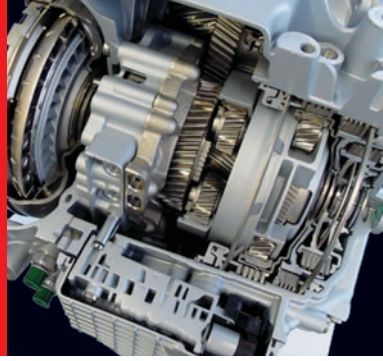
automotive
ENGINEERING
international®
100 SINCE 1911

Inside ZF's 9HP

An exclusive look at the industry's first nine-speed transaxle for MY2013



Cutting the cost of carbon

McLaren, others streamline production to reduce costs

SAE International®

Crossing industry borders

Tech transfer benefits commercial- and military-vehicle markets

Reaching higher

Will the car of the future fly?

NOVEMBER 1, 2011

AEI-ONLINE.ORG

Panasonic
ideas for life

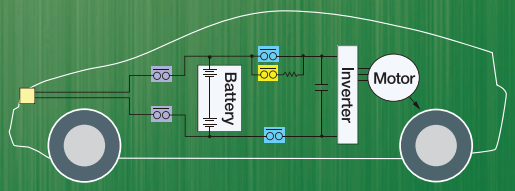
A Vital Piece to the EV & HEV Puzzle



EVs and HEVs are pioneers of the Eco age. Essential to their development and success are relays that combine compact design with a high DC voltage cutoff. Panasonic has developed relays that meet those requirements by encapsulating the contacts in hydrogen.

Compact, Lightweight, High-voltage Cutoff	Compact, lightweight relays are filled with hydrogen gas providing efficient high arc cooling and short gap high DC voltage cutoff at the contact points.
Safety	A ceramic anti-explosive structure prevents arc leakage and provides a high level of safety.
High Contact Reliability	Hydrogen encapsulated contacts keep out water, dust and prevent contact oxidation.

Relay Application Example





Panasonic EV Relay

Panasonic Electric Works Co., Ltd.

Panasonic Electric Works Corporation of America
Phone: (908) 464-3550 || 1-800-276-6289
Components@us.pewg.panasonic.com || http://pewa.panasonic.com/ev-relays

Where Do I Go for Pressure, Strain and Force Products?

omega.com, of Course!

Your single source for process measurement and control products!

Ideal for Use in Test Benches, Filter Monitoring and Hydraulic Applications



Micro-Machined Silicon Transducers
Wet/Wet Differential Pressure Models

Five Electrical Termination Styles

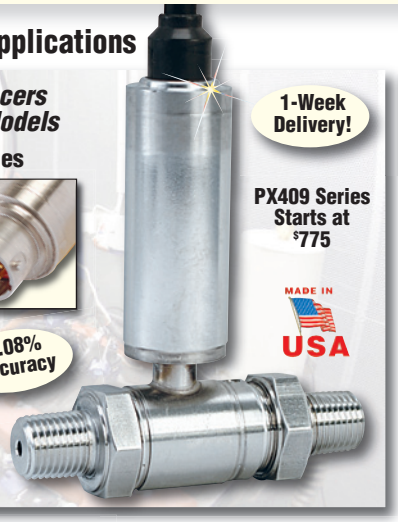


1-Week Delivery!

PX409 Series Starts at $775

MADE IN USA

0.08% Accuracy



Visit omega.com/px409-wwdif

Barometric Pressure Transducers, High Accuracy

MADE IN USA



PX409 Series Starts at $625

Visit omega.com/px409_bar

Heavy Duty Flush Diaphragm Transmitter



MADE IN USA

PX43 Series All Ranges $530

Visit omega.com/px43-i

High Accuracy Digital Barometer

HHP360 Series Starts at $1475

MADE IN USA



Visit omega.com/hhp360

Subminiature Pressure Transducer with Flush Diaphragm

PX600 Series All Ranges $495



Visit omega.com/px600

MADE IN USA

FREE! Hardbound Handbook and Encyclopedia

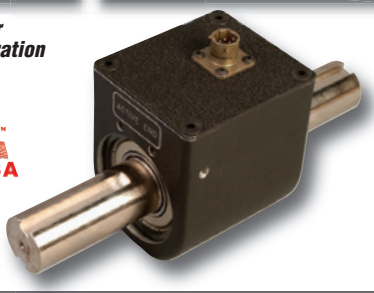


Find thousands of pressure, strain and force products in one place! Visit omega.com to order your FREE copy of The OMEGA Complete Pressure, Strain and Force Measurement Handbook and Encyclopedia®

Rotating Torque Sensor Shaft to Shaft Configuration

TQ513 Series All Models $1910

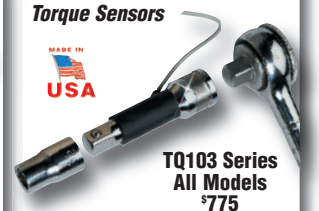
MADE IN USA



Visit omega.com/tq513

Socket Extension Reaction Torque Sensors

MADE IN USA



TQ103 Series All Models $775

Visit omega.com/tq103



International Phone:
203-359-1660
International Fax:
203-359-7700

Circle No.

Over 100,000 Products Online!

Because of transmission frequency regulations, these wireless products may only be used in the United States and Canada (915 mHz models) or Europe (868 mHz models).

OMEGA®

www.omega.com info@omega.com
www.omega.ca info@omega.ca
www.omegaeng.nl sales@omegaeng.nl
www.omegaeng.cz info@omegashop.cz
www.omega.fr sales@omega.fr
www.omega.de info@omega.de
www.omega.com espanol@omega.com
www.omega.co.uk sales@omega.co.uk

Cover Art: Printed by permission of the Norman Rockwell Family Agency. Copyright © 1935 the Norman Rockwell Family Entities.
Dilbert © United Feature Syndicate, Inc.

© COPYRIGHT 2011 OMEGA ENGINEERING INC. ALL RIGHTS RESERVED.

automotive
ENGINEERING
international

CONTENTS

features

28 Driving the pace of change

Engineers speak out on software's impact on the automotive industry in online survey. RESEARCH

32 Inside ZF's nine-speed transaxle for 2013

AEI travels to Friedrichshafen for an exclusive look at the development and technology behind the 9HP—the industry's first nine-speed transaxle slated for MY2013 production. POWERTRAIN

36 Technology crosses industry borders

Between the commercial- and military-vehicle markets, knowledge sharing and tech transfer benefits both in areas such as vehicle electrification and alternative fuels. PRODUCT DEVELOPMENT

39 Cutting the cost of carbon

Automakers streamline production to reduce the price premium for lightweight carbon fiber. MATERIALS | BODY & CHASSIS

cover

The McLaren MP4-12C sports car is built on a carbon-fiber tub, which is unusual even for its high-end market segment.



regulars

4 What's Online
Top products, Top news, Webcasts

8 Editorial

10 Technology Report

10 New TwoStage module leads Honeywell's turbocharger boom POWERTRAIN

13 New filter technology raises LPI system efficiency POWERTRAIN | ENERGY

15 OnStar, QNX broaden role of operating systems ELECTRONICS

16 Johnson Controls' fiber diet for weight loss INTERIORS | MATERIALS

18 Global Vehicles

18 Evos concept spells out Ford's worldwide design and technology language

20 New-generation 911 Carrera

22 Jaguar reveals hybrid two-seat concept

23 Mercedes-Benz B-Class engineered for alternative powertrains

24 Concept previews 2015 Land Rover Defender replacement

26 Prius Plug-In tweaked following Euro trials

42 Companies Mentioned

43 Upcoming

43 Ad Index

43 Classified Advertising

44 AEI 100 Future Look
Reaching higher
Will the car of the future fly?



Automotive Engineering International®, *AEI*®, November 1, 2011, Volume 119, Number 8. *AEI* (ISSN 1543-849X) is published 8 times a year by SAE International®, 400 Commonwealth Dr., Warrendale, PA 15096 and printed in Mechanicsburg, PA. Annual print subscription for SAE members: first subscription, $20 included in dues; additional single copies, $29 each North America, $34 each overseas. Prices for nonmember subscriptions are $110 North America, $170 overseas. Periodical postage paid at Warrendale, PA, and additional mailing offices. POSTMASTER: Please return form 3579 to *Automotive Engineering International*, 400 Commonwealth Dr., Warrendale, PA 15096. SAE is not responsible for the accuracy of information in the editorial, articles, and advertising sections of this publication. Readers should independently evaluate the accuracy of any statement in the editorial, articles, and advertising sections of this publication that are important to him/her and rely on his/her independent evaluation. For permission to use content in other media, contact copyright@sae.org. To purchase reprints, contact advertising@sae.org. Claims for missing issues of the magazine must be submitted within a six-month time frame of the claimed issue's publication date.

Copyright © 2011 by SAE International. The *Automotive Engineering International* title and logo are registered in the U.S. Patent and Trademark Office, and *Automotive Engineering International* is indexed and abstracted in the SAE Global Mobility Database®.

Article reprints/e-prints and licensing requests:
Wright's Media: Toll Free 877-652-5295

Audited by
BPA WORLDWIDE BUSINESS
SIGNET RESEARCH INC
SAE International



www.contitech-online.com/aaw

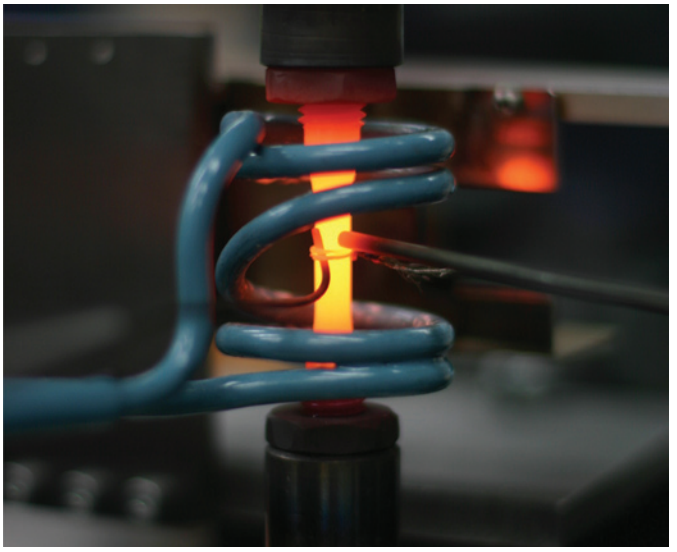
New Technologies – Protecting People and the Environment

People today and tomorrow want to drive economical, eco-friendly cars. This places higher demands on the materials and technology used in the vehicles. A significant point here is that, in a health-conscious world, vehicle interiors must also conform to more stringent requirements. Working with rubber and plastic, the materials of the future, we develop products that are truly innovative: for example, oil-resistant ContiTech timing belts that do the job of chains in oil pumps and camshaft timing drives, cutting CO_2 emissions by reducing friction. With modern hose line systems we cut consumption, while our interior soft trim materials are designed with your health and well-being in mind. When will you allow us to lend a hand in tackling your challenges, creating added value along the way?

ContiTech. Get more with elastic technology.

Continental
CONTITECH

TOP PRODUCTS



High-temperature durability simulation software

The latest release of **HBM**'s nCode DesignLife software offers new solutions for thermo-mechanical fatigue calculations. This feature in nCode version 8 enables a wide range of high-temperature durability simulations. More detail at www.sae.org/mags/aei/10281.

Heat-reflective coatings

Lord Corp.'s heat-reflective coatings (HRCs) are designed for use on automotive suspension systems. The HRCs reflect radiant heat and provide protection against ozone and fluids such as oil and gas, reducing degradation of automotive elastomeric components and lengthening service life. More detail at www.sae.org/mags/aei/10280.

Toolpath for deep-cut machining

CNC Software's 3-D surface high-speed Mastercam OptiRough toolpath supports cutters capable of machining very large depths of cut. The technique is designed to remove large amounts of material quickly using its dynamic milling motion. More detail at www.sae.org/mags/aei/10305.

Integrated gate driver integrated circuits

Atmel's secure ATA5790N is an ultra-low-power AVR microcontroller with advanced encryption standard (AES)-128 immobilizer protocol stack. The device includes low-frequency immobilizer (LF) functionality and a 3-D LF receiver in a single 5 x 7 mm (0.197 x 0.275 in) package. More detail at www.sae.org/mags/aei/10299.

TOP NEWS



The power density of Nissan's 2011-model fuel cell stack is 2.5 times that of its 2005 model.

Nissan engineers a better fuel cell

Through improvements to the membrane electrode assembly and the separator flow path, **Nissan** engineers have significantly improved the power density of the automaker's newest-generation fuel cell stack by 2.5 times over its 2005 model. The result, according to the company, is a world's best (among automakers) of 2.5 kW/L. More detail at www.sae.org/mags/aei/10329.

STMicroelectronics and **Mobileye** N.V. have agreed to co-develop the next generation of their system-on-chip processor for the vision-based driver-assistance segment of the automotive market. The EyeQ3 and EyeQ3-Lite will be the first members of a third-generation family in the companies' cooperation, which began in 2005. More detail at www.sae.org/mags/aei/10330.

A report released Oct. 4 by the **National Academies** concludes that without continued R&D and the construction of pioneering commercial-scale biorefineries to reduce the cost of cellulosic biofuels, the U.S. Renewable Fuel Standard mandates for that type of biofuel are unlikely to be met. The report notes that policy instability would discourage investment in advanced biofuels and make attainment of the goals more difficult. More detail at www.sae.org/mags/aei/10332.

The use of nickel, manganese, and cobalt cathode materials in lithium-ion batteries is expected to increase under a licensing agreement that allows **Umicore** to make and sell the materials developed by **3M**. The companies say the very low concentration of cobalt in the 3M cathode patent will help customers avoid cost fluctuations that are typical of cathode compositions with high cobalt content. More detail at www.sae.org/mags/aei/10331.



With innovations like these, you might want to start referring to them as crash-test smarties.

S-E-A has earned a well deserved reputation in the meticulous reconstruction of vehicular accidents and their analysis. Our expertise in testing vehicle dynamics and vehicle inertia measurements have built S-E-A a worldwide client list for pre-market introductions, as well.

S-E-A engineers, scientists and researchers have created and perfected methodologies and the specialized tools to implement them, including our one-of-a kind automatic steering controller and our unique roll simulator. Let S-E-A's more than forty years of investigative and testing expertise and innovation help you develop a more intelligent vehicle.

Call Jason Baker at 800-782-6851 or visit www.SEAlimited.com or for more details.

S-E-A™

Scientific Expert Analysis™

© 2011

www.SEAlimited.com

WEBCASTS

Nov. 29: Automotive Batteries

New vehicles deploying hybrid, fully electric, and fuel-cell powerplants are presenting significant challenges to automotive engineers, triggering a design revolution that stresses detailed modeling and simulation steps prior to committing to metal and plastic. The need for advanced physical modeling solutions is considerably greater due to increasing system complexity, and the battery is becoming one of the most critical components in alternative-powerplant development. "Physical Models of Automotive Batteries for EV and HEV Applications" is a free, 1-h webcast Nov. 29 at 10 a.m. EDT. The webcast will place particular emphasis on the development of high-fidelity physical models of automotive batteries. Speakers are Dr. John McPhee, **NSERC/Toyota/Maplesoft** Chair for Mathematics-based Modeling, **University of Waterloo**, and Dr. Sam Dao, Application Engineer, Maplesoft. Register at www.sae.org/webcasts.



