhanced exhaust gas recirculation to control emissions.

A standard six-speed manual transmission will be fitted, with a six-speed DSG automated transmission available later as an option.

Due in Europe before the Blue TDI makes its appearance is the latest version of the VW Passat BlueMotion, labeled BlueMotion 2, which should be on sale by



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The Passat BlueMotion II concept integrates the technology of the Passat BlueMotion 2 with the Passat Blue TDI and adds regenerative braking.



The Golf GTI Mk VI is set to return next spring powered by a 210-PS (155-kW) 2.0-L turbocharged gasoline direct-injection engine.

the end of the year. As before, BlueMotion badging indicates the most fuel-efficient and least polluting model in the range. For the Passat, this involves an engine change.

The 1.9-L TDI engine using electronic unit injections is replaced by a new variant of the 2.0-L TDI common-rail engine, which produces 110 PS (81 kW) at 4200 rpm and 250 N·m (184 lb·ft) from 1500 rpm. This drives the front wheels through a five-speed manual transmission. A gear change indicator in the instrument display is standard equipment.

Also new for the BlueMotion 2 Passat is an automatic stop/start system, using a

starter/alternator activated by shifting into neutral and releasing the clutch. The engine automatically restarts when the clutch pedal is depressed. For the sedan, this involves a reduction in EU combined-cycle fuel consumption from 5.1 L/100 km to 4.9 L/100 km, while CO₂ emissions for the sedan, measured on the European cycle, are given as 129 g/km, down from 136 g/km for the previous model.

Other new features of the Passat BlueMotion 2 include low-friction propshafts, enhanced low-rolling-resistance tires, and lightweight wheels made from light flow-forming steel. Low-stressed parts of the wheel are made from thinner

section steel to reduce weight. The Passat BlueMotion 2 conforms to Euro-V emissions requirements.

On display at Paris was a BlueMotion concept Passat Wagon, named Passat BlueMotion II, bringing together the technologies of the Blue TDI and BlueMotion 2. This concept car combines SCR emissions-control technology with the advances of the Passat BlueMotion 2 and adds regenerative braking for the first time on a Volkswagen. The result, measured on the European combined cycle, is fuel consumption of 4.1 L/100 km, giving CO₂ emissions of 109 g/km. VW indicates that a production version, with CO₂ emissions of 114 g/km, will be available in 2009.

Next spring will see the re-introduction of the Golf GTI based on the recently announced Golf Mk VI model. The latest Golf to carry the GTI badge will be powered by a modified version of the turbocharged 2.0-L, direct-injection gasoline TSI engine that powered its predecessor. Power rises to 210 PS (155 kW) from 200 PS (147 kW), but VW says that fuel consumption has been reduced from 8.0 L/100 km to 7.5 L/100 km measured on the European combined cycle. This also registers CO₂ emissions of 178 g/km from the car. Peak torque of 207 lb·ft (280 N·m) is produced at 1800 rpm.

The Golf GTI, shown as a concept car at the Paris Show, follows a familiar path to its predecessors with a ride height reduced by 22 mm (0.87 in) and retuned suspension, featuring MacPherson struts at the front and a multilink system at the rear.

For the first time on a Golf GTI, the car will be fitted with a standard electronic limited-slip differential. This will be followed by the option of dynamic chassis control in time. The system provides active damping, which automatically adjusts the damping rates to reduce pitch and roll. The system, available on other Golf Mk VI models, offers Normal, Sport, and Comfort settings.

GTI production will begin in the spring.

John Kendall

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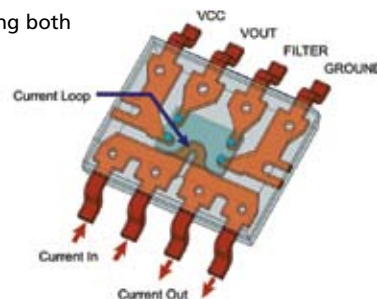
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Bodybuilding 101



Small cars with a short rear overhang, such as this Volvo C30, pose a particular challenge in complying with the U.S. rear impact test. Shown below, Volvo addressed the problem with the use of a boron steel bumper beam (red) and ultra high-strength steel rails (yellow).



The latest designs are pumped up with flagrant use of performance-enhancing substances, such as boron steel, for maximum strength and safety.

by Dan Carney

Steadily rising requirements for crash safety from both tough new government tests and from consumers who demand maximum scores on crash tests have led carmakers to place ever-higher emphasis on designing vehicles that are strong enough to protect their occupants, while being soft enough to cushion the blow of impact.

European pedestrian protection requirements and upcoming U.S. rear-impact and pole side-impact tests are incredibly high hurdles for engineers to clear when designing vehicles for mass production at a reasonable price with maximum fuel efficiency.

This has led carmakers to expend significant computer simulation time on the design of new models, carefully shaping each component to optimize the flow of crash energy around their vehicles' occupants. They are also developing and deploying new materials that help to improve crash protection but can sometimes complicate manufacturing.

While the challenges are getting tougher, interest in smaller, more efficient cars is rising, creating demand for a product that is even more difficult to create. **Volvo Cars** found this to be the case when developing the C30 sport coupe from the S40 sedan platform. The coupe's truncated tail made the U.S. government's rear-impact crash test much more of a challenge because of the reduced amount of crush space, reported Thomas Broberg, Senior Technical Advisor for Safety for Volvo Cars.

"Rear impact, specifically in smaller cars, is a challenge," said Broberg. "The shorter the overhang you have the more difficult the challenge." The solution is in careful design of the load path. "You have to be more clever in how you dissipate the load."

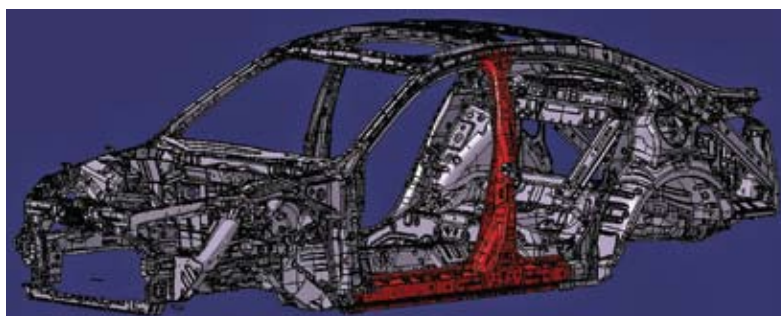
The occupants and passenger compartment are the obvious objects of concern in a crash, but especially in rear impacts it is also critical to protect the fuel tank, Broberg pointed out. In the case of the C30, that task was aided by the tank's location ahead of the rear axle, which permitted engineers to use that component to protect the fuel tank.

Simulation tools

Abundant use of computer-aided design tools makes it possible to develop and refine designs in a faster, cheaper virtual world, but eventually, real hardware must be tested to confirm the results. But even physical testing has been made cheaper and faster than crashing complete proto-



General Motors engineers designed the global Chevrolet Cruze with add-on reinforcements in the rocker panel and B-pillar for cars sold in markets such as the U.S. where specific crash-test requirements demand them.



Acura fortified its new TL against side impacts with a high-strength steel B-pillar that it hot-stamps so it can form the metal into the necessary shape.

type cars, according to Steve Kozak, Chief Engineer for Global Safety Systems at Ford Motor Co.

"We've added a \$16 million analytical barrier building with a servo-controlled sled that allows us to perfectly mimic the crash event in a buck rather than a full vehicle," he said.

That means the company can use the buck to replicate the anticipated crash characteristics of the bodywork, permitting testing of various interior safety systems such as restraints and airbags. This electronically controlled crash-test sled not only moves horizontally, it also pitches upward on impact, replicating the motion of a complete car in a crash.

"That throws the dummies into the airbag at an angle, not straight into the air bag, and that makes all the difference in the world in air bag performance," said Kozak. "It allows us to fine tune the design before we use an expensive prototype."

Thanks to the testing facility, Ford now uses 40% fewer prototypes for crash testing, which the needed development time has been slashed for this phase of a new car's design from five to two months, Kozak added.

High-strength steel

The leading factor in car manufacturers' ability to bolster crash safety has been the increased use of higher-strength steels. Traditional mild steel has a tensile strength of about 250 to 400 MPa (36 to 58 ksi), while high-strength steel falls in the range of 500 to 800 MPa (70 to 120 ksi), according to the **World Steel Association**. Ultra-high-strength steel exceeds 700 MPa (100 ksi), and at the current pinnacle boron steel has a strength of 1500 MPa (220 ksi).

While substituting stronger steel might seem an obvious solution, these tough alloys bring their own sets of challenges for formability and ease of manufacturing that have limited their use until recently.

Now the new **Chevrolet Cruze** mainstream compact car boasts an increase in torsional rigidity of 140% compared to the Cobalt, thanks to the increased use of high-strength steel in critical areas such as the B-pillar, according to Peter Mertens, **General Motors'** global vehicle line executive for compact cars.

In the subcompact **Honda Fit**, use of high-strength steel has grown from 40% in the previous model to 54% in the new



Ford relies on a hydroformed boron steel tube to reinforce the angular A-pillar-to-roof joint on the boxy Flex.



Ford's door aperture and double-walled rocker-panel insert are both stamped of high-strength steel to support the intrusion protection provided by boron steel door beams.

one. And some Nissan models have high-strength steel proportions of 53%, reported Bob Yakushi, Director of Product Safety for Nissan North America.

Strong, but tough to manufacture

To employ high-strength steel, manufacturers must adjust their manufacturing techniques to accommodate the different properties of the new materials. "If you take the stamping process for normal steel to high strength steel, it is a challenge because of the springback effect," said Broberg. Engineers have to overcompensate with stamping to arrive at the final desired part shape.

Hydroforming, rather than stamping, the material into complex shapes using high-pressure water is gaining popularity with manufacturers. "We use hydroforming as a tool to both get the shapes and the form that we want and to be able to increase the strength of the material where it is needed," said Broberg.

Alternatively, stamping can be used for parts if the material is heated. The high-strength steel Honda uses to form the Acura TL's B-pillar is difficult to stamp into the tightly curved shape, explained Chuck Thomas, Chief Engineer of American Honda's auto safety group. The company uses high-strength steel in this area in anticipation of the pole test.

"In the hot stamping process, you take a sheet of high-strength steel that is heated to 980 degrees and placed into die and stamped," Thomas said. "Then you cool the die to quench the metal. Once quenched, it changes to a very hard and strong material. Normally it could never be formed into a shape like a B-pillar.

Thomas could not reveal the additional cost of using this process, but he described it as acceptable. "It is a little bit more expensive but it is pretty manageable," he said.

Everything in its place

Strategic placement of high-strength steel is critical to balancing cost with performance. In the Chevrolet Cruze, the company has devised add-on strengthening in the B-pillar and rocker panel area that is used only in markets such as the U.S. where tougher-to-meet crash test standards demand it, according to Mertens.

Ford has applied not only high-strength steel to the Flex, but even boron steel in a bid for top scores in all tests. This was necessary because of the Flex's boxy shape, which put more strain on the A-pillar in crash tests than other vehicles on the same platform with more arching rooflines, said Kozak.

To provide the needed strength to survive an offset frontal crash test, Ford engineers inserted a boron steel tube that runs from mid-way up the A-pillar all the way back to the B-pillar to provide the necessary structural strength through the inherently weak angular intersection of the A-pillar with the roof.

With its similarly angular style, the F-150 pickup faced a similar challenge and Ford responded with a similar solution, Kozak said. For the pickup, Ford uses an ultra-high-strength steel tube, hydroformed in a similar fashion as with the Flex's boron steel tube, from the base of the A-pillar all the way to the back edge of the roof, where it meets another ultra-high-strength steel tube that runs vertically to the bottom of the cab.

The cab's large door opening posed the most serious challenge when faced with the pole impact test. "That is the worst case I can draw up for a structural engineer," Kozak remarked.

To solve that problem, Ford uses a boron steel tube inside the truck's doors to prevent penetration into the cab. Then, to stop the tube itself from being pushed

into the truck, the periphery of the door opening and a double-walled member inserted into the rocker panel are both made of high-strength steel.

To provide more protection, Ford backed up these structural components with a new side airbag, which is triggered by pressure sensors in the doors for reduced reaction time.

Advanced manufacturing techniques

In addition to the increased use of high-grade steels, there is also the potential for new applications of non-ferrous materials, such as the die-cast aluminum door frames and brace across the rear of the passenger cabin in the Nissan GT-R. Those components contribute to "an extremely rigid structure," according to Yakushi, which has already protected some unfortunate customers who have crashed their new sports cars.

Die-casting techniques are becoming sufficiently cost-effective for use in expensive sports cars like the GT-R, and other metal-forming techniques are also under development. In the realm of computer manufacturing, Apple Corp. has introduced new laptop models, products that cost a little over \$1000 and sell in very high volumes, that employ a one-piece aluminum case that is CNC machined from billet.

This technique has so far been suitable for racing cars and custom parts, but if Apple is able to mass produce a consumer good whose structure is whittled away from a solid chunk of aluminum, then it may well also be suitable for automotive applications. **aei**

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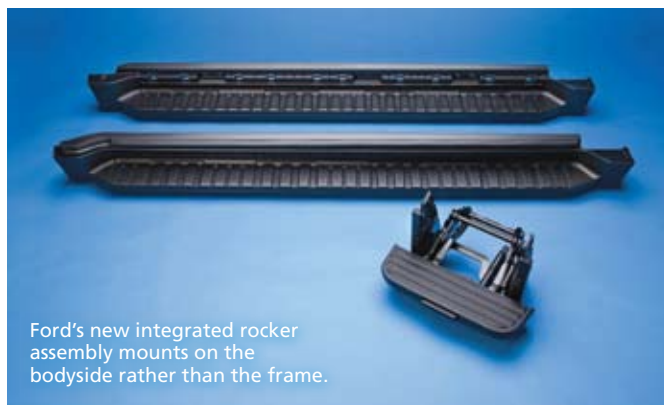
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Prize-winning plastics



Ford's new integrated rocker assembly mounts on the bodyside rather than the frame.



Lower cost, lighter weight solutions highlight the 2008 SPE Automotive Innovation Awards.

by *Lindsay Brooke*



In a year of news dominated by the topics of fuels and emissions-reduction, it's appropriate that a new vehicle fuel tank with excellent environmental performance won the highest honor in the 2008 **Society of Plastics Engineers'** (SPE) Automotive Innovation Awards competition.

BMW's twin-sheet blow-molded tank system used on the company's 2009 7 Series luxury sedan earned the SPE's prestigious Grand Award, beating 25 other finalists. It also topped the Process/Assembly/Enabling Technologies category. The sophisticated tank is permanently sealed to thwart evaporative emissions, and contains all system hardware within.

Ford led all OEMs in 2008 with four individual category-winning innovations. Of the 26 finalists, 16 were from Ford.

Now in its 38th year, the SPE Automotive Innovation Awards is the plastics industry's longest-running recognition activity. The winners in eight primary categories, plus the Grand Award, were determined by a multi-phase judging process.

Rigorous pre-qualification screening was followed by first-round judging that required two days to complete. The surviving candidate teams representing the OEM finalists then presented their cases succinctly before a Blue Ribbon judging panel during a one-day session in mid-October. As in past years, AEI was hon-



The shifter assembly in Ford's new Flex is integrated into the front center console, aiding assembly.



Daimler's newest passenger-car diesel engine features the first production plastic oil-pan module, in a DuPont nylon-66 resin.



The twin-sheet blow-molded BMW fuel tank is designed to accommodate the complex internal hardware.

ored to participate in the final judging.

Many of the 2008 finalist entries are being implemented in production for the first time, said SPE Automotive Awards program chairperson, Maria Ciliberti, Global Automotive Director at **Ticona Engineering Polymers**. She added that many of the innovations also "have resulted in trademarked vehicle options; process, design, and material patents; and licensed rights of practice."

Ciliberti called the SPE finalists "bright spots in a year of uncertainty" for the auto industry in general. The awards were presented November 20 at an evening gala in Livonia, MI. The category winners are presented below, accompanied by a chart showing finalists.

The twin-sheet blow-molded fuel tank for the BMW 7 Series combines the advantages of conventional blow molding with the possibilities of half-shell processes, claimed David Hill, Project Engineer at **Inergy Automotive Systems**, the system supplier and material processor. It can be adapted to all plastic fuel systems.

All components including the fuel pump are integrated in the fuel tank during blow molding. This results in higher tank capacity and reduced emissions, and eliminates post molding operations.

The BMW tank uses Lupolen 4261 high-density polyethylene (HDPE), co-supplied by **LyondellBasell**, **Kurraray**, **Mitsui**, and **Ticona**. The twin-sheet blow-



Lear's BioFoam seat pads in the 2008 Mustang are just the beginning of increased use of soy-based foams across the industry.

molding process replaced co-extrusion blow molding, and eliminated boring and welding of externally mounted components. The internal components are integrated using one of two innovative methodologies: Internal welding is used for small components and internal riveting is used for larger ones.

The process reduces overall fuel-tank mass by approximately 10%, compared to conventional extrusion blow molding. It also improves wall thickness control. Cost vs. co-extrusion blow molding is reduced by up to 5% by reducing additional finishing and machining centers.

In the Body Exterior category, the integrated rocker molding/running board

system for the 2008 Ford Escape is claimed by system and tooling supplier **ABC Group** to be the first use of blow molding to integrate a rocker molding, running board, step pad, and lower door seal surface into a single component.

According to Ford Product Engineer Jeff Mayville, who led the program, the innovation also shifts mounting on the body structures from the frame/underbody/side sill to the bodyside, reducing the lever arm. This decreased the load into the body structure, allowing the elimination of three sheetmetal reinforcements.

ABC Group also served as processor of the Salflex 0 PP resin.

Winner of the Body Interior award was

the integrated floor shifter/front console in Ford's 2009 Flex crossover wagon. The modular floor console supplied by **Automotive Components Holdings** uses an all-plastic structural framework to support the automatic-transmission floor shifter. The design eliminates a steel shifter bracket.

The styrene maleic anhydride (SMA) resin from **Nova Chemical** is claimed to contribute to provide overall stiffness equivalent to the former metal bracket, along with reduced buzz, squeak, and rattle (BSR) issues.

Winning the 2008 Chassis/Hardware/Powertrain award was the reinforced-plastic oil-pan module used in **Daimler's**

2008 SPE Automotive Awards Finalists

Application	Vehicle	Suppliers	Materials
Body exterior			
Acrylic appliques with securecode invisible keypad	Ford Flex	Windsor Mold; Arkema	Acrylic
Pickup cargo management system	Dodge Ram	ABC Group; Salflex Polymers Ltd.; Dow Automotive	PP & PC/ABS
Integrated rocker molding / running board system	Ford Escape	ABC Group; Salflex Polymers Ltd.	PP
Body interior			
Integrated refrigerator / rear-floor console	Ford Flex	Automotive Components Holdings; Washington Penn	PP
Integrated floor shifter / front console	Ford Flex	Automotive Components Holdings; Nova Chemical	Recycled SMA
Integrated roof shade / auxilliary A/C duct / headliner reinforcement	Ford Flex	Dakota Integrated Systems	High-heat ABS, lofted GMT composite
Open-face floor console with flexible storage	Ford Escape	Automotive Components Holdings; Advanced Composites	PP & ABS
TPO for hard seamless passenger airbag applications	Ford Focus	Automotive Components Holdings; Advanced Composites	TPO/TPE
Chassis, hardware, and powertrain			
Overmolded hydroformed structural front-end module	Ford Falcon	Trident Plastics; SABIC Innovative Plastics	MPPE/PA, hydroformed steel
Capless refueling system with mis-fuel inhibitor	Ford Flex	Martinrea Industries; DuPont Automotive	Conductive PPA
Oil-pan module	Mercedes C-Class	G. Bruss; DuPont Automotive	PA 6/6
Environmental			
Soy foam automotive seat cushions	Ford Mustang	Lear; Renosol; USSC	PUR foam from soy polyol
Recycled TPO air inlet panel / leaf screen	GMC Envoy/Chevrolet Trailblazer	Nyloncraft, Inc.; MRC Polymers	Recycled TPO
Materials			
Long-glass PP for first-surface overhead console	Ford Flex	Grupo Antolin; Ticona	Long-glass PP
Rear footwell ambient lighting	Ford Flex	CML Integrated Technologies; Evonik Cyro LLC	Acrylic
TPE for slush molding of IP skins	Saab 9-7X	Inteva Products	TPO/TPE
Low-mass SMC heavy-truck hoods	Navistar International TranStar Truck	Core Molding Technologies; Ashland	SMC
Performance and customization			
Adjustable epoxy/carbon-fiber composite rear wing	Dodge Viper ACR	Plasan Carbon Composites; ETS	Epoxy/carbon fiber
Hood assembly with dual-weave carbon-fiber composite	Chevrolet Corvette ZR1	Plasan Carbon Composites; ETS; ACG	Epoxy/carbon fiber
Exposed-weave carbon-fiber composite roof assembly	Chevrolet Corvette ZR1	Plasan Carbon Composites; ETS; ACG	Epoxy/carbon fiber
Process, assembly, and enabling technologies			
Twin-sheet blow-molded fuel system	BMW 7 Series	Inergy Automotive Systems; LyondellBasell; Kurraray; Mitsui; Ticona	HDPE
Infrared welded headliner assembly	Ford F-Series	Trim Quest; LyondellBasell; Amoco	PP
Air-extractor grille	Lincoln MKS	Intier Automotive; Ticona	POM
Front grille with insert-molded chrome paintfilm	Hyundai Avante	ECoplastics; LG Chemical; Soliant	ASA
Safety			
Polystyrene foam for head-impact protection	Ford Focus	Grupo Antolin North America; Dow Automotive	PS foam sheet
Expanded polypropylene foam head-restraint core for FMVSS-202A	Ford (various)	Windsor Machine Group; JSP	EPP foam

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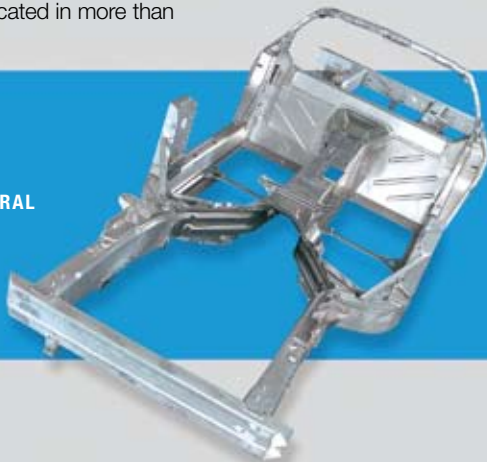
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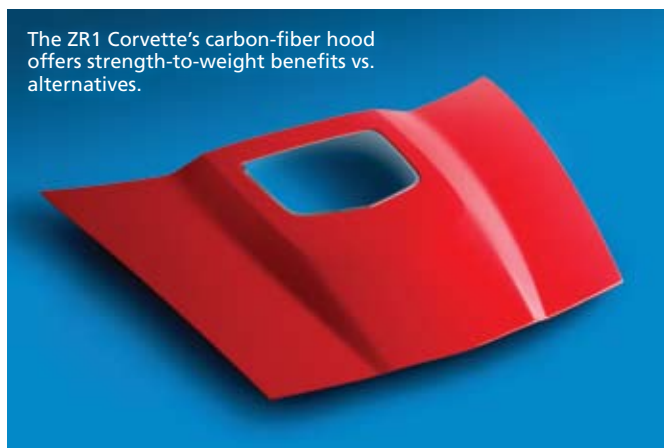




Grupo Antolin North America and Dow helped Ford reduce lead time, mass, and cost using the Impaxx extruded foamed styrene energy-absorbing blocks in the 2008 Focus headliner.