Dr. John McPhee



Dr. Sam Dao

Editorial Series webcasts now on-demand

If you missed the first three installments of **SAE**'s new Technical Editorial Webcast Series, you can now watch the archived versions at www.sae.org/webcasts. They are all free to view.

Tier 4 Regulations

"Tier 4: Past, Present, and Future Technologies for Meeting Regulatory Challenges" explores why meeting T4F has forced engineers and designers to focus on the most esoteric components of the engine and aftertreatment system, and, simultaneously, on the equipment itself, as the optimization of every vehicle system becomes a critical part of the ultimate solution. What the next set of regulations may look like and some of the technological solutions that may follow are also discussed. Speakers are Jason Bieneman, **Mahle** Corp.; Dr. Georg Hüthwohl, **Albonair**; and Charles Throckmorton, **Sauer-Danfoss**. Webcast sponsored by **Delphi**, **Infotech Enterprises**, and **Ticona**.

Green Car Case Study

"Global 24/7 Engineering: Tools and Techniques for Better, Faster Vehicle Development" looks at the struggle between the demand for innovation and the pressure to reduce costs. Featured is a case study on the development of **Genovation Cars**' G2 green car. Speakers are Andrew Saul, Co-Founder & CEO of Genovation Cars; Lionel Grealou, Head of Business Transformation and Thought Leader at **Tata Technologies**; and Tony Hemmelgarn, Senior Vice President and U.S. Country Manager of **Siemens PLM Software**. Webcast sponsored by **Elsevier**, **Ensoft**, and **MKS**.

Driver Distraction

One way engineers can reduce driver distraction is by designing features and functions that give the driver as little cause as possible to focus on anything other than operating the car. Doing so requires knowledge of human behavior, human-machine interface technology, and ancillary technologies. "Driver Distraction: Regulations and Game-Changing Technologies" presents information on newly gained knowledge in these areas, discusses ongoing research, and explores technological solutions for combating driver distraction. Speakers are Jeffrey Hickman of **Virginia Tech Transportation Institute**, Louis Tijerina of **Ford** Motor Co., and Thomas Schalk of **ATX**. Webcast sponsored by **Delphi**.

MOST VIEWED ARTICLES OF PAST MONTH



Ferrari breaks tradition with its first all-wheel-drive hatchback

Read article at www.sae.org/mags/aei/9558

Researchers say lithium-ion batteries have a long way to go

Read article at www.sae.org/mags/aei/10172

ACIS aims to replace the spark plug

Read article at www.sae.org/mags/aei/10216

Stereo camera innovation from Continental

Read article at www.sae.org/mags/aei/10152

'Simulate, then design' emerges as new engineering methodology

Read article at www.sae.org/mags/aei/10019

©2010 The MathWorks, Inc.

Find it at
mathworks.com/accelerate
datasheet
video example
trial request

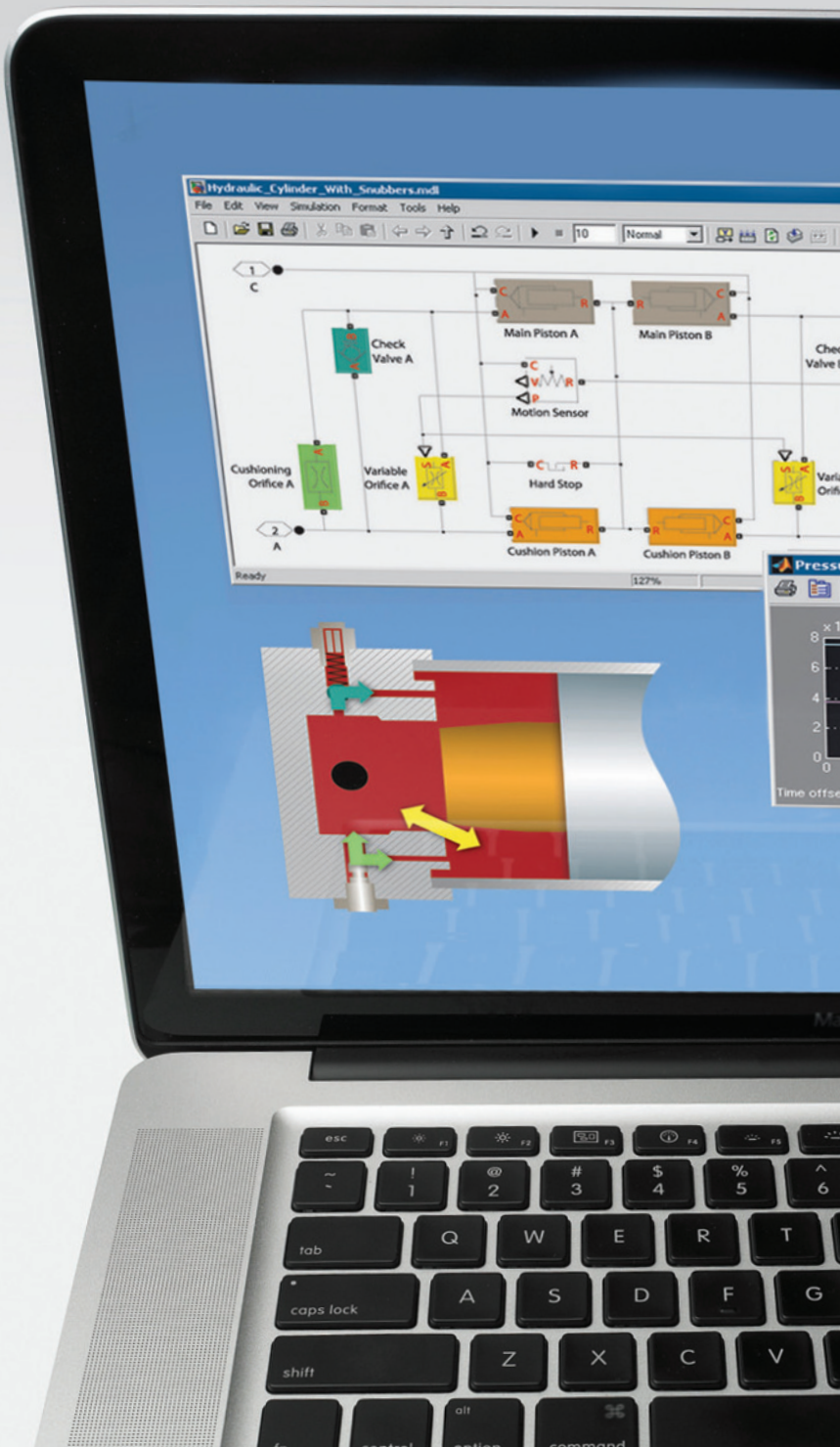
MODEL PHYSICAL SYSTEMS

in

Simulink

with **Simscape™**

- **Electrical**
- **Mechanical**
- **Hydraulic**
  and more



Use SIMSCAPE with SIMULINK to model and simulate the plant and controller of an embedded system. Assemble your model with a graphical interface, or import physical models from CAD systems. Use built-in components or create your own with the Simscape language.

MATLAB® & SIMULINK®

MathWorks®
Accelerating the pace of engineering and science



Carbon dieting

Governments around the world are mandating significantly higher fuel economy requirements for future vehicles. Engineers are responding with more efficient powertrains, but another tool in the industry's toolbox is the reduction of vehicle mass. This can be done through design and/or through the intelligently applied use of lighter-weight metals, plastics, and composites.

One material getting increasing attention is carbon fiber. After a few decades of development in Formula One racing, the material's production use has started to increase, starting with the supercar manufacturers such as **Lamborghini** and **McLaren**. The biggest challenge is bringing more cost-effective solutions to market.

One of the feature articles in this issue, "Cutting the cost of carbon," looks at how automakers are streamlining production to reduce the material's price premium. The 2011 Frankfurt Motor Show in September was a virtual carbon fiber industry expo, as automakers rolled out numerous concepts heavily featuring carbon-fiber-reinforced plastic (CFRP) components.

Supercars such as the Lamborghini Aventador and McLaren MP4-12C are leading the charge, but other automakers are increasingly aiming to exploit the lightweight material's advantages in small, fuel-saving, higher-volume models. **BMW**'s prototype i3 battery-electric model at the show was built on a carbon-fiber tub.

The question is whether mainstream production models can really use carbon fiber on a large scale. BMW's progress on its project i makes the use of carbon fiber on a larger scale look more promsing. The first two models of the project, the i3 pure-electric city car and i8 gasoline hybrid 2+2 sports coupe, each feature a Life module (passenger cell) making extensive use of CFRP, 10% of it recycled, for high levels of torsional rigidity. BMW describes the use of CFRP, developed with **SGL**, on what is expected to become medium-volume vehicles as being unprecedented. Specially woven braided-profile CFRP is used in some areas of the structure, such as door sills, doors, and A-pillars, with preforms molded like a "sock over a mold."

Suppliers are aiming to provide some carbon-fiber development horsepower to augment the OEMs' efforts. Also in this issue, in Tech Report, you can read about how **Johnson Controls** is now aiming to eliminate over 40% of the weight for a new seat design using carbon-fiber-reinforced materials.

The company is developing an advanced seat at its Burscheid, Germany, headquarters together with industry partners and support from the **German Ministry of Education and Research** as part of the three-year CAMISMA (Carbon Fiber/Amid-/Metallic Structural Interior Component Multi-material Approach) project. The project's participants are trying to reduce the traditional carbon-fiber drawbacks of both cost and the added complexity and resultant time involved in making components incorporating the material.

The development of seat structures is a good example for the auto industry's use of economically priced fiber-reinforced composite materials. This project, along with others in development, could help provide a much-needed pathway for the accelerated introduction of fiber-reinforced composite components into high-volume vehicles.

In memoriam

Larry Givens, a longtime editor at **SAE International**, recently passed away after a 30-year battle with Parkinson's Disease. Givens was Editor of *Automotive Engineering* from 1976 until his retirement in 1986. His direction and contributions to SAE's magazines set the stage for the range of media products we now offer. He will be missed by the SAE staff, readers, his family, and friends.

Kevin Jost
Editorial Director

Editorial

Thomas J. Drozda
Director of Programs & Product Development
thomasdrozda@sae.org

Kevin Jost
Editorial Director

Jean L. Broge
Senior Editor

Lindsay Brooke
Senior Editor

Patrick Ponticel
Associate Editor

Ryan Gehm
Assistant Editor

Matt Monaghan
Assistant Editor

Lisa Arrigo
Custom Electronic Products Editor

Kami Buchholz
Detroit Editor

Stuart Birch
European Editor

Jack Yamaguchi
Asian Editor

Contributors
Steven Ashley, Stephen Barlas, Dan Carney, Jörg Christoffel, Terry Costlow, John Kendall, Bruce Morey, Paul Weissler, Mark Wilkinson, Peter Wright, Jenny Hessler, Jennifer Shuttleworth, Linda Trego

Design

Wayne Silvonic
Art Director

Brian Fell
Senior Designer

Ryan Pristow
Senior Designer

William L. Schall
Graphic Artist

Sales & Marketing

Scott Sward
Publisher, Periodicals & Electronic Media
+1.610.399.5279
ssward@sae.org

Marcie L. Hineman
Global Field Sales Manager
+1.724.772.4074
hineman@sae.org

Martha Schanno
Recruitment Sales Manager
+1.724.772.7155
mschanno@sae.org

Robert Kuzawinski
Global Corporate Account Manager
+1.248.568.9455
bobk@sae.org

Terri L. Stange
Global Corporate Account Manager
+1.847.304.8151
tstange@sae.org

Jason Ballard
Media Sales
+1.724.772.8506
jballard@sae.org

Linda Risch
Print Advertising Coordinator
+1.724.772.4039
Fax: +1.724.776.3087
advertising@sae.org

Debby Catalano
Classified/Recruitment/Online Coordinator
+1.724.772.4014
Fax: +1.724.776.3087
emedia@sae.org

Marcy Estok
Marketing Manager
mestok@sae.org

Jodie Mohnkern
Circulation and Mail List Manager
mohnkern@sae.org

Stephanie Stroud
Sales Coordinator
+1.724.772.7521
sstroud@sae.org

Regional Sales

North America

East Coast: CT, MA, ME, NH, NY, West PA, Quebec, RI, VT
Denis O'Malley
+1.203.356.9694 x13
domalley@sae.org

East Coast: DC, DE, FL, GA, MD, NC, NJ, NY, SC, East PA, VA, WV
Bob Fox
+1.203.356.9694 x12
bfox@sae.org

Great Lakes: Eastern MI
Denis O'Malley
+1.203.356.9694 x13
domalley@sae.org

Great Lakes: Western MI
Chris Kennedy
+1.847.498.4520 x3008
ckennedy@sae.org

Midwest: IA, IL, IN, KS, Manitoba, MN, MO, MT, ND, NE, OH, SD, WI, WY
Chris Kennedy
+1.847.498.4520 x3008
ckennedy@sae.org

Southeast: AL, KY, MS, TN, Ontario
Darcy Giovingo
+1.847.498.4520 x3010
dgiovingo@sae.org

Southwest/West Coast: Alberta CAN, AK, AR, AZ, British Columbia CAN, CA, CO, ID, LA, Mexico, NM, NV, OK, OR, TX, UT, WA
Nancy Bateman-Kocsis
+1.310.676.7056
nbateman@sae.org

International

China (Mainland)
Marco Chang
+86.21.6289.5533-101
marco@ringiertrade.com

Europe (Central & Eastern): Austria, Czech Republic, Germany, Hungary, Poland, Switzerland
Sven Anacker
Ralf Gerbracht
+49.202.27169.17
mail@InterMediaPartners.de

Europe (Western): Belgium, Denmark, Finland, France, Ireland, Israel, Italy, Netherlands, Norway, Spain, Sweden, Turkey, United Kingdom
Chris Shaw
+44.1270.522130
chris.shaw@chrisshawmedia.co.uk

Hong Kong
Annie Chin
+852.2369.8788-32
annie@ringier.com.hk

Japan
Shigenori Nagatomo
+81.3.3661.6138
nagatomo-pbi@gol.com

South Korea
Soyeon Kim
+82-2-564-3971/2
international@ksae.org

Taiwan
Kelly Wong
+886.4.2329.7318
kwong@ringier.com.hk

AEI Offices
400 Commonwealth Drive
Warrendale, PA 15096-0001 USA
aei-online.org

Editorial
+1.724.772.8509
Fax: +1.724.776.9765
aei@sae.org

Subscriptions
877.606.7323
+1.724.776.4970 (Outside U.S. & Canada)
Fax: +1.724.776.0790
customerservice@sae.org

3M Automotive





Ac
Acoustics

Mr
Micro-
Replication

Pm
Polymer Melt
Processing

Transforming technologies

Connecting with customers

Solving industry challenges through collaboration and technology innovation

Car makers want lighter-weight, more fuel-efficient vehicles with a quiet ride.

At 3M Automotive, we problem-solve with our customers to creatively apply technologies and create solutions that fit OEM challenges and fulfill consumer desires.

Check us out at 3M.com/AutoEng or call us at 800-328-1624.

3M

© 3M 2011. All rights reserved.

POWERTRAIN

New TwoStage module leads Honeywell's turbocharger boom

Predicting automotive technology trends isn't an easy job for suppliers, who also must focus on how the trends will impact their product lines. But the global trend to engine downsizing has given **Honeywell Turbo Technologies** a clear picture.

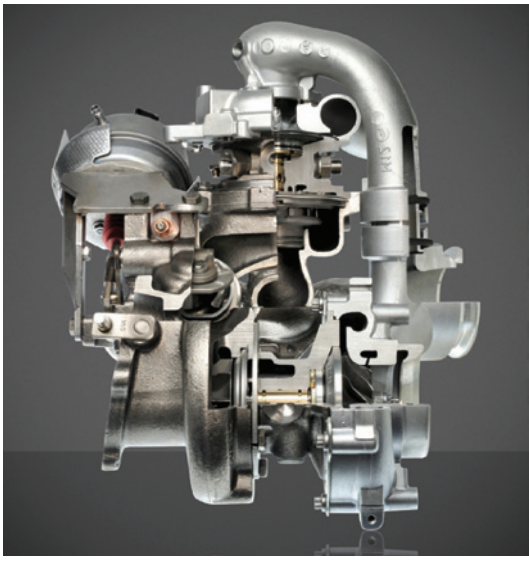
The company projects an upward curve for its signature product line, growing from almost one-quarter of global vehicle production today to over 40% in four years. And by 2020, turbo penetration is expected to exceed 66% worldwide.

The increase is tied to regulatory demand for improved fuel economy but also to customer expectations of performance. In the U.S., where the turbo market share increased from 6% to 10% in the past year, it is expected to reach 23% by 2016. This compares with 56%—primarily diesels—in Europe. Few naturally aspirated diesels remain in production for mainstream automotive use, and indeed Honeywell's newest design is for an **Audi** A6/A7 diesel. So the greatest amount of future growth will be for gasoline engines.

The overall benefit of downsized, boosted engines is evident in this recent performance comparison: a 2.0-L turbocharged four-cylinder develops the same 200 hp (149 kW) rated output as a naturally aspirated 3.0-L V6, while delivering at least 20% better fuel economy. Complementary technologies such as direct injection (DI) and stop-start also benefit fuel efficiency, but the turbo certainly is the key addition for engine performance. Indeed, there are 2.0-L DI turbocharged gasoline engines producing up to 274 hp (204 kW).

The lighter weight of turbocharged four-cylinder engines vs. larger displacement V6s also enables a reduction in vehicle mass, further contributing to fuel economy.

According to a Honeywell study, the average U.S. passenger-vehicle engine in 2011 is a 3.3-L V6. In Europe the typical engine is a 1.8-L four (including diesels); in China it's a 1.6-L four. Turbo penetration in China is approximately the same as in the U.S., also due to that market's lower diesel penetration than in Europe.



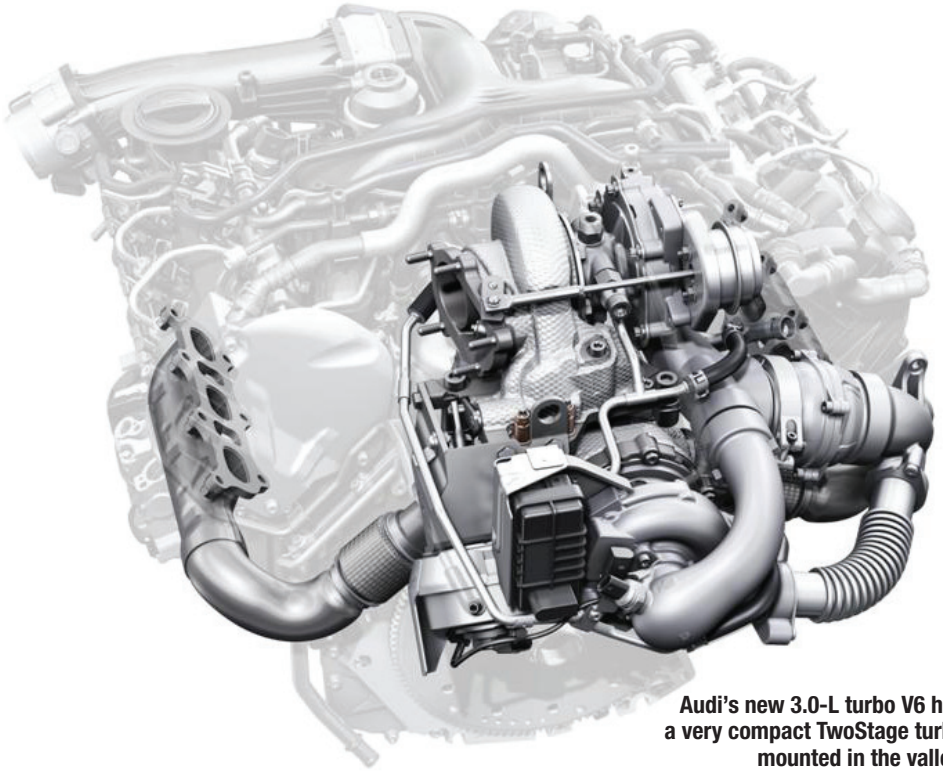
Off-engine view of the Honeywell turbo used on the Audi A6/A7 diesel. One stage is transverse, the other longitudinal.

Integration is critical

But for turbo suppliers (Honeywell is the world's largest), the issue goes deeper—namely what must be done to advance the turbo technologies in ways that will meet OE requirements and be cost-competitive in the marketplace. According to Honeywell's Mike Stone, Application Engineering Leader for gasoline turbos, there is no single approach to turbocharger design nor an area of the design that is escaping engineering attention.

Speaking at the annual Test Days program of the **International Motor Press Association** (IMPA), at the Monticello (NY) Motor Club track facility, Stone noted that turbocharger systems are now part of the initial engine design rather than being a performance add-on. He described some early industry approaches as "just make it [the turbo unit] physically small and let the wastegate get rid of any excess pressure."

Today's configurations range from the simple single turbo with a wastegate to relieve excess exhaust pressure (including single separate turbos for each bank of a V-type), to integrated parallel and series flow two-stage sequential flow designs feeding a single intake manifold.



Audi's new 3.0-L turbo V6 has a very compact TwoStage turbo mounted in the valley.

There are also dual-scroll designs, including those joined to split-interior-path exhaust manifolds to smooth and speed exhaust flow. And since 1990, variable nozzle technology (variable vanes for the turbine) has provided even greater opportunity to tune turbos for specific engines.

Honeywell's newest design, the TwoStage Module for the Audi A6/A7 3.0 diesel V6, is also its most compact. It's a series-flow type, in which a small turbo is joined to a larger turbo. A by-pass (control) valve enables the two turbos to operate together or in single low-pressure stage mode. This provides good response throughout the rpm range as well as low emissions.

The TwoStage is sized and shaped so it packages neatly in the engine valley. The smaller (high-pressure) turbo has a variable nozzle and is mounted transversely. The larger (low-pressure) turbo is mounted longitudinally, so the TwoStage was a challenge for integration, castability, and overall manufacturability.

Thus equipped, the Audi engine produces a claimed 313 hp (233 kW), a 30% increase in power vs. the baseline 3.0-L diesel V6. That's about the same power as a 30% larger displacement engine but with 10% better fuel economy.

Ford's 6.7-L V8 diesel in the 2011 Super Duty truck is another unique design. Its single sequential turbocharger features a double-sided compressor wheel driven by a single variable nozzle turbine. A compact design that is mounted in the engine valley, the Super Duty turbo has the reduced inertia of a single turbine wheel turning a single compressor shaft, so it spools up quickly for fast response.

The primary compressor on the Ford diesel unit operates at low speed, and at a specific rpm or boost pressure, the bypass (control valve) opens and the secondary compressor also comes into play. And because both are on the same shaft, the transition is seamless.

Exhaust temperature challenge

At the IMPA Test Days program, Honeywell had five turbocharged cars for test driving. Two were the single wastegate turbo for gasoline engines, both installed on 1.4-L engines, in a **Chevrolet** Cruze and an **Alfa Romeo** Giulietta. There was also a European market **Volkswagen** Golf with a 1.6-L diesel, a **Lincoln** MKS with a single turbo for each bank of the 3.5-L V6, and a **Mercedes-Benz** E-350 3.0-L diesel V6 with a single turbo with variable nozzle technology.

Proving the point that no area is escaping attention, the Mercedes unit has a shaft ball bearing instead of a plain sleeve, both for durability and better per-





Ford Super Duty 6.7-L V8 diesel also mounts its turbocharger within the vee. The unit has dual compressor wheels on a single shaft, which helps provide seamless gas transfer from one turbo to both.

formance (primarily in transient operation), Stone explained. And although the Cruze turbo is a single scroll, it's integrated with the exhaust manifold to improve flow characteristics and packaging. The design also eliminates a bolt-together joint, which simplifies assembly.

The search for new turbine materials is ongoing, particularly for gasoline engines which run at higher exhaust temperatures than diesels (approximately 950°C vs. 800°C). Ceramics can take the temperatures but they're brittle, posing a durability problem. And debris particles are more of a problem than with steel.

An "exotic" material, titanium aluminide, is used in some commercial aircraft turbines and some racecar turbos, particularly those used by **Porsche**. The lightweight alloy enables the turbo to spool up faster and also is both heat- and corrosion-resistant. However, it has never been used in mass-production cars.

Paul Weissler

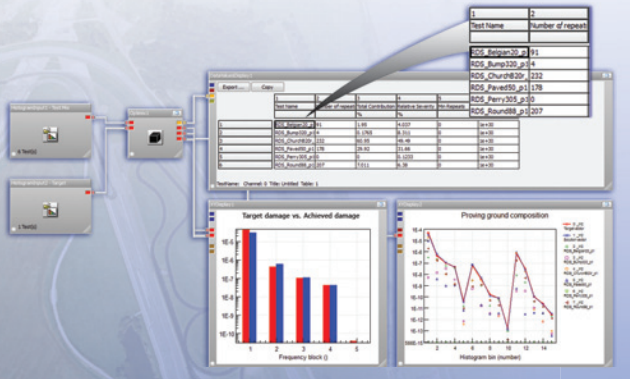
Minimize test time & achieve targets

nCode n'

Optimized Testing now a product option in nCode GlyphWorks 7

With Optimized Testing you can now:

- **Determine optimum**, most efficient mix of proving ground surfaces
- **Reduce** proving ground track usage
- **Transform** huge amounts of measured data into key parameters
- **Understand** how real world usage compares to track data



nCode GlyphWorks G

Learn more at a free webinar: Proving ground optimization & customer usage correlation www.hbm.com/ncodewebinars

www.hbm.com/ncode | ncode@hbm.com

HBM

POWERTRAIN | ENERGY

New filter technology raises LPI system efficiency

Liquefied petroleum gas (LPG) is an alternative fuel option that combines reduced CO_2 emissions with lower fuel cost. Increasingly automakers are offering LPG versions of certain vehicle models, typically with a dual-fuel (bi-fuel) engine. Other gasoline vehicles are converted to dual-fuel combustion.

At the 2011 Frankfurt Motor Show the supplier **Mann+Hummel** presented a filtration technology that is used in vehicles with liquified gas injection. Filtering LPG in its liquid form poses some challenges as the system pressure can go up to 25 bar (363 psi).

"At this level the filter system is exposed to substantial mechanical forces," said Dr. Harald Banzhaf, head of liquid filtration elements R&D at Mann+Hummel in Ludwigsburg, Germany. Reliably filtering liquified gas is absolutely necessary to protect the gas pump and injectors.

Typically, LPG is converted from its liquid form in the tank to the gaseous form before it is injected. Systems that inject the gas as an actual liquid have been around since the mid-1990s; the Dutch company **Vialle** coined the name Liquid Propane Injection (LPI) for this principle.

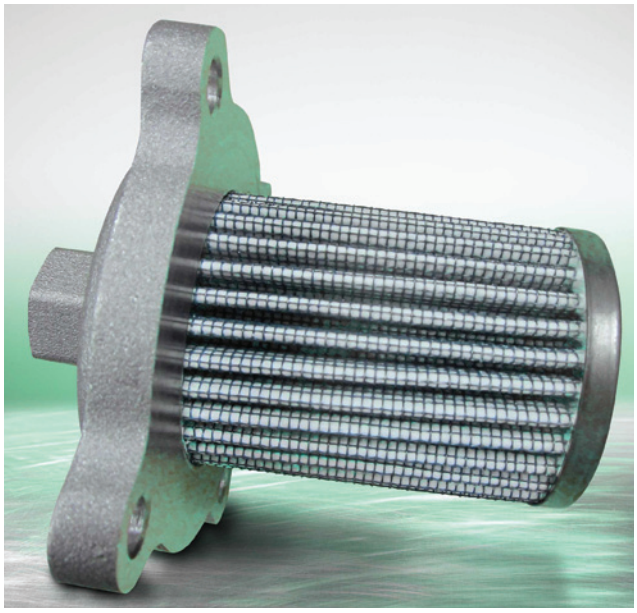
In Australia, **GM Holden** offers LPI technology as an option in some of its cars. And in March 2011, **Hyundai** applied for an LPI patent (application no. 12/621199; http://www.freepatentsonline.com/y2011/0048376.html).

Such LPI systems exploit two major benefits. First, the amount of fuel that is injected into the intake manifold can be controlled more precisely as a liquid than with as a gas. Probably even more importantly, the evaporation cooling effect caused by the expanding propane-butane mix reduces the charge-air temperature, which in turn permits higher compression ratios and improves the energy density in the combustion chamber.

Both benefits help to make the transition from petrol to liquid propane injection mode less noticeable to the driver. In addition, the lower temperature level can help to reduce problems such as burnt valves.

In terms of energy efficiency, LPI makes sense; when the LPG is converted to its gaseous form in an LPG engine, the evaporation cooling must not cause the converter to freeze up. It needs to be heated, which can be done by using warm coolant. In other words, the evaporation cooling is wasted be-





Mann+Hummel's new composite filter's filtration rate, differential pressure, and burst strength aim to reconcile energy-saving and high-performance requirements in liquified-gas filtration.

cause it occurs at the wrong place where more energy has to be dissipated to compensate for the effect.

"The challenge we were entrusted with by our new Australian customer was to come up with a filtration technology that is more efficient than existing filters but retains a low level of differential pressure," Banzhaf explained. "A higher differential pressure would consume more energy, which would have an impact on the fuel consumption. One of our targets was to actually save energy while improving filtration."

The filtration technology that will now be installed by the Australian OEM was developed at the Mann+Hummel site in Korea, where it is also manufactured before it gets shipped to the supplier's Sydney site.

The filter element is a composite of an ultrafine nonwoven glass-fiber medium supported by an outer metal mesh skeleton. Banzhaf noted that the glass fiber has one big advantage.

"During operation no filter cake will build up on the surface. Instead, the particles are transported into the fiber mesh where they are held back deep inside the chaotic filter media structure," he explained. "As a consequence, many liquid paths remain open for the gas flow through the filter medium. Therefore, the differential pressure level of a glass-fiber filter medium will remain constant for a long time." In the current application the filter is designed for a 60,000 km (37,300 mi) lifetime.

The glass-fiber filter mats are difficult to handle because they are easily compressed during manufacturing. This is a particular challenge with composite materials, Banzhaf noted. Part of the manufacturing know-how required to avoid glass-fiber compression during production was developed at two German R&D sites of the supplier.

The new filter element has not only been tested to 25 bar as requested by the OEM; during the approval by the **Australian Gas Association** the filter element was successfully taken up to 45 bar (650 psi), said Banzhaf. It has been certified to the rigorous AZ/NZS 1425:2007 standards.

The filter retains 92% of particles down to 5 microns and above 99% of particles down to 10 microns—nearly the fineness required for a modern common-rail diesel injection system filter, Banzhaf noted.