The slush-molding process improves the Saab 9-7X's instrument panel, originally designed for PVC plastics.



The ZR1 Corvette's carbon-fiber hood offers strength-to-weight benefits vs. alternatives.

new OM651 four-cylinder diesel engine, which entered production in the 2008 **Mercedes** C-Class. While plastic oil pans have existed in prototype form for years, this is the first adopted for production cars. Use of **DuPont Automotive's** rugged Zytel 70G35 nylon 66 allowed system supplier/material processor **Bruss** to integrate the windage tray into the module. Daimler claims a 20-25% cost reduction due to improved manufacturing efficiency and reduced secondary processing.

Compared with aluminum oil pans, this one is claimed to save 1.1 kg (2.5 lb) and improve power up to 5% due to lower internal friction related to oil mist clinging to the crankshaft.

SPE Automotive's Environmental Innovation award went to the soy-foam seat pads in the 2008 Ford Mustang. As first reported in *AEI* in March 2007, **Lear** serves as system supplier. The MDI/TDI soy-based polyurethane (PUR) foam is molded by **Renosol**, and **USSC** provides the soy polyol resin. The 5% soy polyol

content in each padset helps reduce use of petroleum-based feedstock.

Topping the 2008 Materials category was the slush-molded instrument-panel skins supplied by **Inteva Products** (formerly **Delphi Interiors**) for GM's T360-based 2009 **Saab 9-7X** SUV. The GM application is claimed to be the first for an IP made in North America. The TPO/TPE resin is Inteva's own STP 747 NA.

This year's safety-related plastics innovation went to a component that was designed and validated within five days. The low-cost, energy-absorption (EA) countermeasure is supplied by **Grupo Antolin North America** for the 2008 Ford Focus sedan and coupe.

By comparison, typical head-impact countermeasures are created with mold tools requiring six to twelve weeks lead time for tooling. The Focus program's short development timing left no room for analytic studies, making material choice critical. The **Dow** Impaxx foamed styrene is extruded into blocks and then wire cut into complex shapes, providing

significant weight (claimed 25% lighter), cost, and timing benefits vs. competitive products.

The hood assembly of one of the most talked-about sports cars sped away with the Performance and Customization innovation award. Supplied by **Plasan Carbon Composites**, the hood assembly of the 2009 **Chevrolet** Corvette ZR1 is constructed of dual-weave carbon fiber and features a clear, see-through polycarbonate window. Chosen by Corvette engineers for its low mass (up to 50% lighter than SMC), strength-to-weight benefits, and Class-A surface capabilities, the assembly is molded in 0 Epoxy prepreg developed by **ACG**.

For more details on each award-winner, go to www.speautomotive.com/inno.htm. **aei**

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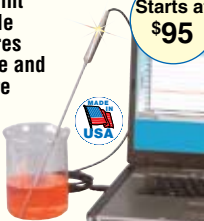
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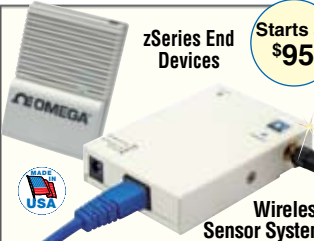
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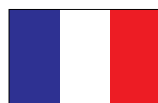
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Mean and green

More than a few companies at last month's SEMA Show heralded the eco-friendly side of their products just as highly as the performance side.

by Ryan Gehm

When most people think about the massive specialty-equipment show held each fall in Las Vegas, they probably think “high performance”—turbos and superchargers, cat-back exhaust systems, short shifters, and coil-over suspension kits. This year's **SEMA** (Specialty Equipment Market Association) Show did not disappoint in that regard, with muscle cars—notably the 2010 **Chevrolet Camaro**, which was the event's “official vehicle,” and the seemingly ubiquitous **Dodge Challenger**—flexing their, well, muscles.

But “high efficiency” likely made an indelible mark on the minds of many show-goers, too, thanks in large part to the inaugural Making Green Cool Zone on the show floor. From solar-panel charging systems to advanced battery technology to onboard hydrogen generation, the abundance of green technologies throughout the exhibition made it clear that, yes, green can be cool. However, one of the main questions posed at a technology seminar devoted to the topic was, “Can green be economical?”

“A lot of what we do is performance-driven. We're all about the horsepower war, making things faster and faster,” said Beau Boeckmann, President and Chief Designer for **Galpin Auto Sports**. But he also believes that a cultural shift has begun in which “mileage wars” are just as exciting. “It's more about the bragging rights and saying, ‘Look at the mileage my car gets. Look at the emissions that I cut down on my vehicle.’ I think that's a great new competition.”

That type of outlook should help propel the positive marketing of green technology, which in turn could help with its economic viability.

Challenges aside, if the products on display at the SEMA Show are any indication, the future of green performance is very bright.

Performance redefined

Front and center at more than a few of the major automakers' exhibits were customized vehicles that boasted enhanced performance and efficiency alike. Take, for example, **Hyundai's** Genesis rear-wheel-drive architecture that was the basis for



All images by Ryan Gehm

Top This 2005 Toyota “Zimbra” Prius, customized by Barris Kustom Industries, illustrates how green can also be cool.

Top Center This Tau 4.6-L V8 concept, engineered by RKSport and Hyundai America Technical Center, features a supercharger as well as cylinder deactivation.

Top Right Honda's 2009 Civic HFP Concept includes “super-light” alloy wheels with aerodynamic covers and an upgraded Showa adjustable-type suspension kit.

Opposite Left The Scorpion exotic car from Ronn Motor incorporates an H2GO fuel-delivery system that produces hydrogen in real time and blends it with the fuel at about a 30% ratio.

Opposite Center A123Systems' Hymotion L5 plug-in conversion module, based on its Nanophosphate lithium-ion batteries, increases the electric capability of the Prius by supplementing the factory battery.

Opposite Right Benefits of ElectroJet's bolt-on EFI control system for motorcycle engines include up to a 15% fuel-economy improvement and, importantly, better performance.

seven custom coupes and sedans shown at SEMA. Under the hood of one 2009 Genesis sedan was a supercharged Tau 4.6-L V8, engineered by **RKSport** and Hyundai America Technical Center, that increases the standard V8's far-from-pedestrian 375 hp (280 kW) to an estimated 460 hp (343 kW) with the help of an **IHI** screw-type supercharger and 11 psi (76 kPa) of boost.

But reminding the audience that fuel economy is “very important as well,” Michael Deitz, Product Manager for Genesis, noted that the concept engine incorporates cylinder deactivation, “which helps us realize an 8% fuel-economy improvement.” The result is an estimated 18/27 mpg city/highway, the same numbers as on the Genesis 3.8-L V6 model, Deitz said.

“This is a no-sacrifice type solution,” he said, adding that the V8 concept points to “what is really available for us in the future.”

Among three featured vehicles at **Honda's** SEMA stand was the 2009 Civic HFP (Honda Factory Performance) Concept that “represents a new and innovative take on performance improvement,” according to Jim Roach, Senior Vice President of Parts and Service for American Honda Motor Co. “With more



consumers expressing concern today about fuel prices, it is likely that future customers seeking to maximize performance of their vehicles will really want to do it without compromising fuel economy."

In response to that dynamic, **Honda Access America**, the automaker's accessory development company, employed aerodynamic improvements to next-generation HFP components. Included on the concept car are a new body kit, "super-light" alloy wheels with aerodynamic covers, a lighter HFP exhaust system, and an upgraded **Showa** adjustable-type HFP suspension kit.

"Greener and faster? Yeah, you bet. That is a possibility," Roach said, noting that a "very similar package has proven its worth on the racetracks of Japan on a Civic Type R racecar."

Hydrogen on the go

On **Ronn Motor Co.**'s website, the Austin, TX-based automotive design and manufacturing start-up poses the question, "How fast can you make water go?" Its answer comes in the form of a hydrogen-fuel-injected (HFI) eco-supercar called the Scorpion, which debuted at the SEMA Show.

"Performance with a conscience" is how the Scorpion was introduced. Most OEMs are moving forward with fuel-cell technology, which requires a high-pressure storage tank in the vehicle and refueling at a station, explained founder and CEO Ronn Maxwell. "It's not bad technology; it's just going to take awhile for the infrastructure to catch up. What we wanted to do is have something that is available today and [acts as] a bridge to that."

Powering the sub-2500-lb (1135-kg) Scorpion is the 2008 **Acura** DOHC 3.5-L V6 Type S engine that develops 450 hp (336 kW) with twin turbos and proprietary refrigerated intercoolers. Ronn's H2GO is a bolt-in HFI delivery system that produces hydrogen in real time and blends it with the fuel at about a 30% ratio. The result is enhanced fuel burn that translates into a 25 to 30% improvement in fuel economy, according to Maxwell.

"In essence, we have a car that will go 200 mph but gets 40 mpg and has almost zero emissions," he said.

"Through a process similar to electrolysis, we fracture the water molecules...and turn it into H-H-O—Brown's gas. We take that gas that's produced and inject it directly into the motor," Maxwell explained, noting that "the real trick" to the system is



Braille Battery's "Hot Rod Hybrid" racecar is based on the Nissan Altima Hybrid. Features include a Braille carbon racing pack—Phase 1 Experimental, a 2.5-L I4 engine that runs on E85 fuel, a solar-panel charging system (inset), and Yokohama low-rolling-resistance high-performance tires.



Alternative fuels play a big part in the green-performance equation. The Scythe, made by Galpin Auto Sports and on display in the Ford booth, runs on 100% methanol.

sophisticated electronics. "We're not trying to run our motor on 100% hydrogen; we're not there yet. All we're trying to do is enhance the fuel burn."

The company plans to produce 200 cars per year. "Our long-term goal is to use the technologies that we develop for this car and put those out there in the public so the average [person] can use them," he said.

Hybrids are hot

Perhaps nothing better captured the intersection between "mean" and "green" than the many souped-up hybrid-electric vehicles (HEVs)—**Toyota** Priuses, in particular—that dotted the show floor. One Prius on display was converted from an HEV to a PHEV (plug-in hybrid).

Decades ago, "we were promised flying cars by 2015. I don't think we're going to have that, but what we will have are plug-in hybrids," said Sanjeev Choudhary, General Manager of the Hymotion group at battery supplier **A123Systems**, during "The Green Scene" technology seminar. He acknowledged that some plug-in vehicles are to come soon from OEMs, such as the Chevy Volt and **Saturn** Vue, but then asked, "Why wait?"

"Through battery technology available today, we can take a hybrid-electric vehicle and, in the aftermarket..., convert it into a plug-in hybrid," Choudhary said. "There are many advantages to doing that: The fuel consumption goes down dramatically, by about 60%, and greenhouse gas emissions go down by about two-thirds."

The company's Hymotion plug-in conversion modules, based on its Nanophosphate lithium-ion batteries, increase the electric capability of the Prius by supplementing the factory battery. Through increased use of electric drive, the module enables the Prius to achieve up to 100 mpg for a range of up to 40 mi (64 km), depending on driving conditions.

The Hymotion L5 plug-in conversion module uses regular 120-V grid power to recharge in about 5 h, providing 5 kW-h of energy storage at full capacity. Once the L5 module is depleted, the vehicle reverts to the normal drive cycle.

The L5 battery pack, which costs \$10,000, takes about 3 h to install, at select Toyota dealers or some "green-car garages." It has been crash-tested and is drop-in technology, taking the place

of the spare tire at the rear of the vehicle. No modifications are made to the Prius' control systems.

Chinese motorcycles made clean

Probably the smallest booth at the exhibition—about a 3 x 3-ft (0.9 x 0.9-m) area in the Making Green Cool Zone—belonged to Brighton, MI-based **ElectroJet**, joked the company's founder and CEO, Kyle Schwulst. Occupying that space was a Chinese motorcycle engine fitted with ElectroJet's bolt-on electronic fuel injection (EFI) control system, which replaces the carburetor with no engine redesign necessary.

"These [motorcycles] pollute, for every mile driven, literally more than four times the average automobile on American roads," Schwulst said. "But with new regulations and with our product, they're actually cleaner than one for one per every mile. On average, that's like a 75% reduction in total pollution."

He pointed out that many Chinese "are worried about where they're getting their next meal, or if they have a roof over their heads; they're not going to spend a couple hundred dollars to be environmentally friendly."

The total system cost is under \$50. "The key thing in China is it's only about a \$10 to \$15 incremental cost at the consumer level, so they can recoup that in fuel-saving costs alone in about six months," Schwulst explained. Tangible benefits include up to a 15% fuel-economy improvement and, importantly, more power, better vehicle acceleration, and easier engine starting, he noted.

The technology is limited to engines of three cylinders or less, regardless of displacement. "Once you get up to above three cylinders, we start losing accuracy. Rather than multiplying our system, it's cheaper to do the traditional automotive stuff," he said, claiming that ElectroJet's EFI system can satisfy over 80% of the motorcycle market in China and India.

The company's specialty is in the control electronics, and that expertise is what enables it to offer an affordable solution. "Conventional automotive control systems need five or six sensors physically tooled to the engine, so we get our information in a smarter way, which reduces cost," Schwulst said. "We've got one sensor in the unit itself that gets five screens of data, rather than five sensors that each gets one screen." **aei**



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Powertrain

Axeon aids RUF with electric 911

An electric **Porsche** 911 prototype has been announced by **RUF Automobile** in Germany. Step-off acceleration to 100 km/h (62 mph) in about 7 s is claimed, and its single-charge range is described as being better than 300 km (186 mi).

tion is in the bracket expected of a 911.

The overall 96-cell battery system has a mass of 550 kg (1210 lb), and RUF states that "preliminary data" puts vehicle mass at 1910 kg (4210 lb).

The battery technology for

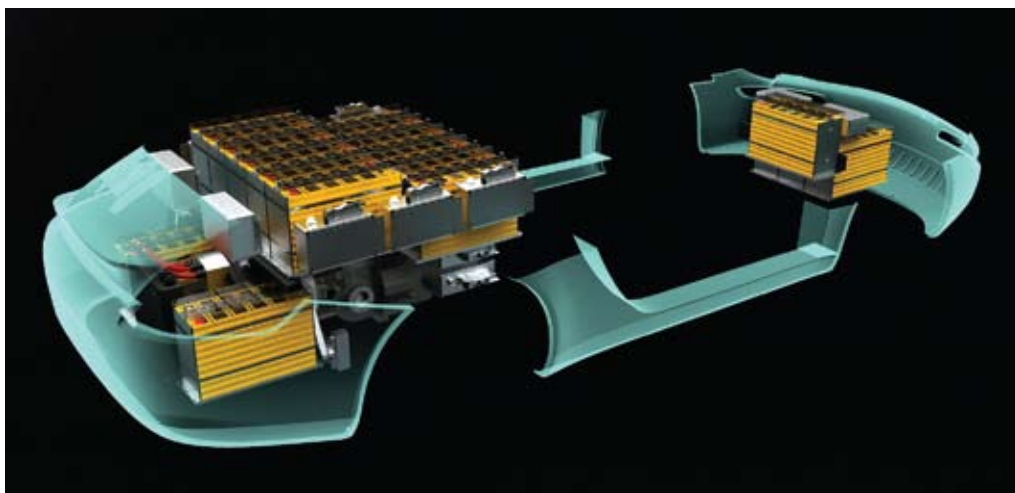
across its applications.

Axeon designs and manufactures batteries and battery-management systems for three main sectors: automotive, power tools, and mobile power. It also provides battery management systems for managing lithium-ion batteries.

Hamish Grant, CEO of Axeon, said: "RUF's all-electric prototype car, equipped with a high-technology Axeon battery pack, demonstrates that electric-powered vehicles can perform in every sense. The world's first all-electric German sports car from RUF, together with our other work for clients in need of less speed but more carrying capacity, demonstrates our capability to design and produce a range of batteries for electric and hybrid-electric vehicles with very different performance criteria. We look forward to working on the second prototype RUF vehicle."

The first eRUF prototype was built by U.S. specialist design and engineering company **CalMotors**. It builds prototype vehicles with hybrid-electric and electric-only powertrains. CalMotors' President, Mike Kasaba, said: "We chose Axeon as the battery supplier for its integration capability and independence from cell suppliers. We have been delighted with the support we have received during the development process."

Stuart Birch



The overall 96-cell battery system from Axeon has a mass of 550 kg (1210 lb), and RUF states that "preliminary data" puts vehicle mass at 1910 kg (4210 lb).

The eRUF 911 is equipped with a prototype advanced-technology **Axeon** lithium-ion phosphate base battery. The battery has undergone a six-month evaluation program and is to be followed by a second prototype, which is expected to lead to a production model in 10-12 months, revealed Axeon. Battery capacity is 48 kW·h, and charging time is 10 h.

The eRUF 911 has a three-phase brushless ac electric motor with peak figures of 650 N·m (479 lb·ft) and 150 kW. Target performance of the production vehicle is a top speed of up to 225 km/h (140 mph) with a range of 250 to 320 km (155 to 199 mi) on a single charge. Initial accelera-

tion is in the bracket expected of a 911. The company, based in Scotland, already supplies its lithium-ion battery technology to the **Modex** commercial vehicle range as well as taxis and other vehicles converted by **Allied Vehicles**.

RUF is a producer of high-performance vehicles, specializing in manufacturing new RUF automobiles from the bare chassis and conversions to RUF specification. RUF has a long association with Porsche models.

Axeon Holdings plc describes itself as Europe's largest independent supplier of lithium-ion battery solutions, manufacturing more than 5 million battery packs a year

Powertrain**Delphi chooses common rail for future heavy diesel injection systems**

Delphi's new heavy-duty common-rail system, with engine-oil-lubricated cam and plunger pump, should be in production in 2012.



Cam-in-block engines will use another distributed pump variant named F2 P.

Delphi revealed its medium- and heavy-duty diesel fuel injection systems, designed to meet the needs of engine manufacturers for Euro 6, **U.S. EPA 2010**, Japan PNLT, and future emissions requirements, at the recent IAA Commercial Vehicles show in Hanover, Germany. The new systems signal a change in strategy for the company, which relies on rate-shaping unit pump and injector technology for its current systems. Delphi will switch to common rail for future needs; the technology is better suited to the multiple injection pulses required to meet tightening emissions limits.

Three system architectures will be offered, enabling Delphi to provide a system for a wide variety of engine designs. There is a "conventional" common-rail system with rail pressure provided by a cam and plunger pump lubri-

cated with engine oil. The system architecture draws on Delphi's common-rail expertise gained from lighter-duty diesel systems.

The company will provide two other systems, which it describes as "distributed pump common rail." Both draw on the company's current electronic unit pump (EUP) and electronic unit injector (EUI) technologies. Delphi has developed EUP systems for cam-in-block engines, with a cam-actuated pump body mounted on the engine block, connected to the injector via a high-pressure pipe. The system shares the same fundamental components as the E3 EUI combined pump and injector designed for cam-in-head engines.

What Delphi has done for the common-rail systems is to adapt the EUP and EUI systems so that the pump elements feed a high-pressure common rail at pressures of

2400, 2500, 2700, or 3000 bar (34.8, 36.3, 39.2, or 43.5 ksi), as required.

For both variants of the system, up to one pump per cylinder can be used to charge the rail, depending on engine capacity. Delphi will provide two variants of each system: one designed for engines between 4.0- and 9.0-L capacity, and a larger system designed for engines between 9.0- and 16-L capacity. For an engine of 13 L, Delphi expects that a system equipped with three pumps should suffice, while two pumps should be able to handle the needs of smaller engines.

The EUP-derived system is known as F2 P. The three basic elements of the system are the cam-driven pumps, rail, and separate injectors. The EUI-derived system operates differently.