Jörg Christoffel

50 YEARS
Rittal. Power and Vision!
Rittal – The System.
Faster – better – worldwide.
Enclosures
from XS to 3XL
ENCLOSURES
POWER DISTRIBUTION
CLIMATE CONTROL
FRIEDHELM LOH GROUP

ELECTRONICS

OnStar, QNX broaden role of operating systems

Real-time operating systems (RTOSs) are expanding their role in infotainment, giving systems designers a platform that lets them extend capabilities and expand into new markets. **OnStar**'s entrance into the consumer market earlier this year highlights this trend. The company recently announced that OnStar FMV, an aftermarket rearview mirror, uses software made by **QNX Software Systems**.



QNX software helped OnStar trim costs and enter the consumer market with the FMV.

RTOSs have seen expanded use over the past few years as radios expanded their role into infotainment systems that pull portable consumer products and features like navigation together. OnStar leveraged the software's scalability when it entered the consumer market with OnStar FMV early this year.

"When you start selling more consumer-oriented products in the aftermarket, there's a different price point to consider," said Andrew Poliak, QNX's Worldwide Auto Sales Director. "This deal illustrates that products can go from the high levels of automotive-grade requirements to the pricing levels of consumer products."

OnStar began using QNX's Neutrino RTOS in 2006 and now includes it in all new products, Poliak said. A number of other automakers run software made by QNX, which claims to be in more than 20 million vehicles worldwide. Other RTOS suppliers such as **Microsoft**, **Intel**'s **Wind River**, and **Green Hills Software** are also targeting the infotainment segment.

Poliak noted that RTOSs are expanding their role in other interior systems. High-end infotainment systems were among the initial applications, where they helped handle connectivity with a range of consumer devices.

"Low-end radios now require connectivity, and instrument clusters are going from analog systems to reconfigurable displays so they need more capabilities," Poliak said. "In some cases, a single multicore device will handle, say, the instrument cluster and a center stack display using an RTOS to handle various tasks in each environment."

OnStar FMV also uses the QNX Aviage acoustic processing suite, which lets the system hear the driver's voice clearly in noisy automotive interiors. A major development for this software is an automatic calibration feature that makes it easy to employ voice recognition in any vehicle.

OEMs typically tune voice-recognition systems for each vehicle to achieve optimal performance. That's not possible with aftermarket kits, which will be installed in a range of vehicles.

"Aviage automatically measures audio latency and goes through a self-tuning function to optimize voice-recognition performance," Poliak said.

Terry Costlow

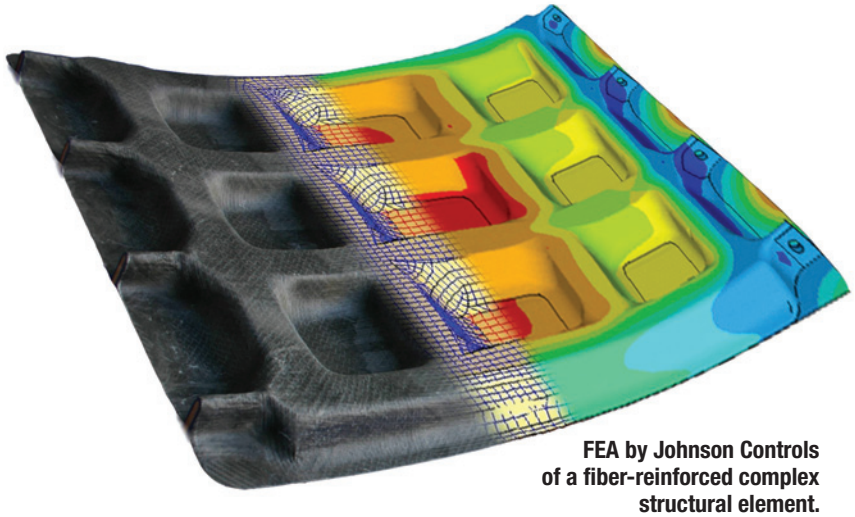


INTERIORS | MATERIALS

Johnson Controls' fiber diet for weight loss

Cutting the weight of components by even a few percentage points can be a difficult task for suppliers and OEMs, but in Germany **Johnson Controls**, not satisfied with a 30% weight reduction in a rear-seat backframe, is now aiming to reach a 40%-plus target for a new seat design using fiber-reinforced materials.

The company is developing the advanced seat at its Burscheid headquarters together with industry partners and support from the **German Government's Ministry of Education and Research** as part of the three-year CAMISMA (Carbon Fiber/Amid-/Metallic Structural Interior Component Multimaterial Approach) project.



FEA by Johnson Controls of a fiber-reinforced complex structural element.

Referring to the earlier seatback-frame work (previously described by *AEI* at www.sae.org/mags/aei/9690), Dr. Andreas Eppinger, Vice President Technology Management, Johnson Controls' Automotive Experience, said: "We will continue to develop additional alternative, even lighter-weight materials with our partners in CAMISMA." The project is a salient part of the Ministry of Education and Research's program, "Innovative Materials for Industry and Society," which aims to accelerate technical solutions via partnerships between both economic and scientific stakeholders.

CAMISMA particularly aims to support the replacement in automotive applications of steel and light alloys by fiber-reinforced composites (FRC), particularly carbon fiber, to complement the auto industry's aggressive fuel and exhaust emissions reduction R&D.

As always, the stumbling block for carbon-fiber use is both cost and the added complexity and resultant time involved in manufacturing components incorporating the material. CAMISMA is focusing on reducing these drawbacks.

Said Dr. Matthias Berghahn of CAMISMA partner **Evonik Industries**: "We are pursuing ways to make high-volume production economically possible." The difficulty of making ever thinner, lighter weight steels is driving the need for new materials and design.

Eppinger and Berghahn regard the development of seat structures as exemplifying a solution for the auto industry's use of economically priced FRC materials. It would also provide a path for the interfaces of FRC components and metal-based vehicles. With that aim, a concept seat is now being developed and tested potentially for manufacture.

The objective is to achieve more than a 40% weight reduction when compared to a conventional metal-based design.

As well as Johnson Controls, Evonik, and the German Ministry, other partners include **Jacob Plastics**, **Toho Tenax Europe**, and the **Technical University of Aachen**.



A Slim Stow Seat for second-row use in pickups has been developed by Johnson Controls, saving space and weight.

Separately from CAMISMA, Johnson Controls is working on improved seat packaging for some vehicles that also brings weight saving. If that design were allied to the FRC work, the opportunity for additional mass reduction might be furthered.

Eppinger stated: "Our Slim Stow Seat enables us to set new standards in foldable rear seats in pickups. When stowed, it takes up 33% less space and is lighter weight compared to traditional rear truck seats. It also improves visibility when stowed since the seatback is lowered 100 mm."

Weight savings comes from a 30% reduction in the use of materials.

The seat panel comprises two components: an upper part that is a tubular frame featuring the child seat attachment points and defined side bolsters, and the lower part with a stable arm that carries the seat pad, which features 50% more foam than usual in the relevant areas.

Stuart Birch

MLX80104

SUPER HERO OF lin ICs

MLX80104 LIN Slave IC

Application Configurable uniROM

- Ready-To-Use Firmware Implementation For J2602 (Ford, GM)
- No Customer Software Development Needed!
- Easy-To-Configure I/O and LIN Messages

LOCAL INTERCONNECT NETWORK

Is It A **Door Switch?**
Is It A **Control Module?**
Is It A **Panel Switch?**



Discover LIN At:

melexis.com/LIN



We Engineer The Sustainable Future.

Melexis
Microelectronic Integrated Systems

www.melexis.com

Evos concept spells out Ford's worldwide design and technology language

Ford has created a new in-house global design language in both style and technology that signals a significant transformation of the brand. Its first manifestation is in the Evos "bespoke concept" unveiled at the 2011 Frankfurt Motor Show.

The vehicle might not be totally indicative of a specific forthcoming product though. "While you will never see this car on the road, the next generation of Ford products around the world will display many of the distinctive design ideas and advanced technologies it showcases," explained Derrick Kuzak, Ford Group Vice President, Global Product Development.

Precisely to which models they will apply, Ford was not saying.But the front and rear gull-wing doors of the Evos do not look likely for the next-generation Fiesta. However, many aspects of the Evos styling and technology will make it to the company's cars, MAVs, and CUVs that will be spawned by Ford's eight design studios with their 1150 staffers across the world as part of the One Ford strategy planned to usher in major changes to the brand.

"Premiumness," smart technologies, and fuel economy leadership are the stated aims for new designs that will go hand-in-hand with vehicles that have substantive driver appeal, exceptional connectivity capability, and style. The fastback Evos has echoes of late 1960s Mustang and Capri without in any way looking retro.

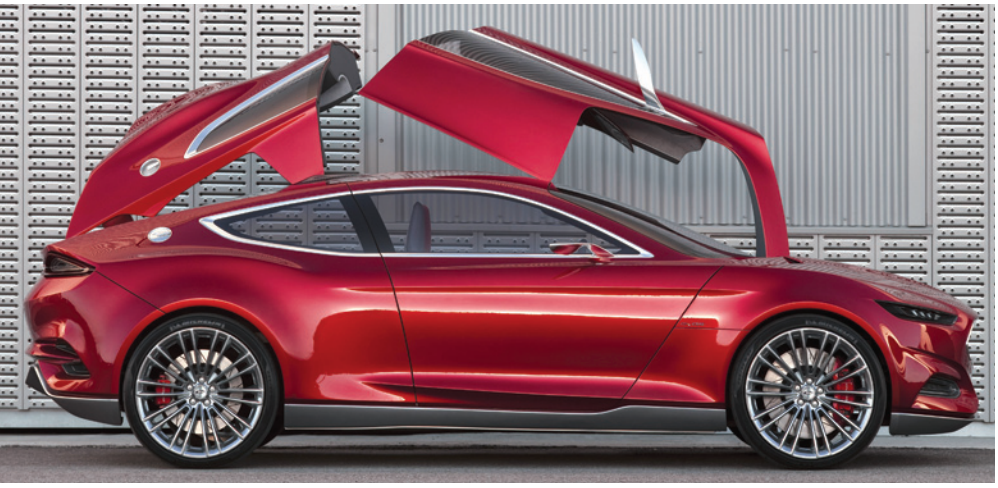
"This new design DNA provides a clear direction for a whole new generation of models," said J Mays, Group Vice President, Design and Chief Creative Officer. It is a strong statement of intent, he said, and is an evolution of Ford's current kinetic design signature demonstrated in the highly successful Fiesta and Focus.

Martin Smith, Ford's Executive Design Director for Europe and Asia Pacific, who has had considerable influence on the company's design direction, added: "With our new global DNA, we have retained the same dynamic character but with a more technical execution and a distinctively premium feel."

Moray Callum, Executive Design Director, North America, stressed: "A common DNA doesn't mean identical-looking products. The design language is flexible enough for different sizes and types of vehicles."

So the blue oval will be nosing its way up market supported by the Evos' appearance. Use is made of "bold technical shapes" stated Ford, including "laser-cut" front headlamps and with front and rear windshields connected by a thin glazed section of roof.

Ford's new exterior and interior de-



The Evos concept has a distinctly sporty air about it, previewing Ford styling cues to come.



It may look futuristic, and it is, but Ford will use many design cues from the Evos in production models.



Hints of late 1960s Mustang and Capri about the fastback Evos. Ford's hybrid-electric engines promise some advanced technology.



Stanyl®

Flexible design for the future.

Thermoplastic solutions for the Automotive Electrical & Electronics industry.

Reducing vehicle mass, creating smaller components and managing the needs for the electric vehicles. DSM offers a full range of innovative resin solutions to meet every design need, now and in future. Learn more at www.livingsolutions.dsmep.com.

HEALTH · NUTRITION · MATERIALS

DSM
BRIGHT SCIENCE. BRIGHTER LIVING.



Two-plus-two seating in the gull-winged Ford Evos concept with red used to delineate the driver's position.

sign vocabulary was a result of "an unprecedented collaboration" among design teams from around the world. Next year will see the first production example of all this. But until then it is the Evos that carries the flag of Ford's forward philosophy.

Paul Mascarenas, Chief Technical Office and Vice President, Ford Research and Innovation, led the team that built the Evos. "We see technology as more that just an impressive list of microprocessors, sensors, and software; it's about the application of that technology to create an experience that enhances the driver's time behind the wheel," he said.

That includes the use of a driver's "personal cloud" of information, said Mascarenas. "The possibilities are fascinating when we explore how to enable a seamless lifestyle between home, office, and car linked by access to the driver's personal information."

The car "knows" the driver, automatically using adaptive vehicle technologies such as chassis and powertrain controls to meet personal preferences with regard to ambient conditions. This even includes advanced air-quality sensors and filtration systems, assessing air quality via the cloud.

The Evos is powered by a lithium-ion, plug-in hybrid powertrain to provide the same level of performance and fuel economy as the Ford C-Max Energi that will be introduced first in the U.S. next year and then Europe. The car runs in pure electric mode until battery charging is necessary, when the 2.0-L gasoline engine starts.

Access to historical driver behavior and typical journeys permits travel patterns to be refined to calculate energy-saving routes by predicting a destination and achieving the most intelligent use of gasoline or battery power. Using both internal combustion engine and electric motor gives a range of about 800 km (500 mi).

The Evos concept is 4.5 m (14.8 ft) long, 1.97 m (6.5 ft) wide, and 1.36 m (4.5 ft) tall, with a wheelbase of 2.74 m (9.0 ft). The figures indicate a certain merging of typical C-car and C/D-car sizes. So there may even be new Ford phrases for generic designations. A case, perhaps, of Ford crossing class barriers.

Stuart Birch

New-generation 911 Carrera

Porsche, that ultimate exemplar of the art of automotive design evolution, continues its long-established philosophy with the announcement of the next-generation 911.

A major point of interest at the Frankfurt Motor Show in September, it may look, at first glance, very similar to its predecessor, but it is lower, sits on a longer wheelbase, and makes use of what Porsche describes as "an intelligent aluminum-steel construction" to create "a completely redesigned generation" of the car. It is also lighter by up to 45 kg (99 lb), more powerful (although the regular Carrera has a slightly downsized 3.4-L engine), is more frugal, and has improved emissions, with a best CO_2 of 194 g/km. The use of a seven-speed manual gearbox is claimed as a first for a production car.

Porsche uses the phrase "tradition meets modernity" to describe the new 911, which confusingly carries the company code name of 991, despite following in recent years the sequence 993, last of the air-cooled models; 996, first of the water-cooled; and from 2005, 997.

The initial announcement of the model range covers just the rear-drive Carrera and Carrera S, but hybrid, all-wheel-drive, cabriolet, and turbo versions are expected to emerge over the next couple of years.

Porsche once tried to design a model to replace the 911. In 1978, the radically different and futuristic looking 928 appeared, with front-mounted V8 engine. It promptly won a Car of the Year accolade—and equally promptly failed to persuade the vast majority of 911 aficionados to shift their affections. The 911 cult would continue and strengthen.

Even 30 years later, Design Director Michael Mauer really did not have much choice when the time came to update the 997. He has overseen the creation of a car that—despite being a little larger with the wheelbase stretched 100 mm (3.9 in), about 10 mm (0.4 in) lower, and with a more steeply sloped rear end—looks very similar in its general configuration to the outgoing model and the 996 of 1997. However, its roofline



New 911's interior has elements of Carrera GT and Panamera. Gearshift/transmission selector is close to steering wheel.

now tapers more smoothly with a steeper angle for the rear windshield and narrower side windows with optional 20-in wheels contributing to the visual effect of a slimmer side elevation.

The car still retains the core DNA of the original 911 (initially designated 901) of 1963. Front fenders remain high with wide arches covering an extended track. The external mirrors are now mounted on the upper forward area of



48 years into Porsche 911 design: a longer wheelbase, narrower glass area, lower height, and aluminum-intensive body shell distinguish the extensively redesigned new generation.

Power IC Solutions for Today's Changing Automotive Environment

Fans/Pumps/Blowers

World class line up of automotive grade BLDC and MOSFET pre-driver control ICs. Allegro ICs simplify the interface to three phase brushless motors and can be integrated into systems from simple six-step (trapezoidal) control to solutions which require complex vector control. A similar product family also exists for driving brush DC motors.

Transmission/Steering

Transmission and steering systems require high reliability and high temperature operation. Automotive qualified BLDC and DC motor control ICs are specified and fully tested to operate in ambient environments up to 150°C.

Infotainment

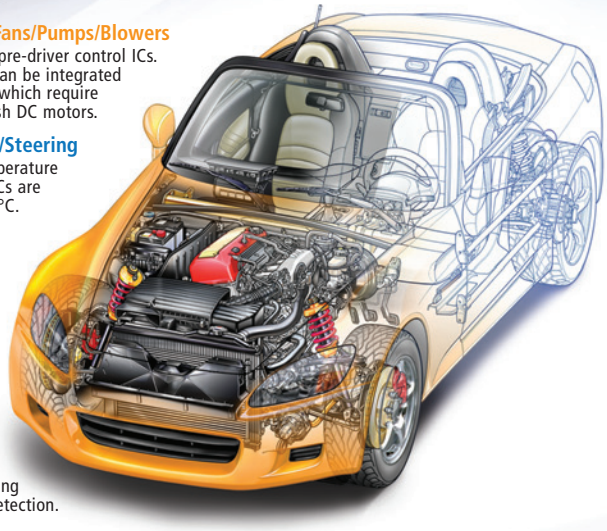
Robust highly integrated LED backlighting drivers and voltage regulators targeting in-dash navigation systems, automotive infotainment, back-up camera displays, and other cluster or center stack applications.

Lighting

LED drivers designed to operate over the typical automotive battery and temperature ranges for automotive interior lighting such as map lights and dome lights, and exterior lighting such as daytime running lights, rear indicator and brake lights, and rear combination lighting.

Closure Systems

Allegro offers a complete line of full bridge automotive grade brush DC control ICs and system basis ICs for solid state solutions allowing greater flexibility for speed control and stall detection.



Allegro® MicroSystems, Inc.

High-Performance Semiconductors

www.allegromicro.com/promo829

115 Northeast Cutoff
Worcester, Massachusetts 01606 USA
508.853.5000

the door like those of much earlier and more basic 911s, including the 3.2 Carrera, which was the last of the type to do without power steering or ABS. Porsche states that body stiffness of the 991 is greater, although it gives no figures.

The front bumper is higher and carries boldly placed LED daylight running lights; rear LED lights are slim, blending less smoothly with the body. There is a wider, variably extending rear spoiler.

The use of a 257-kW (345-hp) 3.4-L engine is down from 3.6 L, but it is marginally more powerful and of similar capacity to the power units of the Boxster and Cayman. In the regular Carrera it is allied to a twin-clutch PDK automated manual transmission, and in Sport Plus mode of the optional Sport Chrono Pack gives a best 0-100 km/h (0-62 mph) time of 4.4 s. The comparative figure for the 294-kW (394-hp) 3.8-L Carrera S is 4.1 s.

Fuel consumption of the 3.4 L with PDK is 8.2 L/100 km in the combined New European Driving Cycle, 1.6 L/100 km less than its predecessor. It is also the first Porsche sports car to achieve less than 200 g/km CO_2 emissions. The Carrera S, now having 11 kW (15 hp) more power, with PDK achieves a combined 8.7 L/100 km and 205 g/km. Auto stop-start is fitted to the Carrera engines, together with thermal management.

Porsche Dynamic Chassis Control (PDCC), an active roll control stabilization system, is now available on the S, which also gets Porsche Torque Vectoring and a limited-slip differential. All 911s gets electromechanical power steering as an aid to reduced fuel consumption.

The interior is traditional 911, with a large centrally mounted rev counter, though it also includes elements of the exotic Carrera GT and of the Panamera. The center console rises toward the front of the car, and the gearshift lever is positioned particularly close to the steering wheel. A 7-in touch screen is fitted. Seats are leather, sports-type.

Stuart Birch

Jaguar reveals hybrid two-seat concept

A hybrid system with KERS (Kinetic Energy Recovery System), aluminum architecture, new supercharged 3.0-L V6 direct injection gasoline engine with auto stop-start, top speed of 300 km/h (186 mph), and CO_2 emissions of only 165 g/km are the core aspects of **Jaguar**'s new C-X16 concept, which looks set for production for MY2013.

A star of this year's Frankfurt Motor Show, it will be manufactured in convertible and coupe forms, both of them two-seaters. The coupe concept has a side-hinged tailgate like the XKE (E-type) coupe's and a clamshell hood. Arguably, the front-engined rear-drive C-X16 is a 21st century successor to the XKE, but there is almost nothing about its aesthetics that echo that car's distinctive shape.

In line with Jaguar's inter-model technology sharing and use of modularity, the C-X16 will incorporate knowledge gained in the use of aluminum for the current XK and XJ models and with planned models including the next XK generation's architecture. Reducing mass is a priority, but the concept is not a lightweight, scaling around 1600 kg (3530 lb).

Its 279-kW (374-hp) V6 2995-cm³ engine puts out 92.7 kW/L (124 hp/L), achieves 450 N·m (332 lb·ft) maximum torque, and is closely related to the company's established 4.0-L V8. Jaguar's extensive experience of supercharging road car engines is being applied to the new sports car.

The decision to use a KERS system



The Jaguar C-X16 concept makes extensive use of aluminum, though weight is about 1600 kg (3527) for the small two-seater.

Jaguar decided to leave aerodynamicist Malcolm Sayer's XKE design (based on his rounded 1950s racing D-type) in the era in which it was created and eschew any overt retro touches. As a road car, the svelte XKE was very different from anything else of its time. Said Director of Design Ian Callum: "Jaguars have always been dramatically different."

Which is why the C-X16 is of a new era. Jaguar's use of past visual cues in the previous-generation XJ sedan—and in the S-type when that appeared a decade ago—were not as stylistically advanced as they might have been. Callum added that the C-X16 now moved the company's current design language on to the next generation, "creating a car that is the very essence of future Jaguar performance."

is a significant element in achieving an on-demand performance boost, low emissions, and some short-range pure-electric drive capability. Sending out the right environmental message while meeting market demand for high performance is a challenge for all performance-oriented products of OEMs, and Jaguar has stated that it will design "sustainable sports cars."

Built on a 2622-mm (103.2-in) wheelbase, the concept is 4445 mm (175.0 in) long, 2048 mm (80.6 in) wide, and 1297 mm (51.1 in) tall. It is shorter than any previous Jaguar since the 1954 two-seat XK120.

The motor/generator (using brake energy regeneration) is integrated into the car's eight-speed **ZF** auto gearbox and is linked to a 1.6-kW·h battery pack positioned behind the seats. This helps



Collision Avoidance & Mitigation

Standards & Resources from SAE International

It's the first opportunity within a crash scenario to save lives and reduce injuries—the prevention of crashes from first occurring. Reduced property damage and traffic congestion, inevitable results of most crashes, are also served by advancing collision avoidance and mitigation technologies. With systems like Electronic Stability Controls, for example, dramatically reducing the number of run-off-road crashes and rollovers, there is a clear need to accelerate the development and use of other advanced safety technologies such as collision warning and collision-imminent braking systems.

To speed that process, the automotive industry can look to SAE International. Providing a neutral forum for the development of needed engineering guidelines, the collective wisdom and thought leadership of the volunteers on its standards development committees can help industry advance these technologies, increase productivity, and reduce costs. With a 106-year history steeped in functional safety standards, SAE stands ready to tackle the complex advanced safety issues of today. Offering one of the largest libraries of intellectual property focused on mobility technology, the past and current work of the global engineering community can be referenced for designing, developing, and implementing the next generation of safety systems to save lives, prevent injuries, and reduce economic costs due to road traffic crashes.

Helping industry engineer safe vehicles

- SAE J2400™, Human Factors in Forward Collision Warning Systems: Operating Characteristics and User Interface Requirements
- SAE J2478™, Proximity Type Lane Change Collision Avoidance
- Crash Avoidance I — Crash Causation, ESC, Lane Keeping, and Other Avoidance Technologies (SAE 2012 Government Industry Meeting, Session)
- Autonomous Connected Vehicle Technologies (Seminar)
- Electronic Braking, Traction, and Stability Controls, Volume 2 (Book T-129)
- SAE J2802™, Road/Lane Departure Warning Systems: Information for the Human Interface
- Driver-Vehicle Interaction, SAE Standards Subscription (Online, SUB-STD-00010)
- Object Detection, Collision Warning and Avoidance Systems, Volume 2 (Book PT-133)
- Active Safety and the Mobility Industry (Book PT-147)
- J1741™, Discriminating Back-Up Alarm System Standard
- Standards Development Committees: Active Safety; Collision Mitigation Interface Performance; and Lane-Keeping Assistance
- Active Safety Systems - HMI for Advanced Driver Assistance Systems (2011 SAE Commercial Vehicle Engineering Congress, Session CV402)
- SAE 2012 World Congress Active Safety topics: Departure Warning/ Lane-Keeping Assistance; Collision & Blindspot Warning; Active Pedestrian Protection; Backover Protection; Collision-Imminent Braking; Collision Avoidance
- Sensors and Transducers, SAE Paper Collection (Online, STDTP-00001, SAE Technical Papers cover both internal and external systems, i.e., object detection and collision avoidance)
- SAE 2011 Intelligent Vehicle Systems Symposium — Advancing the Connected Mobility Experience

For more on Collision Avoidance/Mitigation and all SAE Advanced Safety Standards & Resources, including information on Driver Vehicle Interface and Vehicle Communications, visit sae.org/standardsdev/safety/.

1-877-606-7323 (US, Canada); 1-724-776-4970 (outside US, Canada)

SAE International®

P111475

2012 Jeep Wrangler

A new powertrain, combined with new interior upgrade in 2011, have significantly upgraded the ownership experience for 2012 Jeep Wrangler customers. Chrysler's 3.6-L V6 and five-speed automatic or six-speed manual, along with other vehicle changes, provide more power and torque, better fuel efficiency, improved on-road driving dynamics and refinement, and greater off-road capability.

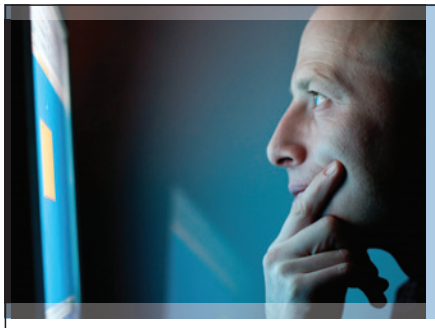


Chrysler Group's 3.6-L Pentastar V6 engine delivers 285 hp (213 kW) and 260 lb·ft (353 N·m). Compared to the previous 3.8-L V6, the new engine makes 40% more power and 10% more torque while helping to deliver up to 21 mpg EPA fuel economy. Engine modifications for Wrangler include specific upper and lower oil pan design to keep oil within reach of the pump when the vehicle operates at steep angles. The intake system is unique, with induction through a revised throttle body on the left side of the engine—vs. the right as on all other Pentastars. Wrangler-specific integral exhaust manifolds are cast into the cylinder heads. Equal-length down pipes, coupled with an optimized collector location, help provide better mid-range torque. To reduce backpressure, the Wrangler's exhaust system features a new intermediate pipe resonator along with a decreased internal restriction muffler. A new 600-W pulse-width-modulated fan with variable speeds offers improved engine cooling and NVH. An upgraded full-face condenser that is more than 20% larger improves A/C performance.



The Wrangler's automatic transmission moves from four to five speeds. The A580 unit, produced in Kokomo, IN, has more refined shifting and gear selection and allows the engine to operate in a more efficient rpm range, aiding fuel economy, and enables the engine to remain in the torque curve, increasing acceleration. The 2012 Wrangler can accelerate from 0 to 60 mph (0 to 97 km/h) 25% faster at 8.4 s. A lower first-gear ratio in the new automatic gives the Wrangler more off-road capability via a lower overall crawl ratio. The first application of a manual transmission with the Pentastar V6 is a six-speed unit. The proven NSG 370 unit, produced in Gaggenau, Germany, gets a new clutch housing, flywheel, and long travel damper clutch engineered for the Wrangler.

More axle gear ratios are provided to allow for better fuel economy and/or vehicle capability. Available are ratios of 3.21:1, 3.73:1, or 4.10:1, depending on model, for towing capacity as high as 3500 lb (1590 kg). Sport and Sahara models get Dana 30 front and Dana 44 rear axles. The Command-Trac NV241, part-time, two-speed transfer case, features a 2.72:1 low-range gear ratio. An optional Trac-Lok limited-slip rear differential provides extra grip in low-traction sand, mud, or snow. The Rubicon model features heavy-duty Dana 44 front and rear axles, a Rock-Trac NV241 two-speed transfer case with a 4.0:1 low-range gear ratio, electric front and rear locking differentials, disconnecting front sway bar, and 32-in tires.



e-Learning from SAE International

Convenient • Accessible • Timely • Relevant

SAE International offers online based learning in multiple formats to suit your learning needs.

- **Webinars**—informative, interactive and content-rich classroom seminars delivered via telephone/internet
- **e-Seminars**—industry expertise and instruction with the convenience of anytime access
- **Fast Tracks**—online short-courses that capture the essence of a topic and teach you exactly what you need to know - fast
- **Ford online courses**—online courses from Ford Motor Company that extend to you Ford's engineering training on essential powertrain and quality topics

Visit **www.sae.org/e-learning** for more information and to access the course listings.

Stay current on the technology, increase your knowledge, and positively affect your organization's bottom line with professional development from SAE International.

SAE International™

P101749

Upgrade *Your Classic Membership Level and Receive More Benefits!*



Elite Membership—The Most Member Benefits

Elite Membership is for those members in the prime of their career, looking to stay sharp with up-to-date information and seeking the best networking opportunities:

- The highest level of discounts on books, technical papers and standards, SAE conference registrations and professional development seminars
- Complimentary subscriptions to **three** SAE industry magazines
- 45-day free access to view selected new video content from SAE events
- VIP services at SAE's conferences

And more…visit sae.org/membership/benefits for a full list of benefits specific to the Elite level.

Premium Membership—Exclusive Member Benefits

Premium Membership is for working engineers who want to advance their career to the next level:

- Higher discounts on books, papers, standards, SAE conference registrations, and professional development seminars
- Complimentary subscriptions to two SAE industry magazines
- 45-day free access to view selected new video content from SAE events

And more…visit sae.org/membership/benefits for a full list of benefits specific to the Premium Level.

Not sure which level is right for you?
Visit www.sae.org/membership to use our interactive e-Valuator tool to help you choose.

P111617

SAE International®

www.sae.org/membership



One of the few links between the Jaguar C-X16 and the XKE coupe is the use of a side-hinged tailgate.



Jaguar uses a regular selector instead of a rotary type as found on other models in the range to control the eight-speed transmission.

achieve a 50:50 weight distribution for the car. The electric motor contributes an added 70 kW and 235 N·m (173 lb·ft).

The driver has a "Push to Pass" steering wheel mounted button to activate the full hybrid state when maximum acceleration is required. The 0-100 km/h (0-62 mph) time is quoted at 4.4 s.