For example, consider a 13-L, six-cylinder engine fitted with three pumps. These



Common-rail variants include the F2 distributed pump system for cam-in-head engines.

would be driven from the overhead cam in the same way as Delphi's current E3 injector, which can already deliver injection pressures of up to 2500 bar (36.3 ksi). Like the E3, the pump and injector are housed in the same body. The difference is that the two

elements operate independently. The pump feeds pressurized fuel to the rail, which in turn supplies fuel back to the injector. For the three cylinders not fitted with the pump/injector body, a more conventional common-rail injector is used, effectively using the same injectors as the F2 P system. To help supply the fuel at the pressures needed, the camshaft carries two lobes, giving two pump strokes per revolution in place of the single stroke for current EUP and EUI systems. Each pump has a plunger diameter of 7 mm (0.28 in) and stroke of 18 mm (0.71 in).

To achieve the required injection pressures and also satisfy the B10 durability requirements of 1.6 million km (1 million mi), Delphi has had to design the valve hydraulics to reduce stress. This involved work around the geometry of the sealing cones, but no changes to the rail architecture were needed.

Delphi apparently sees the distributed pump systems as a short- to medium-term measure. Richard Green, Sales and Marketing Manager for Delphi Powertrain Systems, told *AEI*, "Oil-lubricated systems are the way forward," adding "there is no challenge on oil/fuel separation compared with 2500-bar systems."

To drive the new common-rail systems, Delphi has developed ETC3, a new electronic truck controller. The air-cooled system will manage all engine and duty functions, including cruise control. A fuel-cooled option for extreme environments will also be available. Delphi says that the ETC3 will be ready for 2010 and expects the new heavy-duty common-rail systems to enter production around 2012.

John Kendall

Powertrain

Buehler Motor to keep Volt quiet



Buehler Motor President Robert Riedford called General Motors' upcoming Volt a "tough engineering challenge" for his company's new electric coolant pumps.

General Motors has not released many supplier names for its **Chevrolet** Volt extended-range electric vehicle program, slated for production in 2010. So Germany-based **Buehler Motor** GmbH is way ahead of the pack in confirming a production contract for a key application for the car—12-W and 50-W auxiliary coolant pumps used for cooling multiple subsystems in the advanced-propulsion vehicle.

According to Robert Riedford, President and General Manager of Buehler Motor Inc., the company's U.S. group, the Volt contract presented a "tough engineering challenge" to the 150-year-old supplier of mechatronic technologies, including specialized electric motors and controls.

"The pumps have to run extremely quietly because this is an electric car," Riedford explained, "and they have to be extremely robust." Volt will use "multiple" 50-W pumps and at least one 12-W pump, he said. The 50-W unit features its own integrated electronics.

Another technical challenge was developing a novel method of sensing the pump's impeller speed, Riedford said. The pumps' overall mechatronic design features brushless dc motors, similar to the type used by Buehler in its four-wheel-drive transfer case actuator systems produced for GM, **Magna**, and others since the 1990s.

Speaking at Buehler's booth at the recent Convergence 2008 conference, Riedford explained that

he cannot divulge much technical detail at this stage of the Volt's development. Buehler Motor and GM have been working together in a technology partnership since mid-2007 on the coolant pump systems. Buehler engineers are stationed at GM's Volt engineering center in Warren, MI.

Lindsay Brooke

Energy & Environment**Partners trim scooter emissions**

Scooters are seeing solid growth as fuel prices rise, but there is also growing concern over their emissions. Several companies are addressing this environmental concern with battery-powered systems and fuel-injection techniques on vehicles in Europe and Asia, including those used at the Beijing Olympics.

On the battery side, Italian scooter supplier **Oxygen** SpA is expanding its relationship with **Valence Technology** Inc., which makes lithium-phosphate batteries. Oxygen is expanding its relationship with Valence, buying another \$2 million of its 13-V batteries



Oxygen's Cargoscooters feature advanced fuel injection and lithium-ion batteries for clean emissions.

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as the scooters go into production.

Oxygen uses those batteries in its Cargoscooter, which runs up to 74 mi (119 km) at speeds up to 25 mph (40 km/h) without recharging. To date, 500 Cargoscooters have been shipped, proving the concept.

"Electromotive transportation is already hitting the road in Europe," said Robert L. Kanode, President of Valence Technology. "The Oxygen scooters are being used for postal delivery and some food delivery."

Lithium phosphate offers longer lifetimes and more safety than other lithium alternatives, Kanode said. The batteries greatly simplify design since complex transmissions are not needed. Electric motors deliver high torque over most of their speed range, so shifting is not necessary. Maintenance is also reduced, since bearings have the only metal-on-metal contact in the motor.

Reducing fuel consumption for scooters could have a big impact on air quality and global CO₂ emissions. Though the high mileage of gasoline-powered scooters might be associated with low emissions, that is often not the case.

"Many scooters now use inefficient two-stroke engines that lose 30-40% of the fuel. Each scooter creates as much pollution as 50 cars," said Rich Beyer, **Freescale Semiconductor's** CEO.

Freescale partnered with

ElectroJet, a contract design house that is shipping fuel-injection systems to **Dayang Motorcycle Co.**, the official scooter supplier for the summer Olympics. Compared to previous-generation vehicles with carburetors, Dayang's new scooters generate 65% less carbon monoxide and 35% less hydrocarbon and nitrogen oxide.

Fuel injectors let Dayang meet Euro 3 emissions standards, making a big impact in a country that now has no emissions regulations. ElectroJet's system uses a 16-bit controller to minimize cost and size while simplifying the engine redesign.

"We reduce the number of sensors needed to control the engine, which does two things," said Kyle Schwulst, ElectroJet's CEO. "Our costs are significantly lower, and we have 100% physical compatibility with existing carburetors."

Keeping costs down is a key aspect, since the \$600 some scooters cost represents a full year's wages for many Chinese families, Schwulst said. Though Dayang uses the fuel-injection system on four-stroke motors, the same system can be used on two-stroke engines.

Adopting fuel injection for either type engine could have a huge impact on Asia's air quality and fuel consumption since there are 34 million motorcycles sold in China and India, Schwulst said.

Terry Costlow

Electronics Communications key to safety



U.S. Department of Transportation's challenge: "to reduce the number of crashes by 90% by 2030," said Paul R. Brubaker.

Over the next few years, communications will play an increasing role in a drive to improve safety on America's roadways. Messages sent from roadside beacons and between vehicles can help save lives and billions of dollars, though much work is still needed to implement communication technologies that must be standardized.

Panelists from a range of fields focused on the need for a compatible infrastructure that will enable the advance of connected and autonomous vehicles during a Blue Ribbon Panel at the recent Convergence 2008 conference. Safety will play a key role in the **U.S. Department of Transportation's** (DOT) efforts to promote and fund communications between cars

and with roadside information stations.

"We've challenged the DOT research organization to reduce the number of crashes by 90% by 2030," said Paul R. Brubaker, Administrator, U.S. DOT's Research and Innovative Technology. That will save 383,000 lives and \$2 trillion during the period from 2030 to 2040. The cost of accidents is not widely recognized, so it will be a key element in DOT's discussion on this issue.

Techniques such as dedicated short range communications (DSRC) and Vehicle Infrastructure Integration (VII) need a number of elements before they can be implemented. Brubaker did not estimate a time for the rollout of VII, but it is close enough

that a rebranding is coming soon. "We don't want customers asking us what this 'seven' is," he quipped. The communication systems will reduce accidents by informing drivers of issues that they need to account for such as traffic stoppages or slow-downs. Making sure that there is enough time for them to respond is a critical aspect.

"DSRC has a 500-m range. When you're in Germany driving 200 km/h, that provides a 10 s time to respond to an alert that there's a traffic jam just around a blind intersection," said Dr. Peter E. Rieth, Senior Vice President Systems & Technology at **Continental**.

Several technologies must be developed concurrently for these communications to occur. A key is to settle on standards and architectures that make it simple to integrate them into vehicles.

"Without open architectures, you won't have integration and you won't have growth," said John Waraniak, Vice President of Vehicle Technology, Specialty Equipment Market Association (**SEMA**). As with any network, security and privacy are also issues. "A denial of service could really impact the person driving the vehicle," said Anup Sable, Vice President of **KPIT Cummins** Automotive Line of Business. "Whether you're communicating car-to-infrastructure or car-to-car, security must be part of every layer."

As communications advance, researchers are also hoping to improve safety by having vehicles operate autonomously. This is also a ways off, but technologies and techniques are progressing.

"Automotive radar systems

have come a long way, and high dynamic range cameras that can see in bright sunlight and dim lighting have also come a long way," said Chris Urmson, Assistant Research Professor, Robotics, **Carnegie**

Mellon University. Urmson noted that five vehicles completed the **DARPA** (Defense Advanced Research Projects Agency) Urban Challenge last year, marking a significant advance from the first DARPA

Grand Challenge, when no vehicle completed the race through the desert.

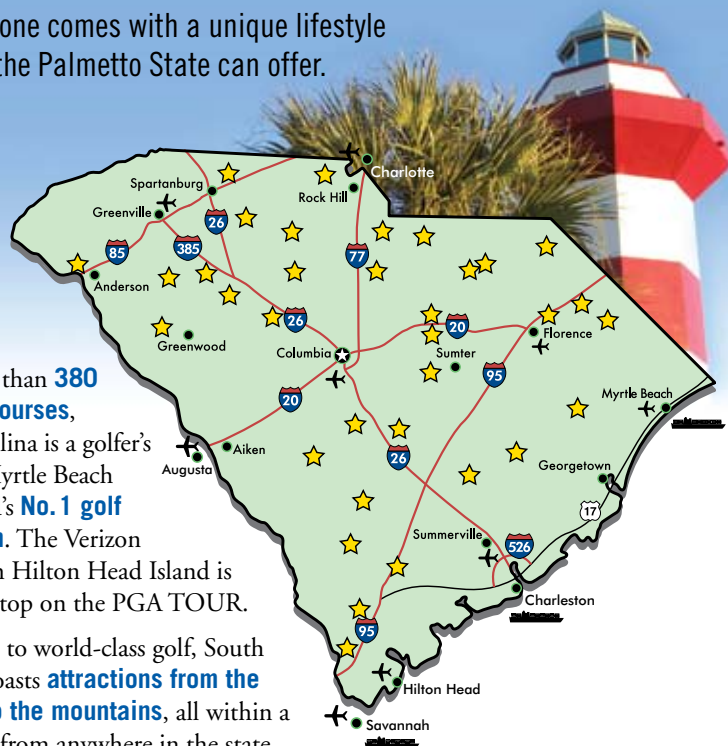
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Electronics

Top automaker E/Es talk electronics

Even during the world's current erratic economic conditions, the task of designing vehicle applications that rely on electrical/electronic technologies continues seemingly unabated.

"We can't turn away from developing critical technologies," said Chris Thibodeau, **General Motors** Corp.'s Director of Global Technology Engineering for Electrical/

undergoing a drastic transformation is the amount of electronic control units (ECUs) on a vehicle.

BMW's "high-end cars" can have as many as 70 ECUs, said Dr. Günter Reichart, Vice President of Driver Assistance, Body Electronic and Electrical Networks for the BMW Group. Other panelists also cited double-digit ECU numbers—although not as many

screen and the same icon beside the switch, but the switch itself needs to be differentiated," Nakajima said. His viewpoint is that alerts—for lane departure, forward collision, and other safety features—should be conveyed as "clear and simple information to the driver." According to Nakajima, even different audible alerts are "kind of annoying and hard to understand."

Speech-recognition technology is "very important now," said James Buczkowski, Director of Electrical and Electronics Systems Engineering Implementation at **Ford** Motor Co. Buczkowski noted that the automaker has 280,000 vehicles on the road today using Sync technology, a factory-installed, voice-activated in-car communications and entertainment system developed by Ford and **Microsoft**.

Natural-language speech recognition is an end goal for automakers. "Consumers don't want to be trained to use certain commands," said Andreas Schell, Vice President of Electrical/Electronics Engineering Core for **Chrysler** LLC. GM's Thibodeau said natural-speech recognition is a technology that needs to be precise. "It's interpretation of natural speech, and that is something you want to model really well," he said.

Kami Buchholz

as on a high-end BMW vehicle—and they gave no indication of any immediate en masse reduction in the number of ECUs. "Connector suppliers should be happy to hear all of your remarks," said Hansen.

Toyohei Nakajima, Senior Chief Engineer for **Honda** R&D in Tochigi, Japan, said the industry should consider adopting a human-machine interface standard. "A customer might want to see the same icon on the [touch]



The "Car Makers Speak" panel at Convergence 2008 featured (from left) Ford's James Buczkowski, Honda's Toyohei Nakajima, BMW's Günter Reichart, Chrysler's Andreas Schell, and General Motors' Chris Thibodeau.

Electronic Products, at the recent Convergence 2008 event. He was part of a panel of top-level electrical/electronic engineers and was responding to moderator Paul Hansen's question about what impact the volatile economy will have on current projects.

Thibodeau suggested that some technology deployments could be delayed. "Portfolio adjustments are a part of business," he said. One aspect of the vehicle-making business that doesn't appear to be

Electronics

Continental's eHorizon boosts vehicle efficiency

Optimizing vehicle fuel efficiency by providing the powertrain and driver with detailed digital previews of the road ahead is one of the potential benefits of eHorizon, a new software package being developed by **Continental's** Multimedia business unit and discussed at Convergence 2008.

The eHorizon concept continuously transmits small data packets containing road terrain, environmental conditions, traffic congestion, route guidance, and other key information to the powertrain and vehicle subsystems (chassis control, for example) via the vehicle's CAN bus.

An eHorizon control unit integrated in the vehicle precisely calculates vehicle position using GPS, wheel speed, and gyroscope data. The map data is then continuously transmitted in a standardized format to the various subsystem control devices through the CAN bus. The individual control units then re-create the virtual road image using a data-reconstructing program. The system's effective memory management ensures that the oldest data packet is always removed from the controller's memory in favor of the most recent data packet. This also helps keep data transfer low and allows simple implementation of new functions.

With this digital-map preview, the engine and transmission control units, energy-storage systems (battery packs on hybrids, for example), and

driver assistance systems can optimize their respective functions, explained Tarun Gupta, the Continental electrical engineer who is eHorizon's portfolio manager for North America."

Vehicle testing thus far is proprietary, but we are confident this system will provide not only reductions in fuel consumption but also potentially better traffic safety due to its ability to anticipate driving conditions," Gupta said.

Among the vehicle-function areas given expanded "intelligence" by eHorizon are engine management, battery-energy management (as for hybrid vehicles), transmission control, "eco-cruise" control; curve assistance (for twisty-road driving), and chassis damping control. The vehicle's



Continental's eHorizon software, which brings navigation system data to the powertrain for greater vehicle efficiency, made its North American debut at Convergence 2008.

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transmission gear-change strategy can be optimized. For example, an automatic transmission could recognize a gradient or curve ahead and delay a shift into a higher gear. Conversely, it could upshift into a more fuel-efficient ratio anticipating a long downhill ahead, Gupta noted.

For hybrids, eHorizon will enable certain functions to be switched on or off, depending on the road ahead. For driver assistance, eHorizon uses the adaptive cruise control system combined with navigation. The eHorizon can be integrated into the vehicle's navigation system, or can comprise a separate control unit with its own simple human-machine interface, said Gupta.

The modular eHorizon concept was conceived by **Siemens VDO's** automotive electronics unit acquired by Continental last year. The company sees opportunity for eHorizon in both the commercial and light-duty passenger vehicle segments. It is being configured as part of Continental's Multi Media Platform (MMP) architecture.

Continental is offering OEMs a complete eHorizon development package allowing them to test new functions and shorten the time to production readiness. Convergence marked the first North American appearance of eHorizon. It debuted at the 2008 IAA show in Hanover, Germany.

Lindsay Brooke

Electronics

ZMD senses applications in EVs, biofuels



"We've become a 'go-to' in sensor technology," said ZMD America President Frank Cooper during an interview at Convergence 2008.

The steady electrification of the vehicle and rapid emergence of biofuels are driving new product-development activities across the automotive-electronics sector. For analog and mixed-signal application-specific integrated circuit supplier **ZMD**, an exhibitor at Convergence 2008, these trends have made sensor technologies a major growth area, said Frank Cooper, President of ZMD America, the North American arm of the Dresden, Germany-based company.

Cooper said the industry's demand for hybrids and electric vehicles, battery-management systems, electronic throttles and piezo-resistive technologies, ultrasonic oil-level detection, and proximity sensing are driving development of better-performing, more cost-effective sensor solutions.

"Flex-fuel powertrains are an area of our development focus," said Cooper. "There is an emerging need to have

very quick, real-time capability to sense water content levels in ethanol-blend fuels," he said, particularly given the broad bandwidth of fuel products (from E10 to E85) in the marketplace. "We've got some things under way in this area that we're very optimistic about."

Sensor signal conditioning is one of ZMD's sensor-IC core competencies. Examples from the company's portfolio are the Advanced Differential Sensor Signal Conditioners. Designed for pressure measurements, these CMOS devices process signals from most resistive-bridge sensors available on the market, ZMD claims. Applications are wide ranging and include engine fuel rail, turbocharger wastegate, exhaust gas recirculation, and HVAC, to cite a few examples. At a reception during Convergence, ZMD executives also revealed battery-management technologies that Cooper indicated will

enter production with an automotive OEM next year.

OEMs have been marching in various directions regarding the proliferation of electronic control units (ECUs) in the vehicle. **Toyota**, for example, has stated its goal to reduce the number of ECUs per vehicle to five or fewer, while the number of ECUs in some high-end European luxury cars continues to grow. The industry's general inconsistency presents challenges to semiconductor and sensor suppliers, Cooper noted.

ZMD is developing metal-oxide semiconductor field-effect transistor (MOSFET)-based fusing solutions for the new electrical/electronic architectures. Cooper said these "FET switches" can be programmed for individual subsystems (LED lighting, for example) and will be capable of significantly reducing the fuse proliferation per vehicle, which will in turn help reduce the mass of the wiring harness.

ZMD's Opto Sensors product line includes CMOS imagers finding many applications in driver-assistance systems including blind-spot recognition, lane recognition, and parking aids, as well as replacement solutions for rearview and outside mirrors.

Lindsay Brooke

Testing

New testing venue for high-pressure components



Maximator's pressure pulse fatigue test machine is used for a variety of tubes, pipes, tanks, and pressurized parts such as diesel system components.

A European-based company recently opened its first overseas testing facility, and the U.S. site offers test machines not found elsewhere in the domestic market.

"Our pressure fatigue test machines are unique in the U.S. market. We are the only test lab in the U.S. with pressure fatigue equipment capable of test pressures up to 4500 bar at a frequency of up to 15 Hz," said Brian Cullen, Managing Director of **Maximator Test LLC** in Gurnee, IL.

The pressure fatigue test machine is used primarily for life-cycle/durability testing. "Some of our typical automotive industry fatigue testing applications are high-pressure diesel fuel components such as common rails, fuel lines, injectors, and pump housings. The machine also can be used to conduct fatigue testing using a pressure pulse on vir-

tually any pressurized part," said Cullen.

Since the Illinois facility can be operational around the clock, a multimillion cycle pressure fatigue test can be done in just over a week's time. "For high-pressure diesel applications, many of our customers have a 10-million cycle requirement to ensure safe operation of the system throughout the lifetime of the vehicle. Our pulse rig can conduct this test in just under eight days running 24/7," Cullen explained.

Maximator GmbH of Germany—part of the **Schmidt, Kranz & Co.** founded in 1885—has been building test machines for 38 years. "Our burst/leak test bench can test components up to 4500 bar. However, some of our customers require higher pressures to burst their components—common rails, for example—and for that we

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can use our Autofrettagage machine, which is capable of 10,000 bar. Our machine can be configured to seal and autofrettagage virtually any type of common rail. The autofrettagage process is a one-time application of ultra-high pressure that generates a compressive residual stress between the inner and outer component walls as a means of counteracting premature component failure," said Cullen.

The new facility means customers can see equipment before buying the machines. "To help generate new machine sales in the U.S. market for Maximator GmbH, the 3850-ft² facility includes a showroom so customers can see the machines in operation without having to travel to Germany. Maximator not only

builds a wide variety of machines, the company also works with customers to design custom machines," Cullen said.

Maximator's new testing facility complements the research, development, and testing work done in Germany. The company also has several production and sales locations around the world.

"As we grow along with the commercial- and passenger-vehicle diesel markets in the U.S., we expect to increase the size of our Illinois facility. And as the business grows, we also expect to hire more lab technicians and service technicians to support our customers," Cullen said.

Kami Buchholz

Simulation

Virtual reality gains foothold as image processing improves

Virtual reality is playing a greater role in automotive development, letting drivers interact with different designs in near real-world operating conditions. **Quantum3D Inc.** recently upgraded its imaging system, which has been tapped by **Ford** and a company that does work for the **U.S. Air Force**.

Quantum3D's image generation system has been using Ford's VIRTual Test Track EXperiment (VIRTTEX) Driving Simulator since 2001. It gives operators six degrees of freedom, moving forward and backward, up and down, and left to right, while also rotating about three perpendicular axes.

Ford recently upgraded the hardware with Quantum3D's fourth-generation Independence 4000, letting VIRTTEX engineers develop simulations that include human behavior. Pedestrian safety is getting more attention from regulators in Europe and Japan, so simulations need to account for this new focus.

"The upgraded system delivers scenes with eight times the number of pedestrians and more than twice the traffic," said Brian K. Overy, Vice President of Business Development at Quantum3D. "That permits simulating rush-hour driving conditions or scenes with very high densities of buildings, road signage, and pedestrians."

For example, when a driver is intentionally distracted and a passing vehicle suddenly swerves in front of the simulated vehicles and slams on

the brakes, the system ensures that all the simulation's images, including the neighboring car to the background effects, are realistic.