A significant departure from recent Jaguar fashion is the use of a conventional gear selector stick in place of the rotary type that has not received unanimous acclaim. The rotary is regarded as more appropriate for sedan models rather than a pure sports car.

The car's cockpit has a wraparound effect and use is made of carbon fiber. But the material is mainly applied as a styling element and probably would not be used in a production version of the car unless its cost could be reduced.

Stuart Birch

Mercedes-Benz B-Class engineered for alternative powertrains

Mercedes-Benz's new B-Class, which uses a fresh front-wheel-drive platform, is now far more deserving of its categorization as a compact sports tourer. In fact, it is not as compact as it was, being some 90 mm (3.5 in) longer and 11 mm (0.4 in) wider than its predecessor, but significantly, it is almost 50 mm (2.0 in) lower at 1557 mm (61.3 in)—all of which gives it a sleeker appearance.

Seat height has been radically reduced by some 86 mm (3.4 in), mainly for easier entry and egress. Rear-seat legroom is 976 mm (38.4 in), which is greater than that of the Mercedes E-Class and S-Class.

It also has remarkably good aerodynamics, with a best per-model Cd figure of 0.26, which is attributable to some effective fine-tuning, including a patent-pending serrated wheel-arch spoiler. Airflow management is particularly focused on the B-Class's underbody and system cooling.

The car, unveiled at the Frankfurt Motor Show, is available with a direct-injection turbocharged gasoline and a new diesel engine, a seven-speed dual-clutch transmission (DCT), and an electric oil pump for stop-start capability is standard on all versions. A six-speed manual gearbox is also standard, described by Mercedes as being "closely related" to the DCT.

The B-Class has also been designed to take nonconventional power sources. Engineered interfaces in the body shell facilitate the car's main floor panel being modified to accept alternative drive systems, and an underfloor compartment covering part of the area beneath the back seat could be used for large battery installation. The car was designed from conception to integrate hydrogen fuel-cell technology, which was recently available on the outgoing model.

The gasoline engines for the B-Class, designated M270, are a new series and use third-generation direct-injection technology introduced in 2010 for Mercedes' BlueDIRECT V6 and V8 engines; they are expected to power other Mercedes models. The four-cylinder engines are designed for lateral or longitudinal installation and are initially available in 1.6-L form with two power levels, producing 90 kW (121 hp) and 200 N·m (145 lb·ft) or 115 kW (154 hp) with 250 N·m (184 lb·ft). Maximum torque is available from a remarkably low 1250 rpm.

The four-cylinder diesel is a development of the company's highly efficient 2.1-L unit downsized to 1.8-L with outputs of 80 and 100 kW (107 and 134 hp), the more powerful unit producing 300 N·m (221 lb·ft) of torque at 1600 rpm.

The engines have been packaged to optimize the car's turning circle, which at 11 m (36.1 ft) is good for a front-wheel-drive car. Suspension includes a new four-link system at the rear. Sports



A compact "sports tourer" from Mercedes-Benz, the new B-Class has good aerodynamics with a Cd of 0.26.



Seat height of the B-Class is reduced by 86 mm (3.4 in) compared with the previous generation.

suspension is optional, lowering the cg by some 20 mm (0.8 in) and incorporating active sports dampers. The electromechanical power steering has been redesigned for the new B-Class, with the motor positioned directly on the steering gear to improve packaging.

As usual with Mercedes, all transmissions and engines have been developed in-house and are manufactured at plants including Stuttgart-Untertürkheim and Stuttgart-Hedelfingen; Rastatt/Baden; Gaggenau/Baden; and Kölleda/Thuringia.

Majoring on safety, the B-Class gets extensive new driver-assistance systems, including radar-based collision warning technology with adaptive Brake Assist as standard, which Mercedes claims as a "world first" in the compact market segment. It gives visual and aural warnings and prepares Brake Assist, which operates if the driver exceeds a specific pedal force. A particular scenario for its operation would be reducing the risk of rear-end collisions in heavy traffic conditions.

Depending on specification, the car also offers adaptive headlight assist; blindspot and lane-keeping assist; Mercedes' established Pre-Safe system; pelvis bags for driver and front passenger; active parking; hill-hold; and a reversing camera. The car's optional Comand system allows Internet access.

The available Easy-Vario-Plus system for optimum interior configuration includes 140 mm (5.5 in) longitudinal adjustment of the rear seats to increase luggage space from 488 to 666 L (17.2 to 23.5 ft³) and "horizontalizing" of the front passenger seat's backrest.

Dr. Thomas Weber, **Daimler** Board Member for Group Research and Head of Development at Mercedes, says he believes the new B-Class has the highest standard of safety that has ever been available in its class. "No model change in the history of Mercedes-Benz has ever seen so many new developments introduced in one fell swoop," he added.

Stuart Birch

Concept previews 2015 Land Rover Defender replacement

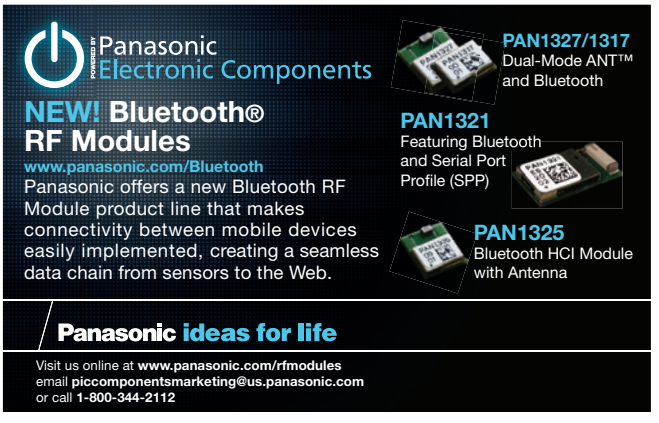
Land Rover came into existence in 1948 with the launch of a WWII **Jeep**-inspired utility vehicle with part-time four-wheel drive. The vehicle has been extensively developed over the years into the Defender, but the same basic construction of aluminum body on steel chassis remains, and the bodywork is more or less assembled by hand.

For ease of manufacturing and regulatory compliance, the company needs a replacement vehicle. It used the 2011 Frankfurt Motor Show to launch a range of prototypes named DC100 to gauge reaction four years ahead of the proposed launch date.

Two prototypes were on display, one a station wagon and the other an open-top two-seater. Both are short-wheelbase models. At the Land Rover press conference, Design Director Gerry McGovern said that the company wanted to attract new customers and retain existing Defender buyers, suggesting that long- and short-wheelbase models would remain in the range.

"How do you ever replace something that's heartfelt and dear to so many people?" said Oliver Le Grice, Chief Designer for Advanced Design Land Rover, speaking to *AEI*. "It's that emotional connection that people have with it, and that's what we've fought hard to keep in balance here. It's very much about that front end, about the 'face.' From the direct front view, we have this approachability and friendliness. We didn't want anything that had a hint of the aggressive nature. A lot of vehicles around now look as though they would bite your head off. This mustn't look like that; this must be about a friendly and approachable feel.

"We very deliberately said if you look at today's car you can draw it from side view. That's the outline, it's really recognizable, and that's absolutely vital. It's simple—the 'plant-on' roof, simple graphics, the short overhangs, breakover angle, and a really strong stance. It's got to have that sense of capability and self-confidence."





DC100 station wagon concept was one of two design excercises shown by Land Rover

Mark Butler, the Interior Design Manager for the DC100 project, told *AEI* where his team started from with the interior design: "It's about capturing the flexibility that's inherent within our Land Rovers. We make something like 120 different variants of the current Defender, so it's about keeping that degree of flexibility within the design. The very simple architectural dashboard with the central instrument cluster very much roots itself in the early (Land Rover) series. We've kept the dashboard very open and we can get the three seats across the front—the centre one being an occasional seat.

In the rear of the vehicle is a concept for an inductive charging system, which could be used for charging a music



DC100 Sport shows open-top design study for the Defender replacement. Land Rover was gauging public reaction to the two studies. The Defender successor is slated for production in 2015.

We are happy to manufacture in the USA.

Development partners in drive train technology.
Masters in forging and machining of precision components.
State of the art equipment and facilities.
Always a step ahead of today's innovations.



HBS
SEISSENSCHMIDT
Corporation
Precision Components

SEISSENSCHMIDT Corporation
6121 Perimeter Road
Oscoda, Michigan 48750, USA
Tel. +1 989 739-7300
Fax +1 989 739-7400
infousa@seissenschmidt.com
www.seissenschmidt.com

WE MOVE THE AUTOMOTIVE WORLD.

system in leisure models or power tools in commercial variants. Other features include a variable seating configuration and drain holes in the floor to permit hosing out.

Sustainability and durability are key features, reckons Joanna Keatley, the Color and Materials Designer for Advanced Design Land Rover. "We wanted to take the exterior inside as well, so we've been looking at really high-performance sports products—how they're stitched together and the detail in them," she told *AEI*, speaking about the DC100 Sport open concept. "The really high-tech material in here is the floor. It was developed with a Canadian company using a high-tech 3-D digital process. It changes its appearance through light, shadow, and pattern, so from one angle you see a mesh rubber floor and from another you see the tribal stripe. It's something that architects use on film sets, so we're just trying to bring in something slightly different."

John Kendall

Prius Plug-In tweaked following Euro trials

Toyota gave the Prius Plug-In Hybrid its world production debut at Frankfurt alongside the European debut of the Prius + seven seater. The Prius + signals the first use of a lithium-ion battery in Toyota's standard parallel hybrid drive system. By packaging the battery pack in the center console between the



The Prius Plug-In Hybrid has been modified ahead of its global launch following European trials.

Physical Models of Automotive Batteries for EV and HEV Applications

Tuesday, November 29, 2011 at 10 a.m. EST/ 3 p.m. GMT
FREE 60-Minute Live, Interactive Webcast!

The battery is becoming one of the most critical components in alternative powerplant development.

Join us to learn about:

- New approaches to modeling and simulation for HEV and EV applications with particular emphasis on the development of high fidelity physical models of automotive batteries, and
- Software solutions that deploy symbolic techniques for high-fidelity physical modeling.

Industry Expert Participants:



Dr. John McPhee, *NSERC/Toyota/Maplesoft Chair for Mathematics-Based Modeling, University of Waterloo*



Dr. Sam Dao, *Application Engineer, Maplesoft*

Register now at www.sae.org/webcasts

automotive ENGINEERING international

Sponsored by: Maplesoft Mathematics • Modeling • Simulation

SAE International

P111595



Changes to the plug-in Prius include moving the charging point from the left to the right front wing.

front seats, the trunk space occupied by the battery pack in the standard Prius has been opened up and the longer model can accommodate two more seats.

Lithium-ion battery technology is also adopted for the Prius Plug-In Hybrid. Unlike the **Chevrolet** Volt/**Opel** Ampera, which have a serial hybrid system, the plug-in Prius uses a variant of the Toyota parallel hybrid system. Compared with the standard Prius, the plug-in version has a 4.4-kW·h Li-ion battery pack having a 80-kg (176-lb) mass. The standard Prius is equipped with a 1.3-kW·h nickel/metal hydride (NiMH) battery pack with a mass of 42 kg (93 lb).

With the greater battery capacity, Toyota has set a target driving range in electric mode of 14.3 mi (23.0 km), and the battery can be recharged in 1.5 h from a regular European 230-V domestic electricity outlet. Using the capabilities of the hybrid system, Toyota has set a target fuel consumption of 134.5 mpg with carbon dioxide emissions of 49 g/km.

A limited production run of plug-in hybrid Prius has been used as part of a European trial since 2010, with 200 vehicles leased to selected clients in 18 countries, resulting in about 497,000 mi (800,000 km) of data. In the trial, users who used the plug-in capability returned a claimed average fuel consumption bettering 141 mpg. Based on user feedback, Toyota will move the charging point on the car from the left to the right side of the vehicle.

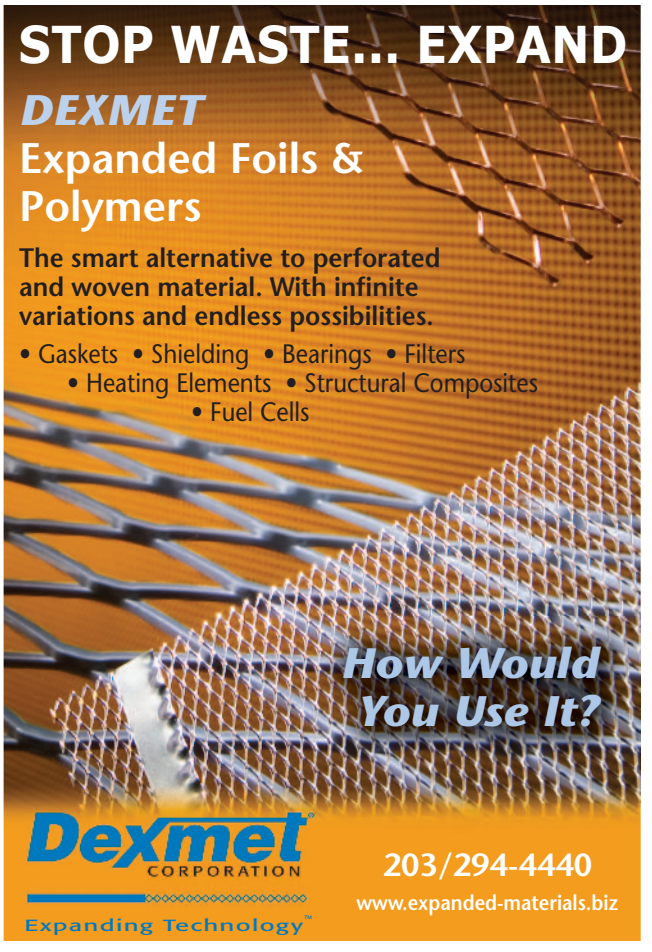
The plug-in Prius can operate in three modes: HV, EV and EV-City. In HV mode, the plug-in model operates as a regular Prius with the two drive systems working in parallel. This mode does not use the full capacity of the battery. In EV mode, the system operates with full battery capacity to give an electric range of up to 14.5 mi (23.3 km) at speeds up to 53 mph (85 km). The gasoline engine will still start if the drive system calculates that additional power is required. This mode allows for light to medium throttle use without activating the gasoline engine. Greater use of the throttle can be made in EV-City mode before the gasoline engine is activated.

The plug-in Prius is distinguished from the regular Prius by dedicated front and rear treatments. A bright silver colored finish is used for the door handles, license plate panel, and battery charger lid.

Other modifications made following the European trial include a more compact charge circuit interface device and a charging cable that is more flexible and weighs 25% less than previously. The battery charger lid now includes a battery charge indicator and LED illumination for nighttime use, while the lid has been incorporated into the cover so that it can be operated single-handedly. The car cannot be started when the charger cable is connected.

Interior changes include a revised trim color scheme, redesigned center console, and revised information display to show clearer EV driving mode information.

John Kendall



Driving the pace of change

Engineers speak out on software's impact on the automotive industry in online survey.

by Matthew Monaghan



In today's automotive industry, companies are faced with pressure in many forms—the pressure to lower cost, reduce cycle times, and ensure high quality—to name a few. The pressure to innovate is also greater than ever. New powertrain, safety, and infotainment technologies are all heavily dependent on software to function. Many of today's vehicles include more than 100 million lines of embedded software code. While offering incredible opportunities for innovation, software also increases complexity and risk.

As the amount and complexity of software in vehicles continue to grow, OEMs and suppliers are recognizing the importance of software engineering as a method to address the challenges of software development in the automotive industry. Change management and requirements management systems as well as version control and configuration management tools are some of the ways companies are addressing these challenges. Stand-alone and coupled suites of tools can also pose their own risks and challenges, such as a lack of traceability across entities in the repositories, limited reuse, process and information silos, and a lack of support for cross-domain product line management.

To evaluate how software is changing the face of product delivery into the market, a survey recently went out to **SAE International**-member engineers and managers. The online survey

was conducted in August 2011 by **Signet Research** Inc., an independent research company.

When asked to rate the importance of software in a variety of areas, the nearly 500 respondents selected innovation, hybrid/electric vehicles, and safety as the top three areas, with 97% rating innovation as "very important" or "important."

Respondents selected the pressure to reduce cycle times, achieve high levels of quality and innovation, and the volume and complexity of software as the top three issues currently being faced in their software development work.

The amount of software content in products is growing at an intermediate rate, according to 49% of respondents, while 39% believe there is high software growth in the automotive industry, faster than other technologies. While 85% of respondents indicate growth of software content in their products over the last several years, more than one-third (36%) indicate that it increased dramatically.

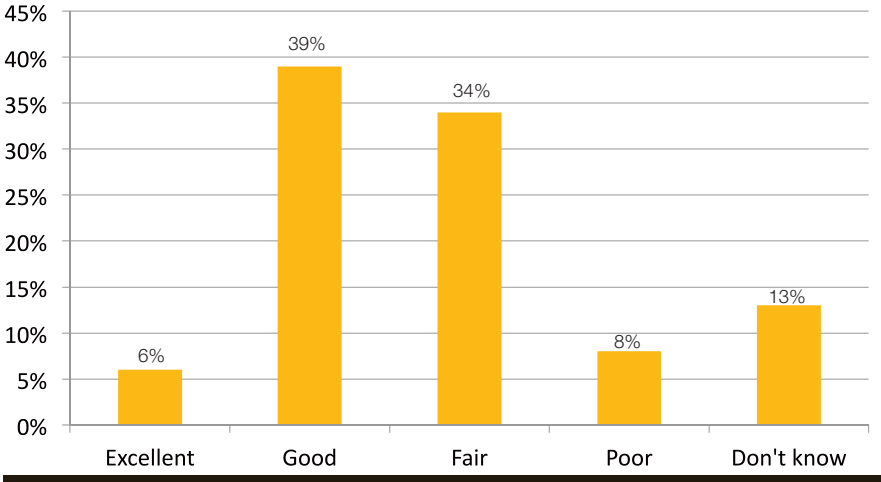
More than 40% of respondents indicated that they use different tooling for managing systems, software, and hardware requirements, which is causing issues with managing change and traceability, while 38% said they use different technologies to manage systems, software, and hardware requirements and are not experiencing any problems.

Within a project, traceability enables upstream impact analysis to requirements or customer requests and downstream traceability to defects or development tasks. While finding and fixing a defect in one device is good, having it surface in a dozen others that make use of the same component can have a profound impact on a business. A lack of traceability can result in errors, rework, risk to quality, and significant manual effort.

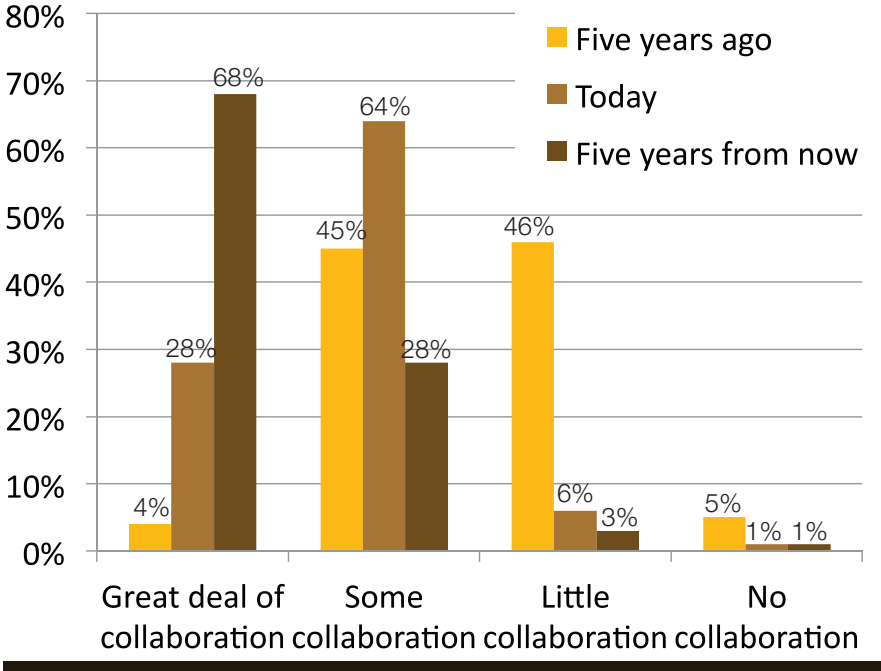
While 39% of respondents rated the current level of traceability across data repositories and the entire product life cycle as "good," 42% rated it as "fair" or "poor." When asked to rate the importance of traceability in a variety of areas, improving quality, reducing errors, and eliminating rework were the top three selections, with 92% of respondents rating those areas as "very important" or "important."

With today's automotive engineering activities distributed across the globe, collaboration is an area of critical importance. Systems and processes that are not efficiently implemented can result in longer development cycles and increased costs, and the lack of coordination between teams creates significant overhead, redundancy, and waste.

While only 49% of respondents believed there was some level of collaboration between software groups five years ago, 92% believe there is some collaboration now.

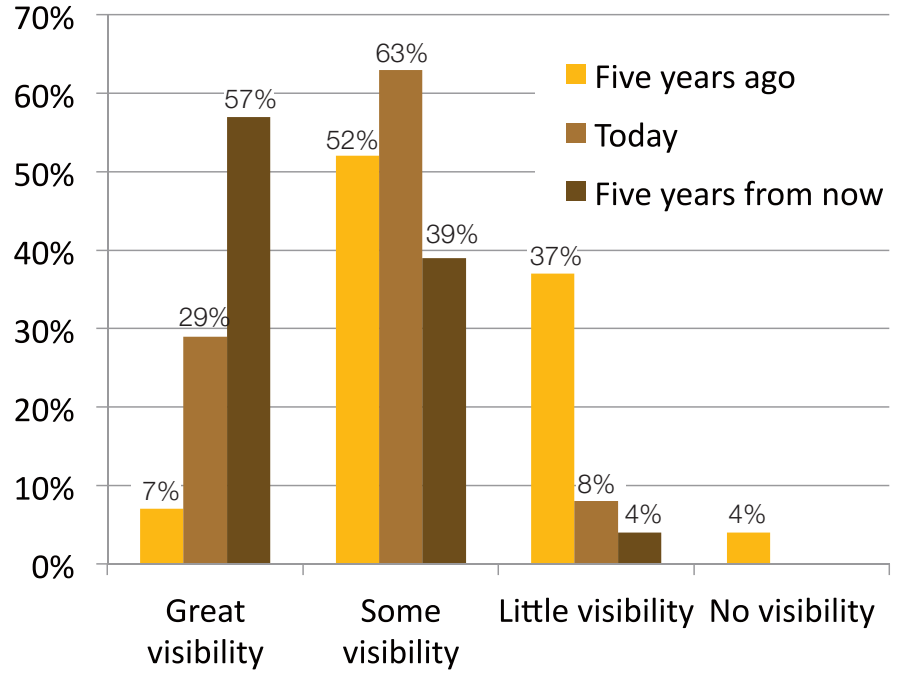


When asked to rate the current level of traceability across data repositories and the entire product life cycle, 45% of respondents rated it as Excellent or Good.

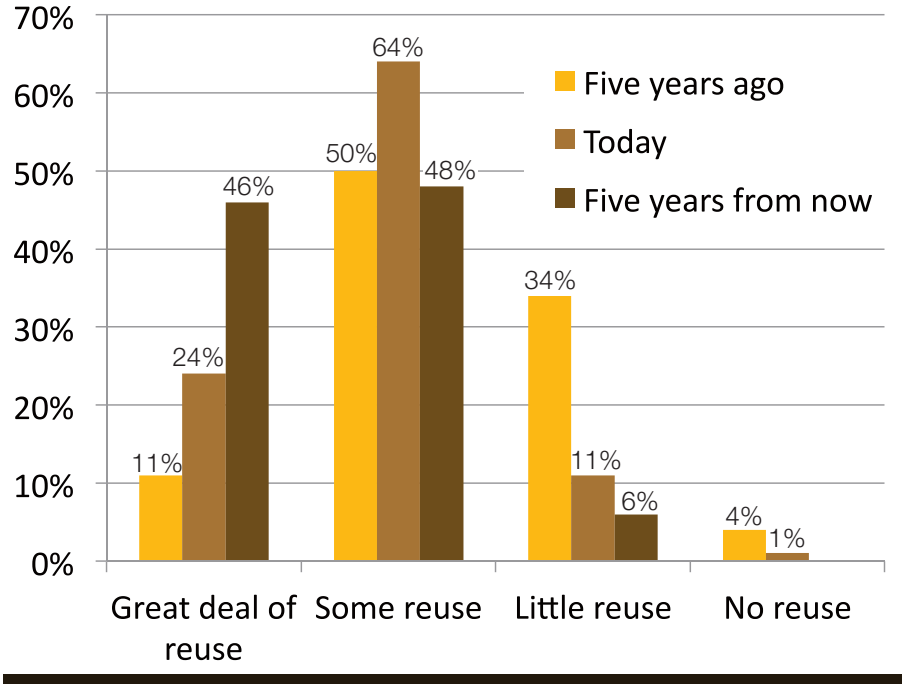


Based on the data, collaboration has and will continue to increase.

Driving the pace of change



More than nine out of 10 respondents (92%) said there is at least some visibility across their organization today.



Where 61% believe there was a great deal or some reuse five years ago, 88% believe so now, and 94% believe there will be five years from now.

That number is expected to climb to 96% five years from now. Collaboration is a bigger problem when collaborating with external software groups, according to 79% of respondents.

Making the right decisions at the right time and ensuring product quality is dependent on real-time visibility into release readiness of features, software components, and systems. Process and information silos across an organization reduce visibility and obscure the impact and cost of change, leading to reduced productivity and a negative effect on product quality.

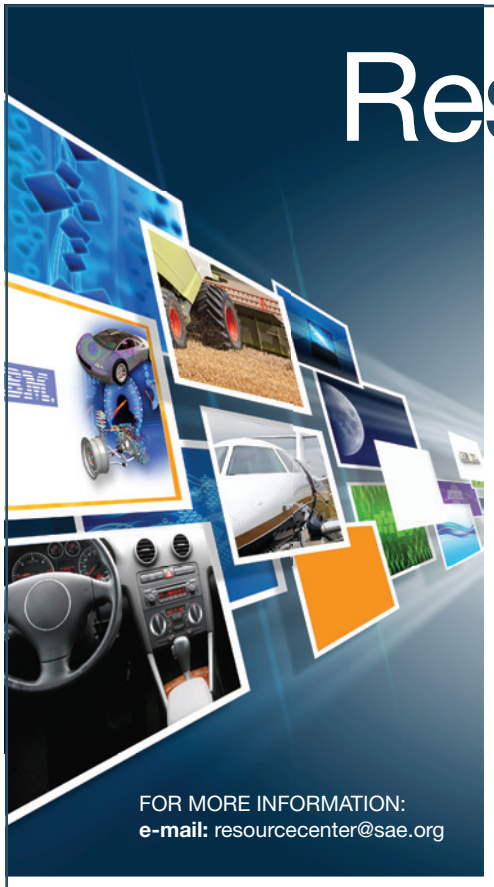
Today, there is currently some or great visibility into product status across organizations, according to 92% of respondents, while only 59% believe that was the case five years ago. That number will continue to increase five years from now, according to 96% of respondents.

Reuse of development assets is one of the most important strategies for improving quality and increasing productivity. Reuse can lead to lower development costs and shorter delivery schedules, better reliability and reduced maintenance costs, and increased productivity as a result of not constantly resolving the same technical problems.

Reuse comes with its own management challenges, however, and development and testing organizations need reliable ways to manage the development, assembly, and ongoing use of software components.

While 92% of respondents agree somewhat or completely that reuse of development assets leads to improved quality and productivity, 85% believe reuse can have a negative impact on quality and productivity when not properly implemented. The level of reuse is sharply on the rise, according to respondents. Where 61% believe there was a great deal or some level of reuse five years ago, 88% believe so now, and 94% believe there will be five years from now.

The independent research that served as the basis for this feature was underwritten by **PTC**. AEI



Resource Center

The SAE website is the gateway to the world's largest collection of technology resources for engineering professionals.

SAE's Resource Center offers a variety of resources from industry's top companies ranging from videos to white papers:

TTTech Computertechnik

Advancing System Integration with Ethernet

The capabilities of system integration technologies impact electronics platform complexity, software design methodology, application design, system integration, reuse, upgrades, obsolescence management and certification for time-, mission-, and safety-critical applications.

Zebra Enterprise Solutions

You Can Reduce Your Inventory by 750K! Zebra Enterprise Solutions newly published white paper, The Path the Peak Supply Chain Performance-Linking ERP with an Automated Wireless Parts Replenishment Solution Gives the Concept of Continuous Improvement Real Meaning, illustrates how an automated Wireless Parts Replenishment solution can transform your bottom line while improving your overall operational efficiencies. Download now for FREE to learn how!

FOR MORE INFORMATION:
e-mail: resourcecenter@sae.org

www.sae.org/mags/rc/aei

SAE International

P110874_AEI

Product Literature | Data Sheets | Webcasts | Application | White Papers Notes | Videos

UNITED STATES POSTAL SERVICE®

Statement of Ownership, Management, and Circulation (All Periodicals Publications Except Requester Publications)

1. Publication Title	2. Publication Number	3. Filing Date
Automotive Engineering International	4 7 4 - 1 0 0	November 2011
4. Issue Frequency	5. Number of Issues Published Annually	6. Annual Subscription Price
8 times/year	8	$110.00

7. Complete Mailing Address of Known Office of Publication (Not printer) (Street, city, county, state, and ZIP+4®): 400 Commonwealth Drive Warrendale PA 15096 — Contact Person: Jodie Mohnkern — Telephone (Include area code): 724-772-7563

8. Complete Mailing Address of Headquarters or General Business Office of Publisher (Not printer)

9. Full Names and Complete Mailing Addresses of Publisher, Editor, and Managing Editor (Do not leave blank)

Publisher (Name and complete mailing address): Scott Sward

Editor (Name and complete mailing address): Kevin Jost

Managing Editor (Name and complete mailing address)

10. Owner (Do not leave blank. If the publication is owned by a corporation, give the name and address of the corporation immediately followed by the names and addresses of all stockholders owning or holding 1 percent or more of the total amount of stock. If not owned by a corporation, give the names and addresses of the individual owners. If owned by a partnership or other unincorporated firm, give its name and address as well as those of each individual owner. If the publication is published by a nonprofit organization, give its name and address.)