That's accomplished with a real-time rendering subsystem that employs **Intel Xeon Multi-Core CPUs**, **NVIDIA** graphics processors, and Quantum3D's precision synchronization module, which supports up to 256 synchronized devices per image generator. The system has approximately twice the performance of the previous generation.

The market for virtual-reality systems is seeing solid growth. Quantum3D's image generator is also being tapped by **QuantaDyn**. The visual computing provider helped design the U.S. Air Force's KC-135 Boom Operator Weapons System Trainer, which simulates aerial aircraft refueling. It's used by the U.S. Air Force, **Navy**, **Marine Corps**, and allied nations.

This growth is attracting more attention from design tool providers. Software suppliers outside the world of virtual reality are also striving to let a broader range of customers gain the benefits of these 3-D simulations.

New software tools from mainstream tool providers aim to bring 3-D simulation to companies that do not have the deep pockets of Ford or the U.S. military. The tools to create virtual-reality systems are coming down in price, providing an alternative to the expense of building physical prototypes.

"It's cheaper to have a

room outfitted with large screens and the appropriate sensors than to build a scaled-down vehicle," said Tom Shoemaker, Product Development Group Manager at **PTC**. "We can put the geometries in lighter weight form, stripping out the CAD information."

Those lightweight programs let engineers leverage their CAD files yet run 3-D simulations on less expensive systems. Smaller files decrease the computing power and communications bandwidth requirements.

"High-end digital mockup tools are the only way you can ever look at a large vehicle. If you tried to do that with complete CAD data, it would be overwhelming," Shoemaker said.



Ford's VIRTTEX module moves on six axes as drivers respond to simulated traffic experiences.

Software is a key for improved performance. Ford's VIRTTEX upgrade includes Quantum3D's Mantis software that lets engineers simulate

lighting sources and characteristics. Mantis also includes special effects such as smoke or dust, advanced weather effects including precipitation,

fog, and haze, and the sun's positioning.

Terry Costlow

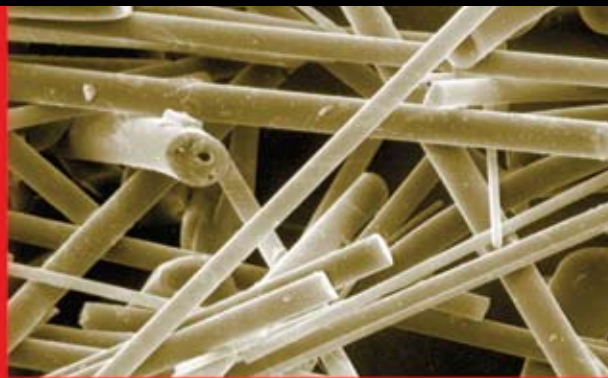
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Simulation

Bosch Engineering grows with niche projects



A Bosch Engineering vehicle dynamics software solution was developed for Bombardier Recreational Products' new three-wheeler, the Can-Am Spyder roadster. Its steel frame in surrounding spar technology has a low number of welds and high structural integrity. The frame's low weight and slender shape help to bring down the center of mass.

Engineering services have been a growing business for years, fueled by the increasing complexity of electronic vehicle systems such as engine management, safety system software, and many more. The market dynamics were further pushed by the tendency of vehicle manufacturers to increase the responsibility of their suppliers.

It has been, and continues to be, primarily the stringent emissions legislation that has raised engineering requirements in Europe ever since the early '90s when the first Euro emissions standard took effect in 1993 (Euro 1). During the same period, it has been a growing supplier and OEM challenge to ensure that a new vehicle meets the current standard.

While it was quite manageable to justify the growing engineering efforts for large

series production vehicle projects, the situation was quickly deteriorating for the makers of niche models since the mid '90s. Said Bernhard Bihr, Managing Director of **Bosch Engineering GmbH**: "Niche-model OEMs always had a down-to-earth understanding of the resources that could go into adapting series car products for their vehicles.

However, with emissions legislation getting tougher and competition getting harder, they realized that they needed more parameters and functions to be customized for their make. Mere homologation was not sufficient any more."

When Bosch Engineering was founded in 1999 with 13 Bosch employees under the initial name of **Asset GmbH**, the start-up company focused on Bosch gasoline system applications for vehicle makers

such as **Ferrari**. From day one, Bosch Engineering had full access to all Bosch product data. Soon, the engineering portfolio began to include the full range of drivetrain applications, safety and comfort, E/E integration services, testing services (capabilities include a high-speed 350-km/h [217-mph] dynamometer), and consulting.

Today, the focus "is on anything that moves" said Bihr. Currently, the company is also getting a foot in the door of the aircraft piston engine market via its Austrian division. Among other things, **Bosch General Aviation Technology** is developing control technology and injection systems to power small aircraft with common-rail diesel engines. "However, the initial effort in the aviation field in general is considerable," said Bihr.

In January 2008, the worldwide number of Bosch Engineering employees passed the 1000 threshold. By July, this figure was 1200 and growing, according to Bihr, who added: "We have just doubled our human resource personnel to be able to hire the required two-digit number of new engineers every month."

While the company's financial results are only published within the results for the whole Bosch Group (sales 2007: €46.3 billion), the speed of growth suggests that Bosch Engineering is inline with the general requirements of the group, which announced a sales growth of 6% (automotive +4.5%) in 2007 at a profitability of 7 to 8%. Only the motor-racing activities of the engineering company, which is, e.g., working for **Audi**, **Porsche**, and **Peugeot** (Le Mans diesel direct injection) and providing technology for the DTM series and to **NASCAR**, are just about in the black, said Bihr.

Managing the speed of growth is one of the daily challenges, he agreed: "As we have to live up to the expectations linked to the name Bosch, we sometimes find it hard to say no to a project. On the other hand, we have to be careful not to overheat this growth. Getting young new people up to speed and to our corporate standards is a daily challenge."

Though the market for engineers is a difficult one in Germany, the manager sees it far from the Japanese situation "where the availability of qualified engineers impacts development cycles."

Today, the work for small customers and niche models

of big OEMs mostly consists of adapting software of series products to the special needs of low-volume models.

"Ninety-five percent of our work is software and system configuration," he said. It is not surprising that the company's share of software experts is between 40 and 50% of all employees—or associates as the engineering specialist prefers to call them. Said Bihr: "Our only asset is people."

Given the importance of project management and software development, the company has one process quality level for all work in place. "We have CMMI maturity level 3, which is the result of a lot of effort," he explained.

A recent example of the company's business is a vehicle dynamic control solution for **Bombardier Recreational Products'**

(BRP's) new three-wheeled vehicle called the Can-Am Spyder roadster. To make this powerful 79-kW (106-hp) vehicle safe for driving, Bosch Engineering adapted software modules from its ESC library to come up with a new software solution that meets the requirements of a three-wheeler and helps to keep the vehicle from rolling over at high cornering speeds. At an expected 25,000 units per year, the Can-Am Spyder is roughly in the middle of a typical niche model definition, "which for us covers everything from a single to 40,000 units per year," said Bihr.

However, not just small OEMs are among the customers of Bosch Engineering. "Makers of luxury limousines also work with us to get emissions-relevant solutions for low-volume high-end vehicles." Audi cars with eight- and 10-cylinder engines provide one example.



Among Bosch Engineering's testing capabilities is a 350-km/h (217-mph) dynamometer. The image shows Audi's R8 during testing.

In comparison to the growth in Germany, the Bosch Engineering activities in the U.S. are still quite small. The North American company was only founded in June 2007.

Among future challenges, Bihr rates CO₂ emissions hurdles very high: "We are getting to the point where we have to make sure whether future legislation goals are technically feasible."

Asked about a paradigm shift from internal combustion to electric driving that may already have begun, Bihr is confident that any such change process will take decades. The need for hybrid vehicle technology and electric driving for passenger car and light commercial vehicle applications, however, translates into growth opportunities for Bihr. "In the U.S., for instance, heavy trucks would

clearly benefit from electric boosting on steep slopes."

In his view, the diesel engine is also in for further growth as there is no other engine that can equally contribute to meet CO₂ fleet emissions targets. "Therefore, I am also convinced that the diesel will make it in the U.S. If there is such a thing as a perfect fit for the compression ignition engine, it is to the U.S. market. The diesel offers the beefy torque of large-capacity gas guzzlers for satisfying acceleration plus the economic cruising at low engine speeds."

Jörg Christoffel

Materials High-heat plastics getting hot

Despite high crude oil prices, the use of plastics in automobiles is likely to grow as the weight reduction facilitated by the material can help to save more oil than was needed to manufacture the plastic part.

"Depending on the application, the shift from metal to plastic can save up to 30% of component weight. When you consider the long utilization time of plastics in a car, plastic components save three times more greenhouse gases than produced during their life cycle," said John Feldmann, Board Member of **BASF SE** (Societas Europaea) at Ludwigshafen, Germany.

Currently, the average share of plastics in a passenger car is around 15%, which equals a weight share that will typically be between 150 and 200 kg (330 and 440 lb) per car, according to Rudolf Stauber, Head of Engineering Strength and Materials and spokesman of the new material cluster, **BMW Group**, R&D center at Munich. New models such as **Volkswagen's** new compact SUV, the Tiguan, with its 18% share of plastics, seem to strengthen the outlook of plastics being on the upswing.

However, there are a few obstacles on that path. One typical limit to using plastics under the bonnet (UTB), for instance, is the exposure to heat. Smaller engines, higher turbocharging pressures, and exhaust gas recirculation keep raising the temperature level in the engine compartment. The problem is thermal oxidation, which can reduce the mechanical properties of



A Stanyl Diablo OCD2100 bar retains 90% of its original tensile strength after 2500 h of aging at continuous temperature levels up to 210°C (410°F).



Soft high-heat components pose a manufacturing challenge: Sufficiently soft materials are prone to collapsing in the mold during suction blow molding. A new Lanxess PA 6 grade offers higher melt stiffness to overcome this problem. An air tube is shown.



The Lanxess semi-crystalline division has developed a high temperature stabilized Nylon 6 glass-filled polyamide that targets engine compartment applications such as intake pipes.

thermoplastic materials to a point where they fail. The critical parameters in this context are long-term tensile and compressive strength.

"After 3000 h of aging at 180°C, standard high-heat polyamides can typically lose up to 50% of their original mechanical strength. So far even this result was still considered to be fairly good," said Bert Havenith, Global R&D Manager Automotive, **DSM Engineering Plastics**. Increasing the oxidative stability of plastics is therefore one precondition for new high-heat UTB applications.

To meet the temperature requirements of such under-

hood applications, DSM has further developed its existing Stanyl polyamide material to a new PA46 generation. The first available product is the Stanyl Diablo OCD2100 polyamide. The two years of development work that went into this material focused on limiting the thermal oxidation breakdown. As a consequence of studying the exact degradation mechanism, the new DSM material does not only rely on traditional antioxidants. "Instead, our technology controls the oxidation mechanism itself," explained Willy Sour, a product development expert for the new polyamide.

"Stanly Diablo withstands more than 3000 h temperature exposure up to 230°C with less than 15% loss in mechanical properties," claimed Havenith, adding that specific parameters such as the burst pressure are 100% better than is the case with standard polyamides. According to the manufacturer, weldability and long-term weld heat stability have also been improved.

Among the potential new applications for this material are plastic components on the hot side of the turbocharger. "One example would be the hot charged air duct between the turbocharger and the intercooler," Havenith said. The DSM manager announced the first UTB series application for a passenger car in 2009.

Under the name Durethan BKV 30 HTS, **Lanxess** has further developed its standard PA 6 GF30 for injection molding by increasing thermal aging quality. This new glass-filled grade with high-temperature stabilization (HTS) is optimized for high impact strength. While this material is "not suited for the hot side of the turbocharger, it is a cost-efficient material option to special polyamides," claimed Jürgen Selig, of the transport application development within the company's

semi-crystalline product business.

BKV 30 HTS will retain more than 50% of its original impact strength after 3000 h of aging at 150°C (302°F) and can take temperature peaks at up to 190°C (374°F) without losing too much of its tensile strength.

Slowing down thermal oxidation is not only an issue with stiff components: The current trend toward turbocharging necessitates air tubes with soft bellows. Currently, sequential blow molding is needed to manufacture pseudoplastic high-heat components from two polyamides of differing hardness with the harder layer preventing the soft layer of the component from collapsing in the mold during manufacturing. After conditioning, the soft-modified Durethan DP BC 6000 HTS PA 6 grade has an elasticity modulus as low as 350 MPa (50.7 ksi) but can be processed to manufacture single material charge air tubes by suction blow molding due to its high melt stiffness.

Jörg Christoffel

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Materials

Plastics seek problem-solver role

The route to a different material solution begins with an idea. In the plastics composite arena, researchers and engineers at **General Motors** are flush with ideas.

"In the materials area, sometimes the freshest ideas come from Tier 2 suppliers. We get ideas from the entire supply chain, but at times

With weight reduction being a perennial chase for automotive engineers and designers, finding ways to lightweight conventional materials is a constant. "It's possible to reduce the weight and thickness of sheet molded composite materials by replacing amounts of fillers and glass fiber with nanoclays. In one

that meets automotive requirements and has a significant cost savings, that would really drive more use of carbon fiber," said Tsien. GM is working with suppliers to characterize, test, and validate a new carbon-fiber material and process that would net cost savings.

Direct long-fiber thermo-

motive uses look promising since LCPs have "thermal expansion coefficients roughly equivalent to metals. A primary advantage of using LCPs is the material's extremely high stiffness, which potentially allows for making thin-wall part applications. In addition, the high temperature resistance makes LCPs potentially good materials for under-the-hood applications," said William Rodgers, Technical Fellow at the GM R&D Center, Materials and Processes Laboratory, in Warren, MI.

GM and Wilmington, MA-headquartered **Quantum Leap Packaging**, a materials supplier, recently produced an approximately 24 x 24 x 0.125-in (610 x 610 x 3.2-mm) test plaque on a 1350-t (1490-ton) molding press at **Husky Injection Molding Systems'** facility in Novi, MI. "The test plaque is a 4.1-lb part, which is one of the largest LCP parts ever molded," said Rodgers.

LCPs are not that far from prime-time exposure. "If testing and validation proves successful, it's possible that LCPs could be used in production applications like body panels, support brackets, and under-hood parts in a timeframe that's probably more than two years away, but likely less than five years," Rodgers predicted.

Kami Buchholz



The 2009 Chevrolet Corvette uses carbon fiber on its exterior panels, including the hood and front splitter.

there is a tendency for a provider of an established solution to want that solution to remain in place. The incumbent never wants to be displaced," said Matt Tsien, Executive Director of Global Technology Engineering for General Motors Corp.

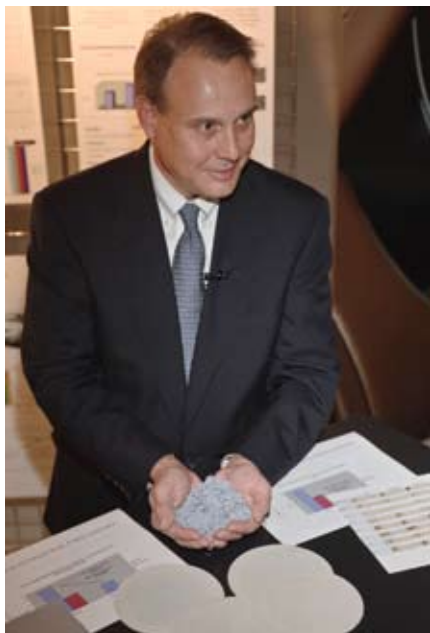
A change in materials might be warranted if a proposed solution proves to have value in the context of cross-platform and global applicability as well as demonstrating other merits. The following examples highlight a few of the plastics-composite projects being evaluated by GM researchers.

development project, a Corvette Z06 carbon-fiber wheelhouse assembly was replaced with a nanocomposite system for a 0.16-kg mass savings and a 35% cost reduction," Tsien said during a keynote speech at the 2008 Automotive Composites Conference sponsored by the **Society of Plastics Engineers**.

The 2009 Corvette ZR1 has a carbon-fiber hood, roof, front splitter, front fender, and rocker panels. "But one of the problems with carbon fiber is it's absolutely expensive. If we're able to come up with an industrial grade of carbon fiber

plastic (D-LFT) is being eyed as a replacement for current preform technology on rear-end compartment applications. "D-LFT presents an opportunity to add ergonomic features, stowage, and other space and parts consolidation at no additional processing cost. We're targeting a project deliverable that would provide a 20% cost reduction in raw material costs and a 35% reduction in tooling costs," said Tsien.

Liquid crystal polymer (LCP) is a material that "has a lot of potential," Tsien believes. While the electrical and electronics industries presently have LCP applications, auto-

Interiors**The 'greening' of interior leather**

Eagle Ottawa's Nathan Mullinix holds leather shavings, which today are sent to landfills. In the future, the leather shavings are planned to be a key ingredient in select automotive interior applications, such as a covering material for door panels.

An investigative program to re-use scrap material generated during the leather-making process could potentially prevent more than 2100 ton (1905 t) of leather shavings from being dumped into landfills each year.

"We are able to redirect or repurpose 95% of our trim-leather waste," said Nathan Mullinix, Vice President of Research and Development in the Americas for **Eagle Ottawa**, the world's largest provider of automotive interior leather. "On a yearly basis, that means approximately 4500 ton of our leather waste is re-used. Leather shavings are not being repurposed today, but we're working to change that."

Perhaps as early as 2010, production vehicle interiors could include products made from Eagle Ottawa's leather shavings. What is needed to transform leather shavings into leather-covered interior applications involves the binding technology.

"Thinner, more pliable substrates are being developed as is the coating and graining technology that would be required to convert these thinner and more pliable substrates into products that will meet or

exceed automotive requirements," said Steve Surbrook, Director of New Business Development for Eagle Ottawa, headquartered in Auburn Hills, MI. "This is still a

concept material, but component wrapping applications and seating applications are being investigated."

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wrapped interior trim easy to clean is also getting attention. Eagle Ottawa researchers are working with representatives of the supply base to evaluate finishing materials as well as new resins that could be used to elicit leather that is cleanable. "Our ultimate goal for anti-soiling coatings would be to develop a leather that does not get dirty, meaning it resists soiling agents," said Mullinix.

Stains from food, ink, and blue jean dyes are among the more common foils for leather, so keeping leather looking new on vehicle seats and other interior surfaces can be a challenge for consumers. "It may be a rather ambitious goal to prevent soiling agents from staining leather, which is why as a practical substitute the development of leathers that are more easily cleanable with simple soap and water is a good improvement and is therefore more realistically obtainable in the near-term," said Mullinix.

Current product offerings include water-resistant leather and Cool Leather. Intended for open-air vehicles, water-resistant leather is designed to slow the penetration of water without adversely affecting the leather. "Through our custom leather tanning process, we impart water-resistant character to the leather," said Mullinix. Cool Leather is designed "to reduce the surface temperature of the leather by as much as 40°F when compared to conventional leather. Our Cool Leather is based on a chemical technology that reflects approximately 50% of the sun's energy away from the leather," said Mullinix.

The privately owned Eagle Ottawa has 19 design, sales, and manufacturing facilities in Asia, Europe, North America, and South America.

Kami Buchholz

Body

Hymer prototype EV uses spaceframe



John Kendall

The Hymer Teamo boat chassis construction incorporates a simple aluminum spaceframe and a sandwich floor housing the electric drivetrain.

Better known as a producer of motorhomes in Europe, German manufacturer **Hymer** unveiled a prototype electrically powered light cargo van at the IAA Commercial Vehicles show in Hanover, Germany. Designed around what the company refers to as a boat chassis, the spaceframe construction would accommodate the complete electric drivetrain beneath the sandwich floor toward the rear of the chassis. The lightweight chassis is designed to accept a number of bodywork options including a cargo van and passenger car.

Named Teamo for True Electric Auto Mobility, the concept is constructed using aluminum profiles and a thermoplastic sandwich construction—chosen to provide a lightweight construction strong enough to offer good impact resistance at reasonable cost for low-volume production.

The Teamo consists of the boat-shaped chassis structure made up from circular, multi-

ple-chamber aluminum profiles. All-round roll bars in the A-, B-, and C-pillar areas make up the simple spaceframe construction. Hymer claims that with the front and rear crash boxes, this setup allows for some 75% of crash safety requirements.

The company claims that it offers 3.0 m³ (106 ft³) of load space volume as a cargo van. A further 200 L (7.1 ft³) of storage space is provided at the front, beneath the hood. Exterior dimensions show an overall length of 4000 mm (157.5 in) and a height of 1720 mm (67.7 in). The design includes a low-height slide-out loading floor.

Hymer quotes an approximate mass for the vehicle with cargo van body of around 1000 kg (2205 lb), offering a payload of approximately 600 kg (1320 lb). The bare chassis has a mass of approximately 500 to 700 kg (1100 to 1540 lb), depending on battery requirements.

The prototype on display was based on a wheelbase of

2700 mm (106.3 in), but Hymer envisages a wheelbase range between 2400 and 2800 mm (94.5 and 110.2 in) as required. Partners for technology include **Alcoa Automotive**, **Continental**, **Hella**, **Formtec**, **IAV**, **Strähle and Hess**, and **Taracell**. The prototype on display at the show was produced by specialist model maker **Berner-Procoda**, based near Stuttgart, Germany.

Using Li-ion batteries, Hymer estimates that the vehicle would have a range of 120 to 150 km (75 to 93 mi). Hybrid and fuel-cell power are also considered in the driveline, in the shape of twin-cylinder internal combustion or fuel-cell range-extending power sources. Rear suspension is by self-leveling air springs, while the company expects power to come from an electric motor of approximately 50 kW.

The bodywork contains a roof module of fiber-reinforced plastic, incorporating parking lamps and integrated sun visors. Other features include a split side door and tailgate. Body panels are produced from recycled thermomolded sections and heavy-duty elastic paneling for relatively low-cost damage replacement parts.

The design team was led by Hymer Managing Director Johann Tomforde, who was involved in electric City Car projects at **Daimler Benz** in the early 1970s. Professor Tomforde was the project leader for the Mercedes City Car in the early 1990s, conceived before **Mercedes-Benz's** involvement with the **Smart** project.

John Kendall

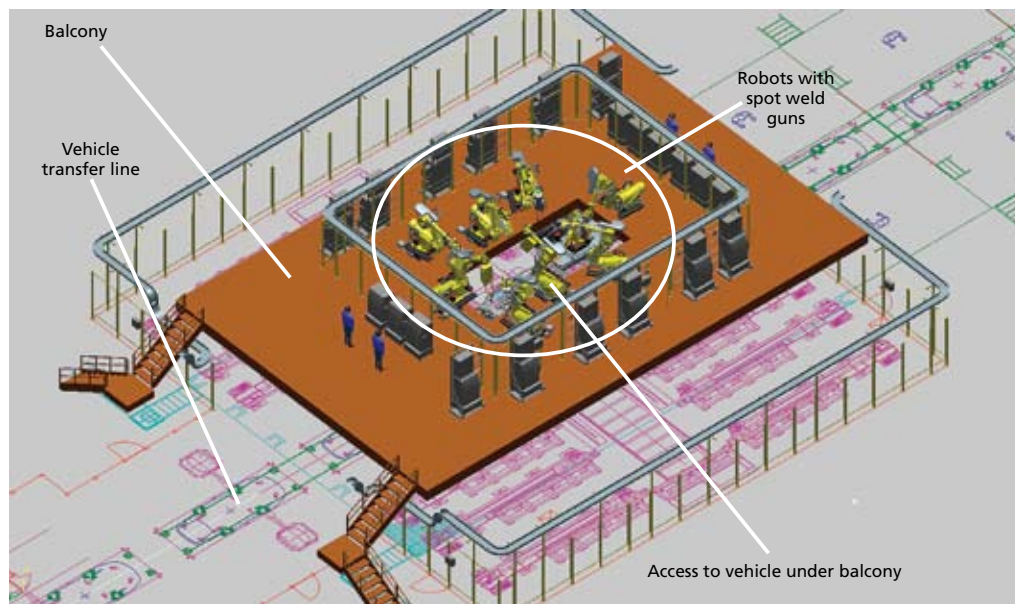
Manufacturing

Ford furthers plant flexibility

Keeping the assembly lines going at a cost-effective pace when public tastes may shift as fast as the price of oil is a challenge that can be met only with highly flexible manufacturing. Considering this seemingly permanent shift by consumers to smaller, fuel-efficient models, **Ford** Motor Co. not only has to make its plants flexible but bring in the right products for them to build.

Getting the plants ready is the job of Joe Hinrichs, Ford Motor Co.'s Global Manufacturing Chief. To start, he said, Ford is undertaking a changeover in three North American truck/SUV factories, including those in Louisville, KY, and Cuautitlan, Mexico, as well as the Michigan Truck Plant in Wayne. When the conversions are complete, the two U.S. plants initially will make cars and crossovers based on the global C-platform (Focus size). The Mexican plant will begin by building the smaller Fiesta. The Michigan truck plant is scheduled to begin C-platform production in 2010.

Flexible manufacturing is not the ability to produce differently badged vehicles primarily with trim differences, such as the Ford Expedition/**Lincoln** Navigator and Ford Escape/**Mercury** Mariner. That has long been done. The object is to be flexible enough to make truly different vehicles in different sizes. Although it even would be possible to produce unit-body and body-on-frame models on the same flexible lines, that would push flexibility into less efficient levels, Hinrichs said. However, he continued, if all were unit



This Ford flexible body shop station has a balcony above the transfer line along which body assembly occurs. Robots are located both on the balcony and at the sides of the transfer line. A large access opening in the balcony above the transfer line permits robots to pivot down to apply spot welds.

body, a size smaller and/or larger than the primary one could easily be accommodated, such as a C-size line also making smaller ("B") and larger ("D") models. Going beyond those limits, he continued, would require greater robotic operating range, and the greatest efficiency and quality is with smaller, simpler robotic movements. But even within those size ranges, crossover, sedan, coupe, SUV, and luxury versions of them could be accommodated on the same line, he noted.

Key to flexible manufacturing is the design of each vehicle and its components. There must be common assembly locating points for all vehicles, and the assembly process must permit almost all of the same tooling to be used. With virtual manufacturing, the process can be commonized on the computer and all tooling clearances veri-

fied for the different models and components, including powertrain.

In a flexible Ford body shop (a line where the metal sections form the body), about 80% of the welding robots can be programmed to switch between different types of vehicles. At present, 87% of Ford body shops worldwide are flexible, including the one at the Michigan Truck Plant, and Ford will have converted all remaining shops by 2012.

The body shop, indicative of the flexible approach, has stations with a balcony surrounding the body buildup transfer line. Robots are strategically placed both on the balcony and at the sides of the transfer line. The robots can reach down from the balcony as well as pivot in from the sides of the line to position components and apply the maximum number of welds at an individual station.

Body and final assembly are where much engineering work remains to be done by Ford. The build sequence must be compatible with all the vehicles to be built, and the assembly lines must be configured properly for the sequence to work efficiently. As an example, Hinrichs said, an instrument panel must not only be installed in the same way on all vehicles, but also be installed in similar assembly conditions, such as with doors off, which is now the Ford universal method.

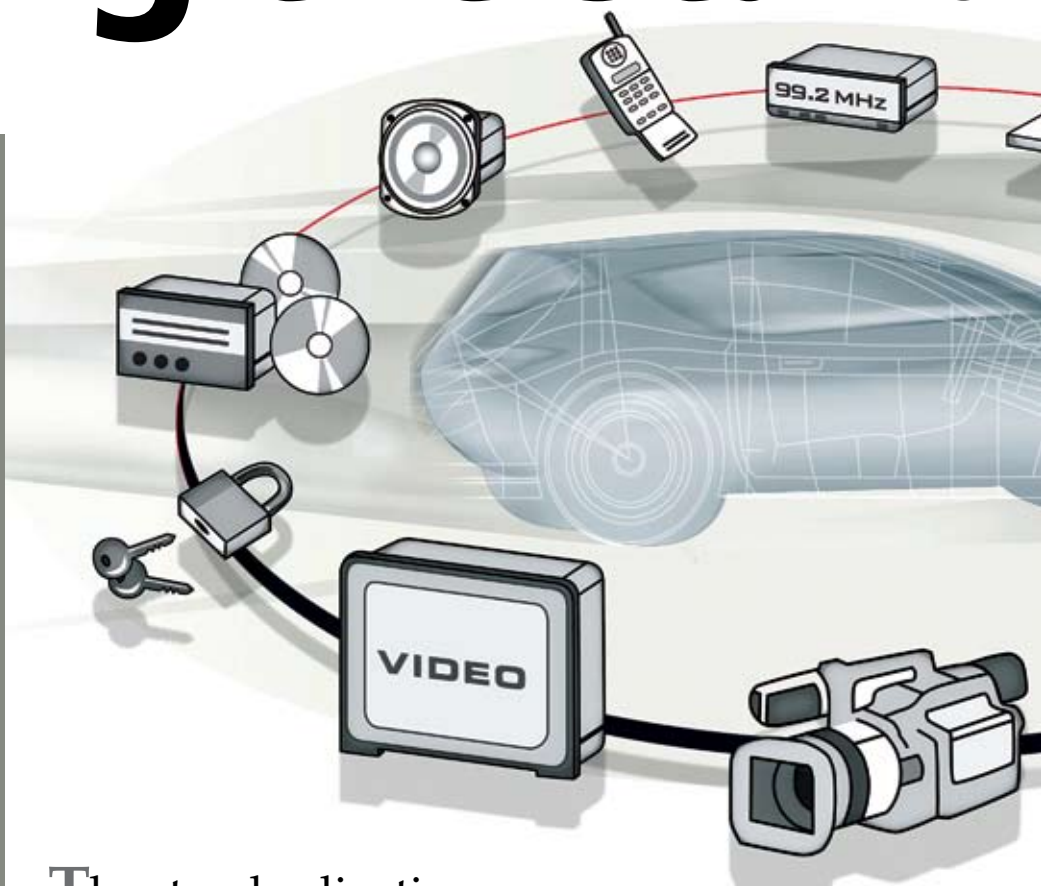
Paul Weissler

Setting the stand

Automakers along with their supplier partners are now embracing many interfaces and protocols to enable compatibility with consumer-electronics devices as well as other advances.

by Terry Costlow

Right: MOST helps link consumer products to the vehicle, providing enough bandwidth for video without slowing other equipment.



The standardization

that is a cornerstone in the success of many electronic technologies is moving into the automotive industry. Automakers who once shunned standards are adopting more of them quickly in some areas, slowly in others.

The need to link consumer-electronics (CE) devices to radio head units has forced automakers to adopt the interfaces commonly used in consumer products. They are also going beyond this necessary step,

looking at consumer electronics to carry video data throughout the vehicles.

At the same time, the AUTOSAR standard is inching forward, providing a common interface between hardware and software. Overall, these adoptions show a marked change from years past, when standards like SAE J1850 were adopted slowly and altered so much that compatibility was impossible.

Today's vehicles adhere to a few modern-day electronics standards and protocols, but more are on the way. CAN (Controller Area Network) buses are now ubiquitous, but acceptance of the first widely used standard was initially quite slow. Since then, the move to standards has gained momentum, prompting some to predict that this trend will foster even more adoption.

"Success breeds success. The Germans, who generally lead in adopting standards, then went to LIN (Local Interconnect Network), which was quite an immediate success as a low-cost bus," said Paul Hansen, Editor of the *Hansen Report* on

Availability of Technology in U.S. Car Models in 2008 and 2009

Model year	Models	Bluetooth	iPod integration	USB interface
2008	Number	149	105	43
	Percentage of total	55%	39%	16%
2009	Number	221	157	90
	Percentage of total	82%	58%	33%

Source: iSuppli Corp., October 2008

Bluetooth is widely available today; MP3 connectivity is becoming far more common.

ards



Automotive Electronics. "Now the industry has gotten better about migrating to standards."

Many of those standards associated with the cabin, where connectivity with consumer electronics requires compatibility, are being adopted more quickly.

Bluetooth wireless connections reached 55% in 2008 models, with growth to 82% in sight for 2009, according to **iSuppli Corp.** Automakers will offer the USB (Universal Serial Bus) interface option for integration with portable media players on one-third of all vehicle models next year, up from just 16% in 2008. In 2009, 58% of car models will have **Apple iPod** support, iSuppli predicted.

Bluetooth is extending its reach beyond phones with the A2DP (Advanced Audio Distribution Profile), which streams audio content to a vehicle's radio head unit. Many do not expect the compatibility issues that plague the fragmented cell phone market to slow growth in the narrow niche of MP3 players.

"Once you support iPod, [Microsoft's] Zune, and [Creative's] Zen, you're pretty much set," said Nathan John, System LSI Manager for **NEC Electronics America's** Automotive Strategic Business Unit. Few expect the new Wireless USB to challenge Bluetooth in this application.

An open question

Though the audio standards driven by the CE industry are fairly well established, there is still plenty of discussion for the



BMW turned to the MOST architecture to carry video to the back seat in its X6.

broader infotainment area, where automakers write the rules. Here, adoption is moving at a slower pace.

Three specifications are currently vying for acceptance as the high-bandwidth architecture for infotainment. They are needed primarily for video, though when telematics and private audio streams from radios that many users want are added, fast infotainment networks may be needed.

Media Oriented Systems Transport (MOST), Ethernet Audio Video Bridging (AVB), and IEEE 1394 (some examples known

as Apple FireWire, Sony i.LINK, and Texas Instruments' Lynx) are all being considered for use as an infotainment backbone. MOST is currently the dominant player, with 55 vehicle designs ranging from BMW and Saab to Kia and Hyundai, according to the **MOST Cooperation**, the technology's trade group.

Some of the current applications have used copper-wire versions, but the majority of new applications employ MOST150, which uses optical fibers to move data at 150 Mbits/s. The architecture is beginning to expand beyond luxury vehicles. "You will see much lower-end cars using MOST in the next few years," said Mandy Ahlendorf, Managing Director of the MOST Cooperation.

Though MOST typically operates as a stand-alone architecture, it can carry Ethernet protocols. Ahlendorf downplayed

competition between the architectures.

"This is not a battle of the interfaces, but rather a cooperation, and a race to see who can design the best user experience by integrating all the CE devices a consumer brings into the vehicle," she said.

The contenders

However, many others contend that there will be some competition. Ethernet AVB uses copper wiring, which is simpler to install than optical. It provides compatibility with widely used networks without any overhead for another standard.

"One application for Ethernet will be as an alternative to MOST," said Kevin Klein, Standard Product Marketing Manager at **Freescale Semiconductor's** 32-bit Embedded Controller

AUTOSAR advances come slowly but surely

AUTOSAR is perhaps the most prominent new standard in automotive electronics today—one that is expected to change the way the industry works. Though it will lower development costs for suppliers and make it easier for OEMs to migrate from one vendor's products to another, it is still surrounded by a number of minor questions.

The standard has broad support throughout the auto industry, and it is generally perceived as a specification that will eventually provide software links that simplify the adoption of new hardware. Release 2.1 was completed early last year, paving the way for adoption.

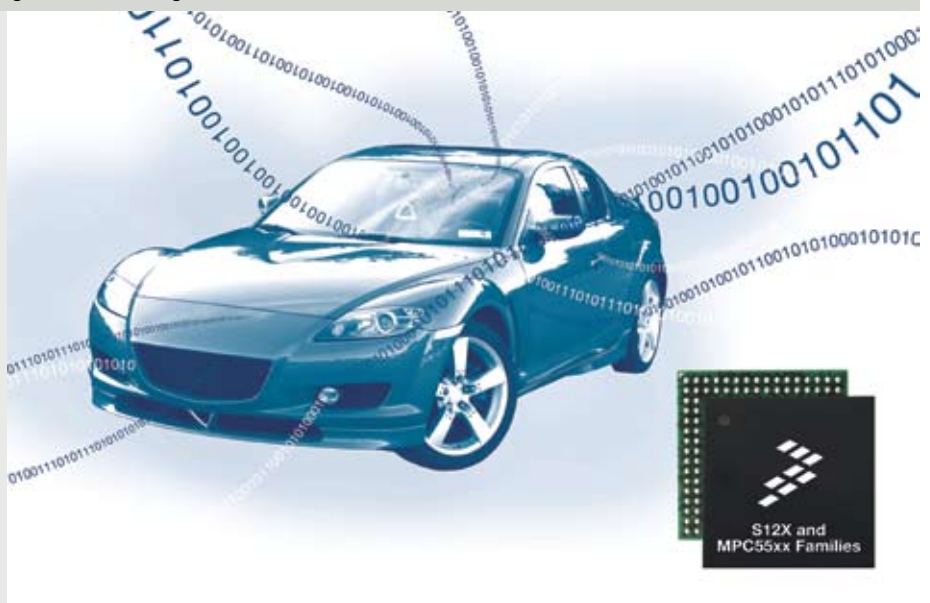
With solid support from member companies, the **AUTOSAR Development Partnership** is moving ahead with improvements that will broaden the benefits. "We're moving from 2.0 to 3.0, adding more safety elements like memory protection and fault tolerance," said Wayne Chavez, Automotive Software Marketing Manager at **Freescale Semiconductor**.

Implementation is inching forward even though it takes a lot of development time and money to adopt AUTOSAR. However, most agree that the trade-offs justify these investments.

"It costs more up front to create compliant drivers, but a generation or so in you get the payoff of easier migration from generation to generation," said Nathan John, System LSI Manager for **NEC Electronics America's** Automotive Strategic Business Unit.

How quickly the industry will make the transition was always in question, and the current economic crisis has only increased uncertainty about these costs. Many observers say the payback for today's expenditures is quite a ways off.

"AUTOSAR is definitely in the works, but it will take a very long time before the industry gets the benefits of the standards, probably 10



AUTOSAR provides a standard format for software, making it simpler to implement hardware such as chips from Freescale.

years or so," said Paul Hansen, Editor of the *Hansen Report on Automotive Electronics*.

That long payback period is due in part to hesitation by many automakers to adopt the technology quickly. There is little incentive to replace existing software modules, so most advances will come in new areas without legacy code.

"Part of the roadblock is existing software," said Bjoern Steurich, Senior Marketing Manager for Microcontrollers at **Infineon**. "Efficiency is there with AUTOSAR, but it's still not as efficient as existing drivers that have been through sometimes years of improvement."

There are also concerns that the goal of universal hardware mobility may not be met. That could occur if OEMs ask for minor

alterations, as happened with some earlier standards.

"We anticipate that the Big 3 in the U.S. will have slightly different variations of AUTOSAR," said Paul Fox, Marketing Director at **Renesas Technology America's** Automotive Business Unit.

Though many feel that modifications may arise, most are hoping they will be curtailed.

"The AUTOSAR consortium does not want to see several versions of the standard for each OEM," Chavez said. "I feel there will be a large drive to avoid fragmentation."

He added that the standard does allow for some alterations. "These are complex drivers, with areas where you can add customization and personalization," Chavez said.

Terry Costlow

Division. "Another will be as a communication pipeline into the vehicle. When you've got 40, 60, 80 micros that need updating, you need a high-bandwidth way into the vehicle."

Other chipmakers say they are also seeing more interest from U.S. automakers who want a single architecture for infotainment and external connectivity. The connectivity of the widely used network is a key factor behind this view.

"Ultimately, Ethernet is a better standard for high-speed links," said NEC Electronics' John. "It's open, while MOST has some proprietary elements. It's a natural bridge to the car, a way to do diagnostics or code updates, and you can hook your car up to your computer."

Ethernet is not the only alternative. Earlier this year, the **1394 Trade Association** completed an automotive version that has

Economies may slow FlexRay's growth

The FlexRay network was expected to be entering a solid growth period over the next few years, but the double whammy of the lousy economy and fuel economy are slowing its adoption. At least one market analyst predicts that automakers will delay implementing the networking standard, instead targeting scant resources on fuel conservation in response to tighter U.S. restrictions.

In 2005, **Frost & Sullivan** predicted that, by 2012, FlexRay would be on 20% of light vehicles sold in the U.S. But that is not likely to happen now.



BMW was the first carmaker to design FlexRay into a vehicle—in its latest X5.

"Automakers have shifted their focus to fuel economy," said Sandeep Kar, Industry Analyst at Frost & Sullivan. "Once they get that under control, they will focus more on safety. That's when FlexRay will come in in a big way."

Kar would not estimate how much growth will be curtailed until further studies are completed. However, he remains bullish in the longer term, noting that the standard will play a central role later in the decade.

FlexRay usage is expanding, primarily in Germany. **BMW** deployed it first on its latest X5, and **Audi** plans to use the network on next-generation A8s.

Implementing the network pays off in the long run, but it is difficult in the short term. During Convergence, Audi engineer Jens Kotz told technical session attendees that "the challenges of such a development are quite demanding, and an intensive cooperation with suppliers was essential for success." **TTTech Automotive** was Audi's networking partner.

Terry Costlow



The Saab 9-3 is among the 55 vehicles that use a high-bandwidth network to carry video signals.

gotten strong support from one chipmaker.

"We feel confident that, at the end of the day, 1394 will be the only viable network for audiovisual networks," said Dan Landeck, Senior Manager of Automotive Solutions for **Fujitsu Microelectronics'** Automotive Business Group. "No other technology offers this bandwidth at a reasonable cost."

Honda is planning to deploy the architecture, Toyohi Nakajima, Senior Chief Engineer at Honda R&D, said during a panel at the Convergence Conference. **aei**

Readers' choice: Top technology stories of the year

The editors look back at some of the past year's most significant engineering and innovation articles according to readers of *Automotive Engineering International* and *AEI Online*.

Zircotec adds to Lamborghini's cool

Lamborghini is using automotive coating specialist **Zircotec's** new thermal barrier for its million-Euro Reventón supercar. The plasma-sprayed Diamond Black coating is applied to the exhaust to inhibit heat transfer from the tailpipe and protect heat-sensitive components from damage. Together with the new black finish, Zircotec was able to deliver a highly durable coating that met the requirements of Lamborghini's styling department. This is the first automotive production application for the Diamond Black surface, a development (patent applied for) using titania alumina and a bond coat. Until now, black was only available using high-



temperature paints, but using paint was less durable and therefore not appropriate for OEM applications. The Zircotec coating was created as a robust system that can "dramatically" inhibit heat transfer from exhausts, turbochargers, and catalysts. The technology, proven on the track in **Formula One** and **World Rally Championship** use and originally developed for the nuclear industry, can also allow OEMs to quickly resolve heat-management challenges on existing platforms. In high-performance car applications, Zircotec's zirconia-based ceramics have a thermal efficiency of less than 1.7 W/m²·K. Applied to an exhaust system, the coating inhibits the radiation of heat from the surface of the material by containing it internally.

To read more, see the October issue (p. 42) or visit www.sae.org/mags/AEI/3394

Delphi claims world-first for direct-acting diesel injection

Production of **Delphi's** Direct Acting Diesel Common Rail (DADCR) system has started following a five-year development program. The system incorporates direct-acting piezo injectors—claimed by the company as a "world first"—that can operate at pressures up to 2000 bar (29 ksi) and help OEMs meet Euro 6 emissions standards. Initial application of the technology will be on **Mercedes-Benz's** OM651 four-cylinder, 2148-cm³ diesel engine for the 2009MY. The system was designed to reduce both noise and emissions; improve fuel consumption, power, and torque; and



help provide generally enhanced refinement and driveability. The system's injector needle is set in motion directly by a piezo-ceramic actuator instead of using an electrohydraulic circuit. Injection into the combustion chamber has much improved momentum and accuracy due to "extremely fast" 3-m/s opening and closing of the needle valve, independent of injection pressure. Other highlights include a high mean effective injection pressure (square rate of injection at any pressure up to 2000 bar); multiple injection flexibility (seven or more injection events); and proportional control of needle lift by the engine control unit, thus allowing the rate of injection to be mapped into it—and elimination of back-leak flow.

To read more, see the October issue (p. 33) or visit www.sae.org/mags/AEI/4200

Shear plate reduces diesel-engine noise



Though the diesel engine's well-known and often criticized "noise" has been heavily treated with acoustic countermeasures to reduce knocking to an acceptable level on today's passenger vehicles, diesel-engine noise is expected to increase with the introduction of new Euro 5 emissions regulations beginning in September 2009. Diesel knocking is, to a very high degree, dependent on the combustion pressure, according to Léon Gavric, who is responsible for **PSA's** Powertrain NVH Department, and more specifically engine-block "breathing modes," excited by combustion. He and his colleagues had the idea of putting a constrained-layer shear plate inside the engine where the deformation in the middle layer damps the knocking. They turned to **Trelleborg Rubore AB**, which made use of its Duru-LAM (durable rubber laminate) material between two steel layers. The shear plate can be positioned differently to suit the packaging requirements of different core engine designs. Not only does the shear plate filter out unwanted noise, Gavric said the real gain is "that by reducing the constraints concerning the noise and vibrations issues, you're able to tune the combustion to reduce emissions, pollutants, and fuel consumption."

To read more, see the October issue (p. 34) or visit www.sae.org/mags/AEI/4420

Volt benefits from tech transfer

The electrical-power-management and control strategies of **Chevrolet's** Volt extended-range electric vehicle and the brand's Equinox fuel-cell vehicle underscore the relevance of technology transfer among fairly



distinct platforms and technologies. Many of the technical specialists who worked on the Equinox hydrogen fuel-cell vehicle are now involved with the Volt. "There are a significant number of engineers and program support people that have transitioned to the Volt team," noted Mark Vann, Program Development Manager for the Chevrolet Equinox Fuel Cell Program. Since the Volt and Equinox are both purely electrically driven vehicles, their electrical-power-management and control strategies are very similar. Technology exchanges are not limited to electrical-power-management and control strategies. The Volt and other vehicles employing "sophisticated technologies for fuel efficiency make use of regenerative braking, rolling resistance tires, and lightweight materials," noted Vann. According to Posawatz, the Volt's regenerative braking was a technology transfer from **General Motors'** two-mode hybrid vehicle programs. The Volt is now in its development-mule phase. About 24 mule development vehicles are likely to be built.

To read more, visit www.sae.org/mags/AEI/4380

Upgrading a pony car

Specialty vehicle maker **Saleen** has turned many mass-produced automobiles into high-performance alternatives. A current example is the transformation of the 300-hp (224-kW) V8 **Ford** Mustang that gains more than double the power en route to becoming the Saleen S302 Extreme. The S302 Extreme's engine gains a forged steel crankshaft, H-beam forged rods, and forged pistons. Engine breathing is aided by CNC machined cylinder head ports and combustion chambers; a Saleen **Lysholm** supercharger; charge cooler; and cold-air induction system. Power is channeled to the ground by a high-performance clutch and driveshaft and 3.73:1 Max Grip axle. "These are the things you must do to harness 620 hp. In addition to the above-noted changes, there are new brakes, a new suspension with second-generation Watts link, new wheels and tires, as well

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as interior and exterior functional and appearance upgrades," said Chris Theodore, Saleen's Vice Chairman and Chief Technical Officer. Saleen has been busy on other fronts. In late 2007, its primary investor, **Hancock Park Associates**, acquired **American Specialty Cars** (ASC) Inc. "As we continue to expand our engineering staff, we're looking for more powertrain engineers, especially calibrators, as well as chassis engineers, and body and interior trim engineers. We're also looking to grow in the electronics-features area, so there is a need for electronics engineers, too," said Theodore. In the near term, ASC and Saleen will be separate companies, but the long-term plan calls for integrating the two. To read more, visit www.sae.org/mags/AEI/2109

A racecar that moves without going anywhere

Formula One racecar drivers could zoom around a track hour after hour to get ready for race-day situations, but that type of preparation is track time-restricted by **FIA** (Fédération Internationale de l'Automobile) rules. There is an alternative way to enhance a racing program, and **Ferrari's** F1 team has opted for it. "The dynamic driving simulator is a new step for us in developing virtual tests that give pilots a true feel of a real environment and direct feedback on their actions," said Marco Fainello, Head of the Car Performance and R&D



Department for **Scuderia Ferrari**. Drivers will be spending time under a domed environment of near-reality. The bottom half of the under-development device will use actuators to mimic the motion of an F1 racecar, while the top half will provide an actual F1 racecar monocoque surrounded by a 180-degree screen showing projections of generated circuit images. The project is said to represent a step-change in human-in-the-loop testing technology, with enhanced fidelity through advanced platform kinematics and optimized motion cues," said Pim van den Dijssel, Market Manager of Test Systems at **Moog FCS**. Simulator maker **Cruden** will deliver the software and image generation as well as the integration of the vehicle models from Ferrari. Delivery of the simulator, which is slated for late 2009, will follow a series of trial runs. To read more, visit www.sae.org/mags/AEI/3559

Corvette Racing laps up E85



The Corvette Racing crew had a challenge: make sure that one of the most technically advanced sports cars ever developed by **General Motors** could flat-out race on ethanol fuel. Developed to compete in **American Le Mans Series** races on E85 racing fuel, GM's LS7.R engines were modified from the E10 specifications of the 2007 race season. Roger Allen, Engine Program Manager for the C6.R (Corvette 6th generation, Racing) program. The C6.R program continues the tradition of racing production-based vehicles. Steve Wesoloski, Road Racing Group Manager for GM Racing. Although the advanced engineering group is kept in the loop on the lessons learned from LS7.R development work, not every technical tweak is directly applicable to today's production applications. "Their focus on emissions, idle quality, and part-throttle fuel economy is much more critical, (so) a direct transfer of our hardware or calibration is not logical," noted Allen. The transition from E10 to E85 was seamless and uneventful, noted Allen. "If I had to say what area we had to work on the most, it would have to be fuel economy. With the reduced energy content of E85, much work was done to be as efficient as possible." To read more, visit www.sae.org/mags/AEI/4359

New GM center focuses on powertrains



General Motors has opened what it says is the world's largest and most technically advanced powertrain engineering development facility. The center was designed to test all kinds of products including gasoline, clean diesel, and biofuel engines, transmissions, hybrids, low-voltage, and high-voltage technologies, said Larry Nitz, Executive Director of General Motors' Hybrid Engineering. Located adjacent to GM Powertrain's Global Headquarters in Pontiac, MI, it links to GM's 11 other global powertrain facilities via a common laboratory operating system that enables around-the-clock development. Automated test procedures enable 24-h testing without in-person monitoring. Other innovations at

the facility include 168 U-shaped pallets supplied by **AVL** to increase test-cell throughput and flexibility and a dynamic test tilt stand, developed by GM and **Moog FCS**, that is capable of 53 degrees of tilt in all directions as well as simulating accelerations in two axes up to 1.3 g. The new \$463 million center effectively paves the way for General Motors to save, on average, 10 weeks of critical development time on programs and \$200-plus million when combining the savings in North America with all of the global Road-to-Lab-to-Math initiatives within GM Powertrain. When combining the 1200 employees being transferred to the new center from four other Michigan facilities, the GM Powertrain Global Headquarters campus will employ approximately 4300. To read more, see the November issue (p. 44) or visit www.sae.org/mags/AEI/3718

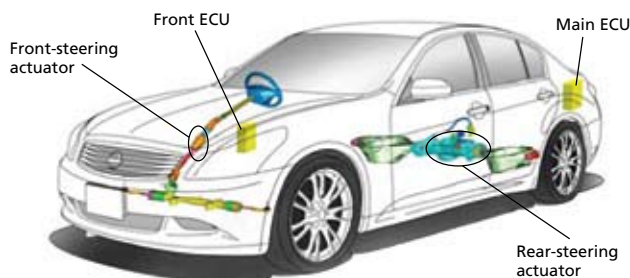
Green the theme of '09 SAE Congress

Honda is challenging automakers, suppliers, and engineers to a race to "greener mobility," with the ultimate goal of "dramatically reducing" CO₂ emissions that contribute to global warming. Proposed by Masaaki Kato, President of Honda R&D Co., Ltd., and Chairman for the **SAE** 2009 World Congress, this race "does not pit us against each other as enemies; rather, we are racing with each other toward a common goal. The ultimate winner will not be just the companies we work for, but rather the human race and the planet that sustains us." As a keynote speaker at this year's SAE World Congress in April, Kato revealed the host company's "Racing to Green Mobility" theme for the '09 show, challenging engineers to be honest with each other about the technical challenges they face and to "compete with technology, not words." Advanced batteries, he noted, are an example of a critical technology that needs to progress for electric vehicles, hybrids, plug-ins, and fuel-cell vehicles to reach their full potential. The challenges that remain are reducing the size, weight, and cost of batteries while improving their durability, safety, and performance. Supporting Honda with its green theme will be Robert **Bosch**, the Tier 1 Strategic Partner for the '09 SAE World Congress. To read more, see the July issue (p. 45) or visit www.sae.org/mags/AEI/3325



Nissan shows benefits of active four-wheel steering

When most people think of steering, they think of the front wheels and tires doing all the work. In reality, the rear wheels aid the process, and some car makers have taken this concept a step farther and added more extensively capabilities to the rear axle to aid overall vehicle steering performance and make higher cornering limits easier for drivers to achieve



while simultaneously easing the steering task. One innovator in the rear-steering area is **Nissan**. Its engineers have been developing rear-steering systems for improved vehicle dynamics for more than 20 years. Its engineering efforts have culminated in what the company calls the world's first four-wheel active steer (4WAS) system. The system integrates rear- and front-wheel active-steering capabilities for the latest Nissan Skyline and **Infiniti** G35. The goal of company engineers was to achieve dynamic performance characteristics traditionally regarded as contradictory: quick, sports car-like reflexes at low to medium speeds combined with vehicle stability in the high-speed range. This was accomplished by increasing steady-state yaw-rate gain at low to medium speeds and reducing it in the high-speed range. Nissan engineers are so encouraged by the benefits of 4WAS that they plan to make continuous improvements and refinements to the system for future vehicle applications. To read more, see the July issue (p. 42) or visit www.sae.org/mags/AEI/3323

Hybrid Class 8 trucks for Wal-Mart

The notion that hybrid-electric technology only makes sense on vehicles with stop-and-go duty cycles could be dispelled after a dual-mode diesel-electric Class 8 truck hits the highway in early 2009. A **Navistar** project could prove that the heavy-duty truck industry is an appropriate fit for hybrid-electric technologies, said Michael Roeth, Director of Global Advanced Engineering for Navistar Inc. **ArvinMeritor's** dual-mode diesel-electric drivetrain will employ the electric motor primarily during low-speed—typically below 50 mph (80 km/h)—operating conditions such as accelerating from a stop. Developers expect the truck to operate in zero-emissions mode for 20 mi (32 km) or 20 min, whichever comes first. When the battery state-of-charge drops to about 15%, the **Cummins** diesel engine will be started and the generator will be used to recharge

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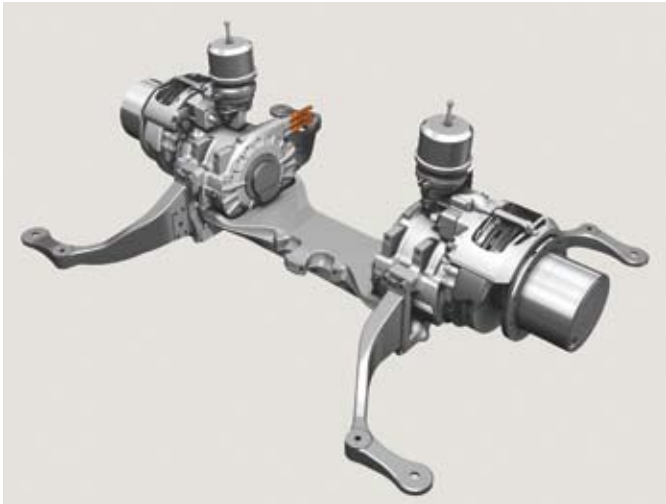
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the battery. Two lithium-ion battery packs will be located along the side rails behind the fuel tanks. At highway speeds, typically above 50 mph (80 km/h), the operation switches to parallel mode, which is primarily diesel-mechanical. Retailer Wal-Mart is expected to take delivery of the Class 8 ProStar demonstrator hybrid truck in early 2009 in anticipation of exceeding its goal to increase fleet efficiency by 25%.

To read more, visit www.sae.org/mags/AEI/2865

Heavy-duty hybrid ZF concepts at Hanover



A serial hybrid drive axle concept for city buses, an independently suspended heavy-truck chassis concept, and revised automated and automatic transmissions were among the exhibits that ZF displayed at September's IAA Commercial Vehicle Show in Hanover, Germany. While ZF expects that parallel hybrid systems will be the choice for most vehicle manufacturers, the company believes that the challenges of inner-city driving faced by city buses will make serial hybrid systems attractive. The company showed an electrically driven low-floor city bus axle for use with serial hybrid drive systems at the show. Designed for a maximum axle loading of 13 t (14 ton), each wheel on the concept axle is driven by a high-speed asynchronous motor with a downstream two-stage ratio. The motor's fixed ratio would eliminate gear changes and the potential discomfort this could bring to passengers. Each motor delivers maximum short-term drive power of 240 kW and continuous power of 120 kW. The liquid-cooled motors can be powered from a variety of sources, either individually or in combination, including an onboard diesel generator, overhead power lines, or fuel cells. ZF plans to put the electric drive axle into production in 2010.

To read more, visit www.sae.org/mags/AEI/3919

DFI and PDK for 911



There seems to be no end to the enduring story of the **Porsche 911**, this year marking the 45th anniversary of its unveiling (initially as the 901) at the Frankfurt Motor Show. Now Porsche has introduced its latest technology evolution: direct fuel injection (DFI) flat-six engines and a ZF seven-speed dual-clutch PDK (doppelkupplungsgetriebe) transmission. The introduction of DFI provides added power and torque for a lower fuel burn and subsequently reduced emissions. For the 3.6-L Carrera, for instance, output rises by 6.2% to 254 kW (340 hp) and torque by 5.4% to 390 N·m (288 lb·ft), while fuel consumption drops by 6.4% with a manual gearbox or 12.5% with the PDK transmission. The PDK (ZF's internal designation is 7DT 50) comprises a manual gearbox and a hydraulic control system divided into two transmission units. Two parallel powershift wet clutches, arranged radially and hydraulically controlled, use oil for cooling and lubrication. While one gear in one of the transmission portions is engaged to provide propulsion, the next gear is ready in the other for selection by the system's control unit. When shifting, one clutch closes as the other opens with no interruption of traction. The 120-kg (265-lb) transmission weighs about 10 kg (22 lb) less than the previous Tiptronic S transmission.

To read more, see the August issue (p. 26) or visit www.sae.org/mags/AEI/3392

Bosch Engineering grows with niche projects



Engineering services have been a growing business for years, fueled by the increasing complexity of electronic vehicle systems such as engine management, safety system software, and many more. The market dynamics were further pushed by the tendency of vehicle manufacturers to increase the responsibility of their suppliers. While it was quite manageable to justify the growing engineering efforts for large series production vehicle projects, the situation was quickly deteriorating for the makers of niche models since the mid '90s. When **Bosch Engineering** was founded in

1999 with 13 Bosch employees under the initial name of Asset GmbH, the startup company focused on Bosch gasoline system applications for vehicle makers such as **Ferrari**. Soon, the engineering portfolio began to include the full range of drivetrain applications, safety and comfort, E/E integration services, testing services, and consulting. Today, the focus "is on anything that moves," said Bernhard Bihr, Managing Director of Bosch Engineering GmbH. In January 2008, the worldwide number of Bosch Engineering employees passed the 1000 threshold. By July, this figure was 1200 and growing, according to Bihr.
To read more, see this issue (p. 44) or visit www.sae.org/mags/AEI/3743

Quo vadis, heavy-duty engine

With environmental awareness at an all-time high, the real challenge for heavy-duty diesel engines is bringing emissions further down while limiting costs. "Emissions legislation is driving over 75% of engine R&D," said Alex Woodrow, Director and Head of Research at **Knibb Gormezano & Partners**. In the NAFTA market, the 2007 **EPA** emissions standards were met with high EGR (exhaust gas recirculation) rates and DPF (diesel particulate filters). In Western Europe, most large trucks will use a combination of EGR, selective catalytic reduction (SCR), and DPFs to meet Euro VI emissions regs. (An exception is **Scania**, which uses optimized EGR without SCR for some of its new engines. Its Euro V-compliant engines are equipped with 2400-bar (34.8-ksi) extra-high-pressure common-rail injection technology and EGR but have no SCR.) Medium applications may only require SCR and DPF technology. With its Post New Long Term standard, Japan will go to the most stringent emissions legislation in



2009. China will clearly be the world's largest market with an increasing focus on heavy trucks. Its adoption of Euro III and IV is agreed upon, but the introduction was delayed to mid-2008 and its lack of low sulfur fuel is an issue. In India, Euro III will be adopted in 2010; Euro IV is scheduled for introduction in major cities three years before the roll-out to the whole country. Poor fuel quality and engine availability put a question mark behind this, though.

To read more, visit www.sae.org/mags/AEI/2996

3-D road mapping to improve economy

Thousands of feet above ground level, specially equipped airplanes are acquiring data that are used to create 3-D road geometries, and those terrain profiles could become a viable tool for tailoring a vehicle's power-train control strategies for better fuel efficiency. "Along with **Auburn University** and **Eaton Corp.**, we're investigating whether knowledge of the road grades ahead can present opportunities for fuel-economy gains in commercial trucks," said Steve Zaroukian, Director of Business Development for the Automotive Division of Denver, CO-headquartered **Intermap Technologies** Inc. The research work looks promising. "It was found that a 2 to 3% fuel-economy savings could be realized by opti-



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mizing the vehicle velocity profile over the course of a long-haul truck run across interstate highways with variations in elevation," explained David Bevely, Associate Professor, Department of Mechanical Engineering at Auburn University. Wei Huang, a mechanical engineering graduate student at Auburn University, "developed a method to determine the optimal speed trajectory over a terrain and then in simulation compared the fuel usage using a standard (i.e., constant) cruise-control setting vs. following the optimized velocity profile for the terrain," noted Bevely. The next step is a real-world test with a Class 8 heavy-duty truck, with more development work expected next year.

To read more, visit www.sae.org/mags/AEI/3980

MOST ups bandwidth to 150 Mbps

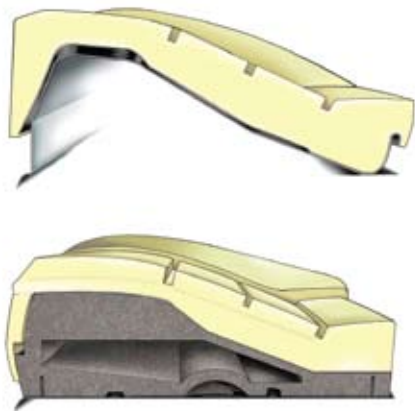
In Frankfurt, Germany, the **MOST Cooperation** presented the third generation of its optical multimedia network protocol called MOST (Media Oriented System Transport). At 150-Mbps bandwidth, the new infotainment backbone offers the muscle for in-vehicle digital video streaming including HDTV. It also incorporates an additional channel for ethernet communication that "would make standard internet protocol applications in the vehicle very well possible," said Christian Thiel, Administrator of the MOST Cooperation. However, 150 Mbps may not be the end of the line. Robert Reiter, System Architect at **BMW** for Information and Communication Systems, explains: "Permanent progress in the LED field means that the opto-electric coupling keeps getting faster. The current limit is around 200 Mbps."

Melexis, a **General Motors** networking component supplier, presented the first component for the new MOST generation at Frankfurt. The highly compact MLX75605 surface-mount transceiver embeds a 650-nm light source and driver IC (integrated circuit). It is based on the recently published 0.9 version of the physical layer specification. After the 1.0 version is published, "that is when series production of our new transceiver can start," said Piet de Pauw, Chairman of the Opto Division of Melexis.

To read more, see the July issue (p. 33) or visit www.sae.org/mags/AEI/3319

Expanded polypropylene simplifies BIW

A weight-saving, anti-submarining rear-seat ramp system designed to reduce body-in-white (BIW) complexity across platforms has been announced by expanded polypropylene (EPP) specialist **JSP**. The company's ARPRO EPP is sufficiently strong and resilient to enable the ramp to be incorporated into the seating itself, replacing the usual metal structure



and contributing to a simpler vehicle platform. As a result, serviceability is improved and weight is reduced by up to 35%, claims JSP. The system is used on the new **Volvo XC60**, the application bringing a cost savings vs. a traditional fixture of some 20% and a mass savings of 2.5 kg (5.5 lb). By varying the size and shape of the seat bench's ARPRO component, designers can tailor the H-point. Platform variants can each benefit from the elimination of the anti-submarine metal stamping and fixing.

To read more, see the September issue (p. 51) or visit www.sae.org/mags/AEI/3779

BMW camera integrates three safety functions



While most automakers move toward implementation of camera systems for lane detection, **BMW** is bundling three vision features in a multifunction system. The BMW 7 Series uses technology from **Continental** and **Mobileye** N.V. The single-camera system provides speed-limit information, high-beam assist, and lane-departure warning (LDW). Last year, BMW offered LDW on its 5 Series, and a handful of competing luxury-vehicle suppliers are also offering LDW. Both systems were developed by Continental, though the 5 Series system was developed by **Siemens VDO**, which was acquired by Continental. Mobileye's EyeQ chip, designed specifically for image processing, is used on both. The 7 Series' speed-limit function determines which road signs have speed-limit information and then displays them in the instrument cluster or the optional head-up display. Road-sign detection is a complex task because the signs vary from country to country and some signs are only for rainy conditions or for trucks. This complexity is increased in multifunction systems since cameras and image processors have to account for different parameters. The system solves this by cranking up camera speeds, tripling the normal frames per second rate to 45 to shorten the time the shutter is open. The reduced amount of available light is compensated for by algorithms that handle inputs relatively quickly. Camera-based systems are expected to see significant growth in coming years as active safety gets more attention. **General Motors** and **Volvo** are also shipping vehicles that use Mobileye's image processors.

To read more, see the November issue (p. 40) or visit www.sae.org/mags/AEI/4341

Alcoa forges ahead to reduce vehicle emissions

Where there's a wheel, there could be a way toward a quick and relatively easy reduction in emissions for existing and future vehicle programs. **Alcoa Wheel Products** states that, by selecting a forged alloy wheel, OEMs can see an immediate weight benefit with subsequent improvements to fuel consumption and CO₂ emissions. Although cast alloy wheels can be produced cost-effectively, Alcoa Wheel

Products believes forging now offers an immediate weight saving solution—even on an existing vehicle platform—where traditional mass re-



duction programs may involve costly tooling and validation. "Our analysis shows that an optimized forged, as opposed to cast or two-piece alloy, wheel can save up to 39 kg per car," said David Yates, Commercial and Marketing Manager, Alcoa Europe. "This is based on a 19-in U.S. SUV wheel. A recent program in Europe for a sports car manufacturer demonstrated that we could save close to 10 kg compared to their current cast wheel." Alcoa states that a weight reduction of 45 kg (99 lb) equates to a fuel economy improvement of 1.5%. The **Lamborghini Reventón** is one of the latest cars to be equipped with Alcoa's forged wheels. Alcoa will supply the forged directional-specific 18 x 9-in front and 18 x 13-in rear wheels, with each undergoing extensive machining and finishing, resulting in lightweight construction while meeting required strength and durability.

To read more, visit www.sae.org/mags/AEI/3838

BMW plays the transmission numbers game

BMW M claims a world first for its new seven-speed double-clutch gearbox (M DCT) with Drivelogic control, conceived and designed for a "high-speed power unit"—that is the 4.0-L V8 in the M3 range. Developed with **Getrag**, BMW says it shifts without interruption of power and traction, gearshift management with M-specific configuration, and seven gears for dynamic acceleration. The M double-clutch transmission uses two oil-cooled, wet multi-disc clutches with carbon coatings, with one or other closed at all times when the transmission is in gear. The system can be used as an auto (D mode) or manual (S mode) and spans variable shift characteristics from comfort to track. Drivelogic provides 11 electronically controlled driving programs in M-specific setup; five shift programs in auto mode and six in manual, including Launch Control for maximum acceleration from stationary. Programming is via a push of the Drivelogic button on the center console. The driving pro-



grams differ in terms of road speed at which gears are shifted as well as engine rpm.

To read more, see the June issue (p. 30) or visit www.sae.org/mags/AEI/2774

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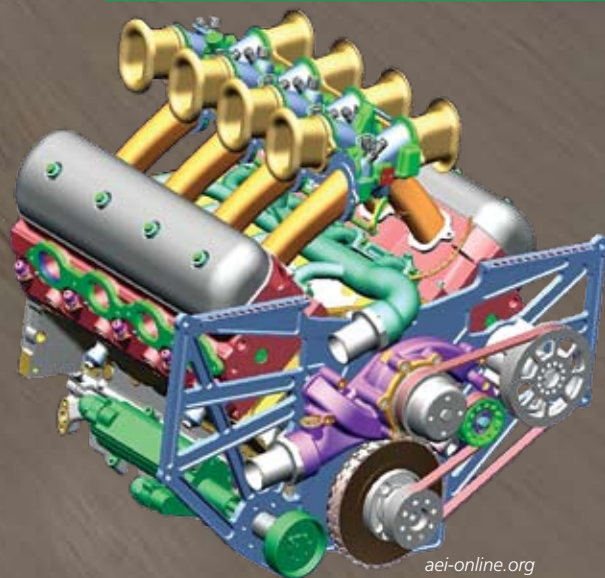
Green victory?

The motorsports community contemplates winning races while leaving behind the smallest environmental footprint.

by Steven Ashley

Above: A Chevrolet Corvette C6.R driven by Johnny O'Connell. Jan Magnussen and Ron Fellows in the GT1 class won the inaugural ALMS Green Challenge competition at this year's Petit Le Mans race in Georgia.

Bottom left and right: Cellulosic-based E85 ethanol fuels the LS7.R small block V8 racing engines that power the Corvette Racing team's two C6.R cars in the American Le Mans Series.



Not long after cars were invented, drivers began to race them. Winning races meant that builders competed to develop faster, more reliable cars that featured the best-available propulsion systems as well as innovative handling technology and related equipment.

Automakers in time realized that race victories boosted sales, engendering the adage: "Race on Sunday; sell on Monday." The rest is history. Honed to a keen edge on the ultimate proving ground, the car has since undergone the most intensive long-term engineering effort ever seen, leading in large part to the incredibly sophisticated vehicles on roads today.

But car racing has seen changes of late. No longer do technical advances on the track necessarily translate directly onto the asphalt. Much race technology is nowadays just too arcane and

stressed Scott Atherton, President and CEO of ALMS. "We believe that there's real substance to this 'race within a race,' especially since it has been validated by the EPA and DOE. We hope that the manufacturers and consumers agree." The inaugural Green Challenge took place on October 4th at this year's Petit Le Mans event in Braselton, GA.

"We need to pursue fresh ideas like green racing," asserted Herb Fishel, former Executive Director of **General Motors** Racing and SAE advisor on the topic. "The concept," he explained, "is to connect to racing the billions of dollars that manufacturers spend on R&D, so as to leverage the motorsport community's proven ability to innovate technology rapidly."

The society has provided a neutral platform by which to convene all the interested parties to look into opportunities of-



The initial Green Challenge trophy for the ALMS LMP2 (prototype) class at the 2008 Petit Le Mans race went to a E10 gasoline direct-injected, 503-hp (375-kW) Porsche RS Spyder prepared by the Penske Racing team.

costly for mass commercialization. And the glut of corporate marketing money has switched much of the fan focus from the winning car to the personalities of the drivers.

In the meantime, the auto industry faces its biggest challenge—the threefold impact of growing foreign oil imports, the threat of petroleum shortages, and looming climate change. For the last several years, farsighted motorsport enthusiasts have envisioned turning the remarkable ability of the auto-racing community to innovate quickly toward solving these problems. Their chosen vehicle? "Green racing," that is, winning in the most environmentally sound way possible.

Contradiction in terms?

Old-timers might consider the concept of green racing to be an oxymoron, given that the main goal in racing is to finish first. But others can legitimately disagree. Recently, under the auspices of **SAE International**, unprecedented cooperation by an unlikely group of car makers, racing-series sanctioning bodies, as well as the **U.S. Department of Energy** (DOE) and the **U.S. Environmental Protection Agency** (EPA) has led to the formulation of the initial standard protocols to govern the means by which racing can go green.

Indeed, the **American Le Mans Series** (ALMS) has just instituted its Green Challenge, whereby its race teams will be ranked according to their entries' fuel efficiency, greenhouse gas emissions, and amount of petroleum use. "It's not just PR spin,"

fered by green racing, Fishel continued. "For this initiative to go anywhere, it had to involve the interests of the entire industry, because the complexities of these issues go well beyond the normal capabilities of individual racing teams."

A novel concept

The notion of green racing has been percolating in various quarters for some time, according to John Glenn, an environmental specialist at the EPA, who started musing about it around 1993. "I could see that, to win races, developers had focused on boosting engine displacement to increase power-to-weight ratios," he recalled. "It occurred to me that things would have been different if auto racing had emphasized a different metric: power per unit of energy."

Glenn was also aware of the long-standing "Index of Performance," a technology-based handicapping system used by the **European Le Mans Series**. But Glenn did not think much more about the concept until a few years back when the U.K.'s **Motorsport Industry Association** (MIA) started promoting "energy-efficient racing."

Then three years ago, EPA managers including Glenn and Tom Ball, a program manager at the agency's Air Office, heard SAE's Fishel advocating that the auto industry should find ways to make racing more relevant to the needs of current cars. "We all realized that it could be possible to take advantage of the synergies among the racing-series sanctioning bodies and the

OEMs to encourage green technology and practices,” Ball said.

The result could be greater relevance for the series, as well as better technology and good publicity for the automakers. “It only made sense to use the innovation and rapid development that racing has always used to improve car performance to produce the green technology we all need,” he added.

After all, says former SAE President Greg Henderson, “in Formula One racing, a vehicle can go from concept to museum piece in as little as five weeks.” During such short periods, he noted, a race team can design a part, fabricate it, conduct structural and wind-tunnel tests, and then track test it before running it in competition.

In addition to speeding technical development, green racing could help teach people on the street about saving the environment, maintained Bob Larsen, Senior Technology Advisor at the **Center for Transportation Research** at the **U.S. Argonne National Laboratory** (ANL). “We want to open the door to educating the fan base, and the public at large, about the full range of these sometimes complex issues—important lessons that everyone needs to learn.”

Meeting of the minds

In early 2007, SAE International, in partnership with the DOE, EPA, the major auto manufacturers, the **International Motor Sports Association**, ALMS, MIA, the **Sports Car Club of America**, and other organizations, established the green-racing activity under the society’s Motorsports Council. Its mandate, said Anderson, is to devise the general green-technology protocols that would set the stage for the sanctioning bodies to write their own rules.

The committee soon brought into the mix specialists from ANL, whose researchers years earlier had developed the widely used Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model for estimating, from a “well-to-wheels” perspective, the overall environmental impact of a vehicular fuel. The goal, Larson reported, was “to use the best science to develop an ‘apples-to-apples’ comparison among car types—a score that could reasonably rate the green performance of all types of vehicles on a level playing field.”

The group, he said, eventually decided that the protocol should encompass three elements: fuel efficiency, the number one consideration—everything that goes into the fuel and engine combination; greenhouse gas emissions—not just what is coming out of the tailpipe, but the fuel’s entire carbon content from its origin to hauling it to the track to burning it; and petroleum substitutes—how much petroleum an alternate fuel displaces (see sidebar, next page).

Calculating rank

To provide valid weighting for each element, Larson continued, the protocol provides for two adjustments to the fuel-efficiency rating “to make it as if all the vehicles had run the same distance” in timed races or ones that end when the winner passes the finish line. One compensatory factor corrects for the distance traveled by the race winner compared to that run by the other competitors and also determines an average speed for each competitor to normalize fuel consumption.

The second adjustment is aimed at closing a potential loophole that might arise should a team decide to drive slowly to improve fuel mileage. “Basically, it’s a force calculation that



Above: The alternative fuel E85 bio-ethanol provides drive energy to the Drayson-Barwell team’s Aston Martin Vantage GT2 (grand touring) entry in the American Le Mans Series GT2 class.

Below: Cars in the American Le Mans Series use one of three street-legal alternative fuels: E10 gasoline (or gasohol), a mixture of 10% ethanol and 90% gasoline; E85 cellulosic ethanol containing up to 85% denatured ethanol made from wood waste; and zero-sulfur diesel.



determines the amount of power needed to run at an average speed with a particular fuel,” Larsen explained. The formula therefore involves the minimum mass for the vehicle-class times the average velocity. “Then we take the ratio of the winner’s number versus each of the other competitors and apply it to the amount of energy each vehicle consumed during the race,” he added.

“We think that it’s a pretty good rating of the fuel efficiency of each vehicle,” Larson said. “Theoretically, the same basic method could be used for any propulsion configuration, including ones that use electricity, such as hybrids, or energy-recovery devices.”

The Argonne researcher readily admits that the committee’s solution is not ideal because many other variables are not taken into account. “But it’s a pretty darn good way to place everyone on the same level,” he stated. “With more experience, we may tweak the protocol to improve our approach.”

The fuel-efficiency number keys into the “downstream side” (in-race) calculations of greenhouse gas and petroleum use in



Corsa Motorsports will field a new hybrid Zytek-built race car featuring an ethanol-fueled V8 engine together with a lithium-ion powered electric motor in the LMP1 (prototype) class of the 2009 American Le Mans Series.

the various fuels, be they corn or cellulosic ethanol or whatever other alternative fuel comes onto the scene. The GREET model is meanwhile employed to figure in the “upstream side” of the fuels’ oil and carbon-dioxide-equivalent content.

Sixty percent of the final green value is accounted for by the fuel-efficiency rating, with the remainder coming from the ratings of greenhouse gas and petroleum content. “We believe that we’ve structured the calculation so that everyone has a reasonable chance of being competitive,” Larson concluded.

Build it and they may come

The ALMS Green Challenge is based on the committee’s protocol as stated in the recently released SAE J2880 document. Nearly all involved seem to agree that it makes sense that ALMS should be the first to adopt the new approach because all the fuels the series uses have some non-petroleum content and because ALMS races both prototype- and production-based cars.

But ALMS’ Atherton remains unsure whether the industry will fully accept it: “We’ll have to see whether the manufacturers salute or ignore it,” he said.

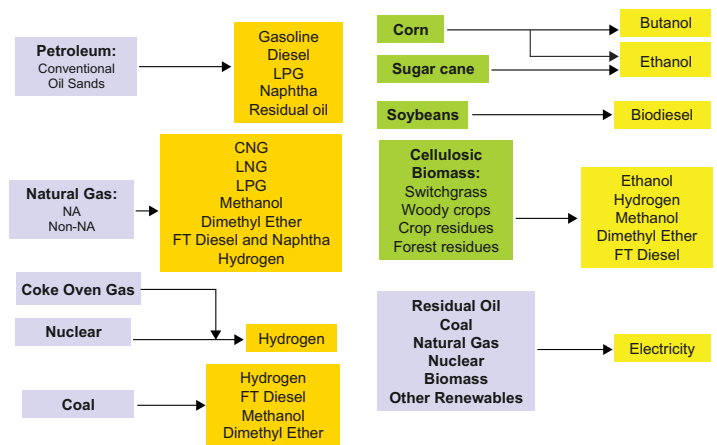
One of those manufacturers, **Honda**, is mulling over the opportunities. Erik Berkman, President of Honda Performance Development, says that his group is now trying to figure out how it might respond to the Green Challenge rules: “Do you try to win the race, win the challenge, or both?”

Berkman, for one, does not consider the concept of green racing to be that far out. “Racing is often about fuel economy,” he said. “For instance, one of our leading cars in a recent race ran out of gas. Better fuel efficiency could have avoided that outcome.” Green racing might even call for new strategies, he added. “Say you fall out of contention because of technical problems. You might run the rest of the race to win the Challenge.”

The Honda racing chief says that the Green Challenge and the like could also be significant for OEM sales. “People used to say that ‘safety doesn’t sell,’ but today safety is very important to car sales. The same thing is happening with environmental responsibility, and certainly with sky-rocketing gas prices, fuel efficiency.”

The selection of fuel is the crucial choice for the challenge, Berkman pointed out. “If you choose an E85-ethanol blend, for example, you can trade off some ultimate performance.” Also important is a team’s approach to fuel combustion. “Typically for peak power, you run with a rich mixture, which is usually not the cleanest or most efficient way to burn fuel,” he added. “So it comes down to: Do you run clean and give up perfor-

Fuel Production Pathways from Various Energy Feedstocks (Well-to-Pump) in GREET



The GREET (Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation) model developed at Argonne National Laboratory estimates the overall environmental impact of the manufacture and use of many hydrocarbon fuels, enabling an “apples-to-apples comparison” to be made among them.

mance?”

For Honda, in particular, these considerations lie well in the future as “our next car has already left the dock, so we’ll have to look at the Green Challenge over the long term to determine how we can work with it.”

For other contestants in the ALMS, though, the new rules will soon be put to good use. **Corsa Motorsport** just announced that it will field an electric-hybrid **Zytek** vehicle in the American Le Mans Prototype-class starting with this season’s Petit Le Mans race. And, according to Atherton, “two major manufacturers not in ALMS now are actively working on new propulsion technology for prototype entries. One could introduce such a car as early as the end of 2009.”

It just may be that novel race formats like the Green Challenge have arrived precisely in time. Several other racing organizations including Formula One and the original Le Mans are reportedly working on similar programs. Who knows, if this groundbreaking environmental competition succeeds, automakers’ new marketing mantra just might be: “Race green on Sunday; sell on Monday.” **aei**

Top products of the year

AEI editors highlight some of 2008's top offerings from the industry's component suppliers that were most popular among online readers.



Embedded system development

VaST's CoMET and METeor version 6.1 are integrated into the Eclipse 3.3 (Europa) Framework. CoMET is a system engineering tool that enables creation of a virtual system prototype. METeor is an interactive software development environment for embedded systems and system-on-chip. The integration of Europa provides features including Core Eclipse 3.3 IDE, C/C++ Developer Tools 4.0, Eclipse Modeling Framework, and the Graphical Editing Framework. These features enhance platform creation, debugging, design navigation, and graphical user interface interaction.



Power electronics

Arens displays a line of compact PowerPro Power Distribution Modules (PDM) that mount to any convenient surface in the interior of the vehicle or in the engine

compartment. All PDMs are designed with an IP-67 rated sealed housing to protect against weather and moisture and can accommodate up to 200 A, with multiple I/O configurations and CAN technology compatibility. The PowerPro-W offers a wireless control feature using a handheld computer to control a range of vehicle functions remotely. Also featured, Arens traction inverters range in size from 25 to 500 kW (34 to 670 hp) and are designed for hybrid automotive and off-highway applications.



Harness design tool

The latest wire harness design from **Synopsys**, Saber Harness 2008.09 Release, is a software tool for designing and analyzing complex wire harnesses found in automotive, space, and aircraft systems. Improvements include multi- and modular connector enhancements; temperature zones and harness filtering; variant management and assembly tool improvements; harness verification improvements including loads and drivers; customizable mechanical CAD (MCAD) export for manufacturing output; assembly database concurrency for harness and sub-harness design; harness site manager graphical

user interface improvements; enhanced design flow support for global design teams; and updated interfaces to MCAD systems.



Innovative sunroof

The UltraView roof for the new **Cadillac CTS** (pictured), designed by Cadillac and **Webasto** Roof Systems, is one of the largest of its kind in a sedan—almost 70% of the car's roof is glass that allows in natural sunlight for both front- and rear-seat passengers. The roof consists of two UV-protected glass panels arranged in tandem. Like a traditional sunroof, the front panel of glass can tilt for venting or, when opened, retracts and stows under the back panel thereby letting fresh air in, but with the advantage of continuing to provide light and a view of the sky to rear-seat occupants. For times when softer light is preferred, a retractable power interior shade can be used.

Halogen-free cable

Featuring halogen-free requirements, high performance, durability, smaller size, and recyclability, **Delphi's** halogen-free cable can reduce both cable mass and harness diameter by more than 20% in automotive applications. Under the right circumstances, according



to the company, the cable could provide reductions in mass, weight, and diameter of cable and wiring harnesses that are significant for the commercial and specialty vehicle markets. The insulation on halogen-free cable weighs less than conventional coatings and can achieve abrasion- and pinch-resistance benchmarks with thinner applications. The halogen-free cable made its debut on the 2007 **Toyota** Tundra.



Charging connector

Yazaki has teamed with the **SAE** J1772 Working Group to define a standard connector interface for charging batteries in the next generation of plug-in hybrid electric vehicles (PHEVs) with standard electrical power. The group selected Yazaki's charge coupler

design proposal to develop the standard for PHEVs, which depend on electricity sourced from the utility grid to replace gasoline for improved economy and reduced greenhouse gas emissions. Design features of the coupler include a compact size and crush-proof design; support of up to 70 A charge rate; and safe, touch-proof contacts. The connector was designed for more than 10,000 insertion cycles.



Overspeed sensor

BorgWarner's eddy current speed sensor features more compact dimensions and a longer lifetime for turbochargers. Offering a "non-pigtail" solution with integrated electronics, the cost-effective sensor is now directly attached to the compressor housing. Unlike the predecessor model, the new speed sensor can for the first time also be used in passenger-car applications. The previously used passive speed sensor was based on the inductive principle without a supply voltage. By contrast, the new sensor is a 5-V active speed sensor that transmits a rotational speed signal to the engine management unit. By using the eddy current effect, the sensor operates without contact and is therefore mechanically wear-free and requires no maintenance. The new generation of turbocharger speed sensors can measure rotation from about 1000 to 350,000 rpm.

Human-machine interface design

Mecel's Populus Engine and Populus Editor allow car manufacturers to reduce software development time, thus reducing cost and improving time to market.



Using database-driven human machine interface, no traditional coding is needed. When the information stored in the database changes, the interface automatically changes as well. This allows engineers to create a new interface quickly and immediately see how it looks in the vehicle. They can use the same platform to create products for different car models because the software works with various displays and applications.



Advanced console

Preh's center console is made using black-panel display technology, allowing function icons to appear after the ignition is turned on. A slight pressure on the start button illuminates the controls. A silver button uses PVD translucent technology, with black panel effect transferred to metallic surfaces. The button is coated with a metal surface of a few nanometers thickness. The metal surface only reveals the function symbol after the ignition switch is on. Other features include a new gear shifter design, master control knob with haptic user guidance, dual-zone climate control with a single control knob for driver and front-seat passenger, and integrated touch pad for navigation and telephone.

LIN bus microcontroller

Micronas' easyLIN 8-bit microcontrollers simplify the design and reduce the cost of LIN bus mod-



ules by combining all logic functions, peripheral modules, interfaces, and a LIN bus interface in a single device. The HVC 22xyA and HVC 24xyA units can be used in applications where networking capability is required, including doors, seats, mirrors, and even powertrain applications. The devices can drive up to eight 12-V loads, such as lamps and relays, directly. The on-chip transistors resist moderate loads and can drive external power transistors for large loads.

Value chain agent

The Value Chain Agent (IVA) from **iPoint** automatically visits design-



nated portals at regular intervals, checks for changes, reports them autonomously, and leaves a digital fingerprint for the manufacturer to indicate that the supplier visited the portal at the required time. It also extracts, converts, and integrates data with internal IT infrastructures. If the manufacturer requests data, the system

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Metal matrix composite

AlSiC (aluminum silicon carbide) is a metal matrix composite from CPS that is suited for base plates material for insulated gate bipolar transistor (IGBT) used in high-power traction, power control, hybrid-electric vehicle power systems, and fly-by-wire applications. A lightweight material (1/3 that of Cu), AlSiC is a suitable cooler material for the weight-sensitive IGBT applications. AlSiC also has higher strength and stiffness than



Cu, which, combined with its lightweight nature, makes AlSiC assemblies more tolerant to shock and vibration. The low isotropic coefficient of thermal expansion value of AlSiC-9 (8 ppm/°C: 30 to 100°C [86 to 212°F]) is compatible with the thermal expansion value of the die or substrate used in IGBT applications.

Adaptive cruise control

A part of **Continental Automotive Systems'** Vision Zero road-safety package, the company's adaptive cruise control (ACC) features a radar sensor and computer in the front of the car



that measures the distance from the vehicle in front and the relative speed of the two vehicles. If the vehicle in front brakes or a vehicle suddenly cuts in front, ACC reduces the speed or applies the brakes. The driver is also prompted to apply the brakes if the system's initial intervention is insufficient. The enhanced ACC with Full Speed Range function controls the distance and speed until the vehicle comes to a complete standstill and then controls the speed again as the vehicle pulls away.

Memory device

The FM25040A-GA from **Ramtron International** is a



4-Kb, 5-V nonvolatile ferroelectric random access memory (F-RAM) with a high-speed serial peripheral interface. Part of the company's grade 1 AEC-Q100-qualified automotive product line, the FM25040A-GA is specified to operate over the automotive temperature range of -40 to +125°C (-40 to +257°F) and is guaranteed to retain data for 9000 h at that extreme temperature and for 17 years at 55°C (131°F). Suitable for advanced powertrain systems, the FM25040A-GA reads and writes at bus speeds up to 14 MHz, boasts a 10µA standby current, and includes an advanced write-protection scheme to prevent

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inadvertent writes and data corruption. In stringent data collection applications, F-RAM guarantees data integrity in noisy automotive environments.



In-cylinder pressure sensor

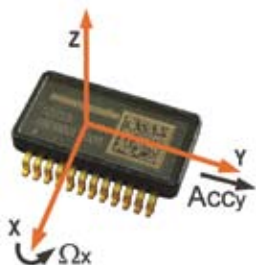
Kavlico's in-cylinder pressure sensor optimizes engine combustion, thus increasing fuel efficiency while reducing emissions. The sensor assists with the timing and delivery of the fuel by providing accurate pressure information to the engine control unit to control fuel injection pulses. It uses a thin-film titanium oxynitride sense element in an all-welded, hermetically sealed, stainless steel housing. The package is suited for hostile environments and comes in pressure ranges from 0 to 200 bar (0 to 2900 psi) through 0 to 300 bar (0 to 4350 psi).



Motorcycle microcontrollers

Infineon Technologies' XC2700 family of microcontrollers with 32-bit performance allows system makers to build cost-effective electronic engine control in motorcycles, worldwide, to meet upcoming emissions standards. Based on the C166SV2 high-performance microcontroller core, the XC2700 family provides single-cycle execution from a 66-MHz five-stage pipeline at up to 80 MHz. It also integrates key peripherals such as memory, voltage regulator, and interfaces to reduce the overall system cost, as

well as make the family a cost-effective solution. Software developed for existing C166SV2 controllers can be easily reused with this new family. With 64 to 176 pins, the 10-product XC2700 family provides a scalable package range from lower-cost versions to higher-performance devices.



Gyrometer and accelerometer

SensorDynamics' SD755 integrates a gyrometer and accelerometer in a single package. Both sensors transmit their signals over a shared serial peripheral interface that assists further processing as well as minimizes development time and system costs. Self monitoring of sensor elements and signal conditioning path alerts immediately if a parameter goes out of precisely defined limits. More than 40 parameters are monitored to ensure that the system is fail-safe. The system can be installed in the passenger compartment or under the hood. Applications include stability control and rollover detection systems.

Injection moldable elastomer

Silastic 100% fluoro liquid silicone rubber (F-LSR) from **Dow Corning** is a fully fluorinated two-part injection moldable elastomer designed to meet increasingly stringent automotive engine temperature, fuel, and oil-resistance specifications while improving environmental sustainability during manufacturing. This solution combines the ease of processing of liquid silicone rubber (LSR) with the temperature and fuel resistance characteristics of fluorosilicone rubber (FSR) to improve manufacturing efficiency and part performance. Silastic 100% F-LSR provides labor savings, higher equipment capacity,

and reduced scrap rates to customers currently using high-consistency fluorosilicone rubber. Automated injection molding with Silastic 100% F-LSR makes the production of intricately designed, high-quality, high-precision parts possible.



Heated frameless wiper

The electrically heated HeatFlexx windshield wiper from **Von Stach Products** is designed to quickly melt ice and snow. The frameless design of the all-season blade provides continuous even pressure to the windshield, reducing streaks while also reducing wind lift at speeds up to 150 mph (241 km/h). The HeatFlexx will come as standard equipment on **DiMora Motorcar's** Natalia SLS 2 sport luxury sedan, the world's most expensive production automobile.



Compact failure simulation

ETAS' ES4440 compact failure simulation module is used to insert electrical faults in the wire harness of a powertrain electronic control unit to verify the software and hardware passes diagnostic tests, like OBDII. The ES4440 provides a blend of high-current channels to simulate errors in high-current components like fuel pumps or glow plugs, and high-voltage channels to simulate errors in high-voltage components like piezo-electric fuel injectors. High-current channel faults are simulated using precision MOSFET transistors that offer a very high channel count at a cost-effective price-to-performance ratio. High-voltage channels use relays to simulate single or multiple faults.

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Edited by **Patrick Ponticel**

Pedestrians in crosshairs of upcoming NHTSA rules

NHTSA (the U.S. National Highway Traffic Safety Administration), traditionally concerned about passenger safety in car crashes, is moving toward new rulemaking on pedestrian safety. One proposed rule addresses energy-absorbing requirements of hoods and bumpers in accidents involving vehicles traveling under 40 km/h. It is on a relatively fast track. Another proposed rule, the "Quiet Car," focuses on how to incorporate a sound warning into hybrid-electric vehicles, which would be particularly helpful to blind pedestrians.

SAE International is intimately involved in the "Quiet Car" effort. Jay Joseph, Chairman of the SAE Vehicle Sound for Pedestrians Subcommittee, explained at a NHTSA-sponsored meeting in June that his subcommittee was working toward publishing either a technical report or recommended practice by the end of 2008. That subcommittee has three task forces currently at work, including one dedicated to exploring countermeasures. Explaining the complexity of coming up with a standard on sound, Joseph said, "For example, simply adding a certain sound might work well in a suburban setting, but we have no idea if there is any benefit in a busy city street where the ambient sound levels are relatively higher."

At that meeting, Jim Ports, NHTSA Deputy Administrator, said any new regulation dealing with "Quiet Cars"—chiefly hybrids and all-electric vehicles—would be part of the comprehensive pedestrian safety plan the agency is working on. That plan will focus on injuries to pedestrians from all cars, not just hybrids. Interestingly, the number of pedestrian deaths declined considerably between 1996 and 2006, from 5449 to 4784.

But Essie Wagner, an official in the NHTSA Safety Countermeasures Division, told the "Quiet Car" meeting this summer that 4700 deaths are still way too high.

SAE became interested in the issue at the behest of groups such as the

National Federation of the Blind.

"New silent vehicle technology, such as that used in hybrid-electric vehicles, poses an imminent threat to the lives of all blind Americans," said Deborah Kent Stein, Chair of the Federation's Committee on Automobile and Pedestrian Safety.

She added that the problem is not limited to the blind. "All pedestrians, cyclists, runners, and small children use the sound of traffic to make judgments about when it is safe to step into an intersection or when navigating their neighborhoods or moving through the parking lot of the local shopping center."

Any proposed "Quiet Car" standard from NHTSA is still on the horizon. But the proposed NHTSA standard on pedestrian safety is just around the corner. It will be based on a global technical regulation (GTR) that the **World Forum for Harmonization of Vehicle Regulations** is expected to endorse imminently. The U.S., the European Union, and Japan are participating in development of this new international standard, which they have been tweaking for half a decade or so. The GTR essentially would mandate a number of European-developed performance head-form and leg-form tests related to energy-absorption capabilities of hoods and bumpers. The tests could also address various related components, such as grille guards and hood ornaments.

Auto manufacturers want NHTSA to put the international standard into U.S. law, as long as it is relatively reasonable, which it appears to be, based on complaints from consumer groups such as **Advocates for Highway and Auto Safety**. Gerald A. Donaldson, Senior Research Director for the group, said the draft GTR "clearly exhibits the inordinate influence of European motor vehicle manufacturers in drafting weak GTRs, which the global vehicle manufacturing industry in turn leverages to reduce the stringency of U.S. motor vehicle safety standards."

But Michael X. Cammisa, Director of



Ford and all other automakers are researching pedestrian safety.

Safety, **Association of International Automobile Manufacturers**, defended GTRs, saying, "An internationally harmonized standard will allow manufacturers to focus their engineering resources on a single regulatory design target for vehicle models that might be offered for sale in different markets throughout the world."

The GTR consists of two sets of performance criteria, one applying to the front bumper and the other to the hood top and fenders. The standard is broadly based on EU Directive 2003/102/EC originally issued in 2003 and modified in 2007. Its implementation has been delayed as the EU attempts to synchronize the directive with the emerging GTR standard. There have been some differences of opinion between the Europeans and Americans as the GTR has developed, mostly over which type of vehicles the GTR should apply to. NHTSA has pressed for wide application, to passenger cars, sport utility vehicles, light trucks, and light commercial vehicles. Japan presented a modified proposal that would extend the scope to heavier vehicles but with the consideration that vehicle shape be the deciding factor for these vehicles. That issue remains to be resolved.

Once the GTR is adopted, NHTSA will have to initiate a rulemaking, get comments, and then decide how much of the GTR—or how little—it will translate into a federal motor vehicle safety standard.

Stephen Barlas

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P81799

Preparing an amphibious assault

Neil Jenkins is looking for a few good engineers to staff Gibbs Technologies' three high-speed amphibian programs in the U.S.



Jenkins brought aerospace and supercar-program expertise to Alan Gibbs' startup.

Developing vehicles that are equally capable operating on land and in water is no easy feat. History shows that the most famous examples—the Amphicar of the 1960s, and the World War II

Volkswagen Schwimmwagen and **GMC 6x6 "Duck"**—were compromised performers in both their land and sea roles.

But Neil Jenkins believes history will soon be changed. Jenkins is President and CEO of **Gibbs Technologies**, founded by New Zealand entrepreneur Alan Gibbs. In the mid-1990s Gibbs set out to build an amphibious car capable of 100 mph (160 km/h) on the road. But it could also exit the pavement, drive

into the water and, with the push of a button, be planing at 30 mph (48 km/h) within 12 s—while carrying three passengers, 66 lb (30 kg) of cargo, and a full tank of fuel.

The result of his investigation was the Aquada, the world's first sports-amphibian car. Its maximum speed on water is more than 45 mph (72 km/h). Loaded with clever design features, the proof-of-concept version of Aquada became the cornerstone of Gibbs' HSA (high-speed amphibian) vehicle technology. It has spawned more than 60 patents and influenced two other vehicle types Gibbs currently has under development for per-

sonal and commercial markets.

Aquada's potential also inspired Jenkins to fly from his native Britain to New Zealand and ask Gibbs for a job. His background in composites, structural analysis, and lightweight vehicles was ideal for a project with such an extreme performance envelope (not to mention challenges such as fully water-sealing the powertrain). As an engineer at British Aerospace, Jenkins worked on the **Panavia** Tornado fighter-bomber. And while at **Jaguar**, he was a senior engineer on the XJ220 supercar program.

"When Neil came aboard he gave us the knowledge and direction to work out the body and chassis combination we needed for both on-road and marine uses," Alan Gibbs told *AEI* in 2007.

Gibbs explained that in his original Aquada mockups, the frame was insufficiently stiff by itself for a road vehicle, and the body was too flimsy to make a robust boat hull. With Jenkins' expertise, both the aluminum frame and molded-composite body structures were optimized for overall strength and mass.

Lockheed Martin collaboration

Gibbs continued to refine Aquada and the little open-top car impressed all who witnessed its performance, including a record-setting dash across the English Channel. It also spawned the smaller Quadski, which visually resembles the offspring of a personal watercraft-and-all-terrain-vehicle liaison. Quadski will be the first of Gibbs' HSAs to enter production late in 2009, as a 2010 model.

On the other side of the portfolio are commercial/military vehicles of a much larger scale. Gibbs' first proof-of-concept, called Humdinga, was a 300-hp (224-kW) amphibian aimed at military and first-responder rescue applications. In its original form it was capable of accelerating on

land from 0-60 mph (97 km/h) in 9.2 s. Upon entering the water, it could be planing in less than 10 s, carrying five passengers and their gear.

In 2007, Gibbs entered into a contractual agreement with **Lockheed Martin** to develop a family of scalable HSAs designed specifically for military operations. Three concepts are in the works, including one 35 ft (10.7 m) long designed for riverine combat and capable of 40 mph (64 km/h) in water and 65 mph (105 km/h) on land.

Jenkins explained that while each of Gibbs' current trio of vehicle families are unique, all share the company's HSA technology based on proprietary water-jet propulsion systems and driver-actuated retracting wheels for marine operation.

"Each wheel is lifted into its retracted position within the wheel house by a specially developed hydraulic strut," he said. "At the same time, the wheels are decoupled from the driveline for reduced drag and greater maneuverability in water."

More than seven years of development went into the Aquada's articulated suspension, which provides composed handling, ride compliance, and variable ride height on the road. A unique locking pin mechanism prevents the wheels from retracting when on dry land, he noted.

Ramping up U.S. R&D

To support production engineering and the HSAs' launch in North America, Gibbs last month opened a new 37,000-ft² (3437-m²) global headquarters and R&D facility in Auburn Hills, MI. Early development of Aquada and Humdinger was handled jointly by Gibbs' in-house engineering staff in Nuneaton, U.K., and **Lotus Engineering**, with design and prototype support from **MSX** and **Entech** in Michigan.

"Since July 2008, we've ramped up to a team of 55 senior engineers in the U.S. By early 2009, the total will have doubled," Jenkins recently told *AEI*. He said that while Gibbs Technologies currently is advertising for structural engineer, jet designer, FEA engineer and market/research specialist positions in the U.S., "we're looking for high-caliber engineers of all mettle, from conceptual through 'launch' (release)," he explained.

"They must really know their stuff in the whole brunt of vehicle engineering



Clever lightweight articulated suspension and wheel-locating system is key to Gibbs' HSA's rapid deployment and hydrodynamic efficiency when the vehicle hits the water.



The Quadski will be Gibbs' first production HSA when it enters production late in 2009. Personal-sports and military/rescue versions are planned.

because we're running the Aquada, Quadski, and commercial-vehicle programs concurrently," Jenkins asserted.

Gibbs is testing a fleet of 10 mule vehicles in the U.S., two of which recently were torn down for durability checks. The company has not yet decided on an engine supplier for Aquada but Jenkins said the candidate list has been narrowed to two OEMs. One of them has production facilities in North America.

"Over the next six to 12 months we'll decide on Aquada's features based on consumer research for the U.S. market," said Jenkins. "The start-of-production timing will depend on final feature content. Other than the engine, which will remain a transversely mounted V6 and

deliver more power (than the **Rover** V6 mules), the basic vehicle architecture and all the fundamental technology running in the mule vehicles will remain unchanged."

He said Gibbs' engineers will take advantage of new developments in composite materials and joining technologies to improve fuel economy, weight, and performance. Challenges still to be met include meeting all North American safety standards for road vehicles and the marine industry, and selecting manufacturing partners.

It is not your typical vehicle program at all, but rather one that intends to make a very different kind of splash.

Lindsay Brooke

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Another Chinese automaker to make NAIAS debut

For the fourth year in a row, a different Chinese automaker will make its debut at the North American International Auto Show. The new-to-NAIAS Chinese OEM at the January 11-25 event in Detroit will be **Brilliance Auto**, which produces its own models under the **Zhonghua** (sedans) and **Jinbei** (minibuses) brands, as well as 3 Series and 5 Series sedan models for **BMW**.

Brilliance has not announced which models it will display at the NAIAS. Neither has **BYD Auto**, a Chinese automaker that first exhibited at the NAIAS in 2008 and that will return for the 2009 event. Both companies see a potentially lucrative market in the U.S.—but then again so did the first Chinese OEM exhibitor at NAIAS, **Geely**. At the 2006 event, that company stated its now-unrealized hope of beginning car exports to the U.S. by 2008.

Requests for details from Brilliance and

BYD Auto about their plans for exporting vehicles to the U.S. were not provided. Both companies also are hoping to sell product in Europe, and to that end have exhibited at auto shows there.

Brilliance China Automotive Holdings Ltd. is registered in Bermuda but says its head office is in Hong Kong. In 2007 it sold 106,770 sedans, an increase of 71.4% over previous-year sales, and 73,415 minibuses, a 10.8% increase. It built 32,100 sedans for BMW. The company also has a components division.

At last year's NAIAS, BYD was one of four Chinese OEMs with displays, including two-time exhibitors Geely and **Changfeng**. BYD showed, among other things, a hybrid, the F6DM, that it said was slated to go on sale in China this year and in the U.S. within three to five years.

American investment firm **MidAmerican Energy Holdings Co.**, a



BYD Auto has not revealed which models it will display at the NAIAS in January, but is known to have plans for selling hybrids in the U.S. Shown is one of its dual-mode plug-in hybrids, the F3DM.

subsidiary of Warren Buffet's **Berkshire Hathaway Inc.**, in September announced it had agreed to invest about \$230 million in a purchase of shares amounting to a 10% interest in BYD.

Patrick Ponticel

Emerging markets are 'where the music plays'

Supplying components to affordable cars sold in emerging markets occurs in "an entirely different environment" from established markets, Dr. Karl-Thomas Neumann, Chairman of the Executive Board for **Continental AG**, said during his keynote address on the final day (Oct. 22) of Convergence 2008 in Detroit.

Whereas mature markets are "all boring in terms of growth," emerging markets are "where the music plays," said Neumann. Continental has had a presence in India, China, and other emerging markets for some time. Finding success in developing countries can be summarized as being where the customers are. In terms of research and development, it's a good strategy to "have your engineers on the ground," said Neumann. Having a presence in the local markets also applies to sourcing and manufacturing.

Neumann cited labor costs as the underlying difference between two of Continental's wheel speed sensor factories, one in Belgium and one in China.

The China plant has 1200 workers—600 of whom monitor parts quality. Only a few hundred workers are employed at the Belgium plant, but the plant in China with many more workers has considerably lower labor costs, according to Neumann.

"The most important point is you have to balance your investment with labor costs," he said. "That means if you have a very low labor cost it makes no sense to do high investments, and vice versa. It's possible to create the same quality out of a very simple, hand-labor-intensive environment as you can from a fully automated, highly robotic environment."

In developing product for an emerging market, the technology should match the performance needs of that market, said Neumann. "We must benefit from [our knowledge and expertise] because if we don't do that, then basically anyone could be our competitor in this field and do as well as we do."

Kami Buchholz



Dr. Karl-Thomas Neumann serves as the Chairman of the Executive Board at Continental AG, a 137-year-old company whose Automotive Group is focused on safety, powertrain, and interiors.

the big picture

Edited by Kevin Jost

Dodge Challenger SRT10 Concept

Although small and efficient was a popular car theme at the 2008 SEMA Show, Chrysler did its best to uphold "muscle car" tradition by stuffing a Viper V10 into a 2009 Dodge Challenger. The concept car was upgraded by in-house performance engineering organization Street and Racing Technology (SRT).

1 Alcoa 20-in front and rear forged-aluminum wheels reduce unsprung mass and are wrapped with Pirelli P-Zero tires

2 A carbon-fiber hood (and decklid) reduce vehicle mass

3 A "shaker" hood like on the famed 1970 Hemi Cuda returns for better engine breathing

4 Brembo fixed-caliper brakes have six pistons in front and four in back and 390-mm (15.4-in) front and 355-mm (14.0-in) rear vented rotors

5 The five-link independent rear suspension features better control of camber and toe; Bilstein mono-tube dampers; 20% stiffer spring rates; and a larger rear sway bar

6 A significantly retuned SRT8 front suspension features a short- and long-arm arrangement and Bilstein monotube dampers attached to a cradle

7 The adapted Viper 8.4-L V10 engine produces 600 hp (447 kW) and 560 lb-ft (759 N-m)

8 Viper ACR-like carbon-fiber aerodynamic treatments include a front splitter (and rear spoiler) for enhanced down-force at high speeds





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