Full Name	Complete Mailing Address
SAE International	400 Commonwealth Drive Warrendale PA 15096

11. Known Bondholders, Mortgagees, and Other Security Holders Owning or Holding 1 Percent or More of Total Amount of Bonds, Mortgages, or Other Securities. If none, check box → ☐ None

Full Name	Complete Mailing Address

12. Tax Status (For completion by nonprofit organizations authorized to mail at nonprofit rates) (Check one)
The purpose, function, and nonprofit status of this organization and the exempt status for federal income tax purposes:
☐ Has Not Changed During Preceding 12 Months
☐ Has Changed During Preceding 12 Months (Publisher must submit explanation of change with this statement)

PS Form 3526, September 2007 (Page 1 of 3 (Instructions Page 3)) PSN 7530-01-000-9931 PRIVACY NOTICE: See our privacy policy on www.usps.com

13. Publication Title	14. Issue Date for Circulation Data Below
Automotive Engineering International	October 2011

15. Extent and Nature of Circulation			Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
a. Total Number of Copies (Net press run)			58,916	62,672
b. Paid Circulation (By Mail and Outside the Mail)	(1)	Mailed Outside-County Paid Subscriptions Stated on PS Form 3541 (Include paid distribution above nominal rate, advertiser's proof copies, and exchange copies)	57,472	61,384
	(2)	Mailed In-County Paid Subscriptions Stated on PS Form 3541 (Include paid distribution above nominal rate, advertiser's proof copies, and exchange copies)		
	(3)	Paid Distribution Outside the Mails Including Sales Through Dealers and Carriers, Street Vendors, Counter Sales, and Other Paid Distribution Outside USPS®		
	(4)	Paid Distribution by Other Classes of Mail Through the USPS (e.g. First-Class Mail®)		
c. Total Paid Distribution (Sum of 15b (1), (2), (3), and (4))			57,472	61,384
d. Free or Nominal Rate Distribution (By Mail and Outside the Mail)	(1)	Free or Nominal Rate Outside-County Copies included on PS Form 3541		
	(2)	Free or Nominal Rate In-County Copies Included on PS Form 3541		
	(3)	Free or Nominal Rate Copies Mailed at Other Classes Through the USPS (e.g. First-Class Mail)		
	(4)	Free or Nominal Rate Distribution Outside the Mail (Carriers or other means)		
e. Total Free or Nominal Rate Distribution (Sum of 15d (1), (2), (3) and (4))				
f. Total Distribution (Sum of 15c and 15e)			57,472	61,384
g. Copies not Distributed (See Instructions to Publishers #4 (page #3))			1,444	1,288
h. Total (Sum of 15f and g)			58,916	62,672
i. Percent Paid (15c divided by 15f times 100)			97.5%	97.9%

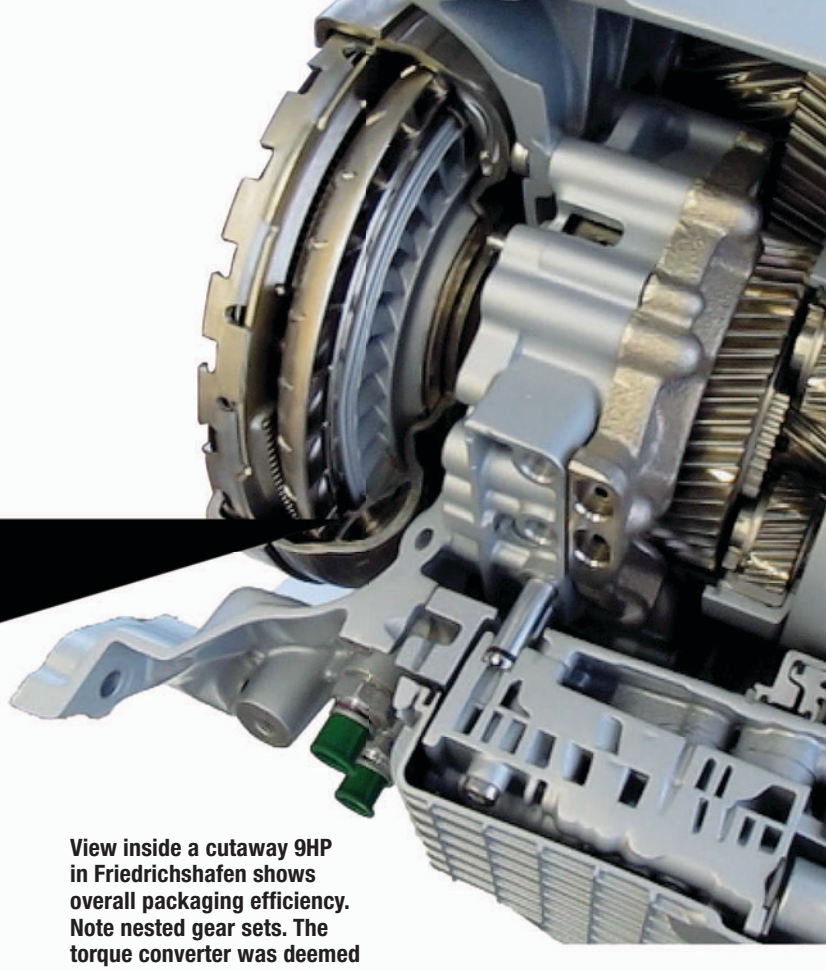
16. Publication of Statement of Ownership
☐ If the publication is a general publication, publication of this statement is required. Will be printed in the November issue of this publication. ☐ Publication not required.

17. Signature and Title of Editor, Publisher, Business Manager, or Owner: Circulation Manager — Date: October 20,2011

I certify that all information furnished on this form is true and complete. I understand that anyone who furnishes false or misleading information on this form or who omits material or information requested on the form may be subject to criminal sanctions (including fines and imprisonment) and/or civil sanctions (including civil penalties).

PS Form 3526, September 2007 (Page 2 of 3)

Inside ZF's nine-speed transaxle for 2013



View inside a cutaway 9HP in Friedrichshafen shows overall packaging efficiency. Note nested gear sets. The torque converter was deemed essential for North American and Asian markets. (Photo by Lindsay Brooke)

AEI travels to Friedrichshafen for an exclusive look at the development and technology behind the 9HP—the industry's first nine-speed transaxle slated for MY2013 production.

by **Lindsay Brooke**

With its 9.84 ratio spread, clever controls, and compact packaging, **ZF**'s new nine-speed automatic transaxle will offer OEMs capability to increase fuel economy in their front-wheel-drive vehicles by 10-16% at 75 mph (121 kph), based on the NEDC cycle, when the gearbox is launched for MY2013 production next year.

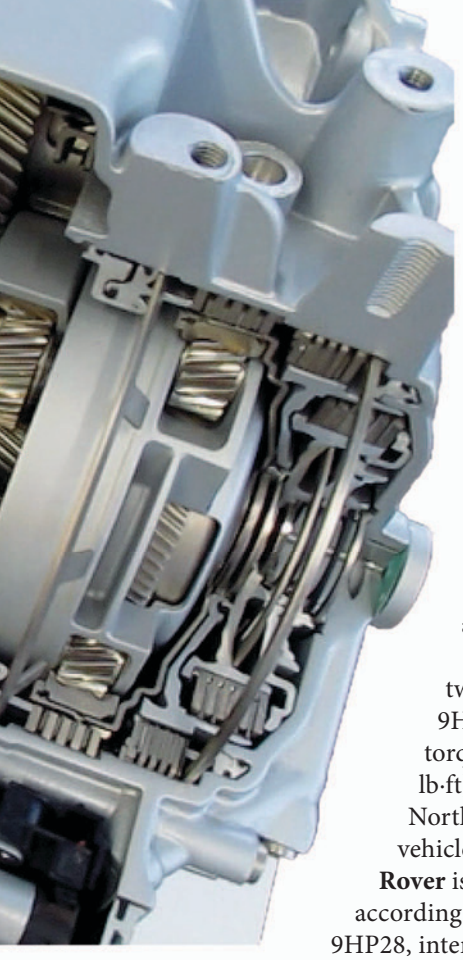
Few new transmissions have caused as much buzz within the industry as the 9HP. ZF announced it at the 2011 Detroit auto show but provided almost no details of its inner workings. But this summer, ZF's top engineers gave a select group of media, including *AEI*, a look inside the 9HP and its development. The visit to the company's Friedrichshafen R&D center included a long test drive of three 9HP-equipped mules (see sidebar).

We came away convinced that ZF has engineered a major leap forward in fwd automatics, in terms of functionality, overall efficiency, and clever use of technology. Among the 9HP's many surprises are the pair of dog clutches that activate the 4-5 and 7-8 gear shifts. The dog-clutch shifting elements (typically found in manual gearboxes) virtually eliminate the drag-torque losses inherent in multidisc friction clutches. The dog clutches used in the 9HP are an industry first for fwd automatics.

Dog-clutch actuation is not generally associated with refinement, which makes the 9HP all the more impressive. The remarkably smooth shift quality of the prototypes we evaluated on the Alpine-roads-and-autobahn test loop was more akin to a traditional planetary automatic than the six-speed dry and wet dual-clutch transmissions (DCT) that ZF's development team believes are its major competitors.

"Our dog clutch decision was part of a very systematic approach to developing this new transmission family," said Dr. Jürgen Greiner, ZF's Executive Vice President of Product Development. "Optimizing internal efficiencies throughout the unit was a major goal."

He said the engineering team analyzed a universe of 50 million potential mechanical combinations before choosing the dog-clutch alternative.



The 9HP family includes parallel hybrid

The 9HP will be built exclusively in ZF's new Greenville, SC, plant. Start of production for MY2013 **Chrysler** vehicles is slated for late 2012. The facility, nearing completion, will also build the company's eight-speed 8HP for rear-drive applications.

Initially there will be two nine-speed models. The 9HP48 is designed for input torques up to 480 N·m (354 lb·ft) and is aimed primarily at North American and European vehicle applications—**Land Rover** is another early customer, according to supplier sources. The 9HP28, intended for the China market, can handle input torques up to 280 N·m (207 lb·ft).

A parallel-type "full" hybrid variant with plug-in capability, designated 9P48H, is in development. Its housing is longer than those of the -48 and -28 to accommodate a single electric motor. The 9P48H will not employ dog clutches.

Among current production automatics, only the **Porsche** Panamera's seven-speed DCT has a higher ratio spread (10.1) than the 9HP. ZF's design strategy had much to do with the industry trend to "downspeed" combustion engines—"a big challenge for us as a transmission supplier," noted Dr. Peter Ottenbruch, a member of ZF's Board of Management.

"OEMs are working on engines that run less than 1000 rpm. How far can we go, in terms of transmission design, to match this trend? We have to find a compromise, and we believe our competitors going from six to eight speeds changed very little, compared with what we can do with nine speeds," he said. For a video interview with Dr. Ottenbruch, go to http://www.youtube.com/watch?v=rWtAh_rstRk.

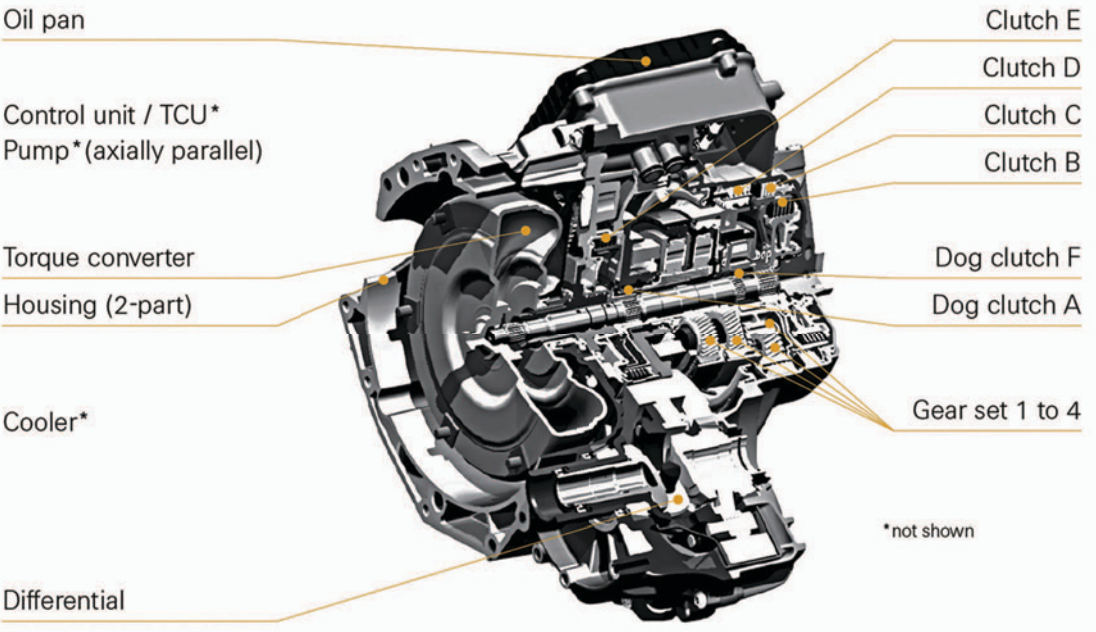
Powertrain-industry experts are intrigued by the 9HP's design and market potential. "ZF can win big if the 9HP48 delivers the refinement consumers have been trained to accept," noted veteran transmission engineer Skip Nydam, an analyst with **ND-Automotive**.

"This product is likely to have a significant effect on the marketplace, as OEMs struggle to catch up with the nine-speeds now available to ZF's customers," observed Chris Guile, **IHS** Automotive Manager of Europe, Middle East, and Asia Powertrain Forecasting.

Guile added that ZF's move into the fwd market "could significantly affect existing supplier relationships, assuming that ZF is able to price the new 9HP favorably against the products from other fwd [transmission] suppliers like **Aisin** and **Jatco**," he explained.

Optimizing mass and package

As installed in the vehicle, the 9HP48 measures 521 x 367 x 429 mm (20.5 x 14.4 x 16.9 in). Claimed wet weight is 86 kg (190 lb). "Each tenth of a millimeter of space in the transmission requires one month of negotiations with the OEM," quipped Dr. Michael Ebenoch, Director of Product Engineering.



Driving the 9HP in the Alps

Our road test loop was one used regularly by the ZF engineers. It begins at **ZF**'s Freidrichshafen headquarters on Germany's Lake Constance and continues across the nearby Austrian border and up into the Alps. Once off the autobahn, the route's extreme elevation changes would reveal any inherent driveability issues in the 9HP48 prototypes. The transaxles were installed in three **MINI** Cooper Clubman mules, chosen by ZF because their 1.6-L engines, fwd layout, and overall size are similar to the 2013 **Chrysler** vehicles that will get the production 9HP.

Two German magazine editors and I each piloted a MINI, accompanied by an engineer riding shotgun. My car also carried another ZF staffer in the backseat. We three were all rather large, leading me to expect much shift-busyness in the mountains. Our full suite of data-acquisition equipment included a gear-position display on the CAN bus—the only indicator I had of what gear the transmission was in at any given time.

Whether running at nearly wide-open throttle on the autobahn or clawing up and down Alpine switchbacks, the 9HP48 performed impressively. At an indicated 120 km/h (75 mph) in steady-state driving, the engine was turning 2000 rpm—about 700 rpm less than if a six-speed automatic was fitted. Shifts were executed in 450 ms, my engineer-navigator reported. On the twisting mountain climbs the gearbox rarely downshifted below fifth gear, which fairly stunned me given our payload. It held the high ratios remarkably well in a duty cycle that I was sure would prove it to be shift-busy. But it wasn't.

Overall NVH and general transparency, from the driver's seat, was superior to some DCTs I've driven. The amazing aspect of the 9HP, in my view, is how smooth and transparent it is in prototype form. I'm betting it will be even better when it enters production.

Lindsay Brooke



ZF fitted the 9HP48 prototypes to MINI Clubman mules for its development program. *AEI* was impressed by its overall performance.



In his spare time, ZF Board of Management member Dr. Peter Ottenbruch is a lifelong Porsche fanatic who lives for hot laps at the Nurburgring.

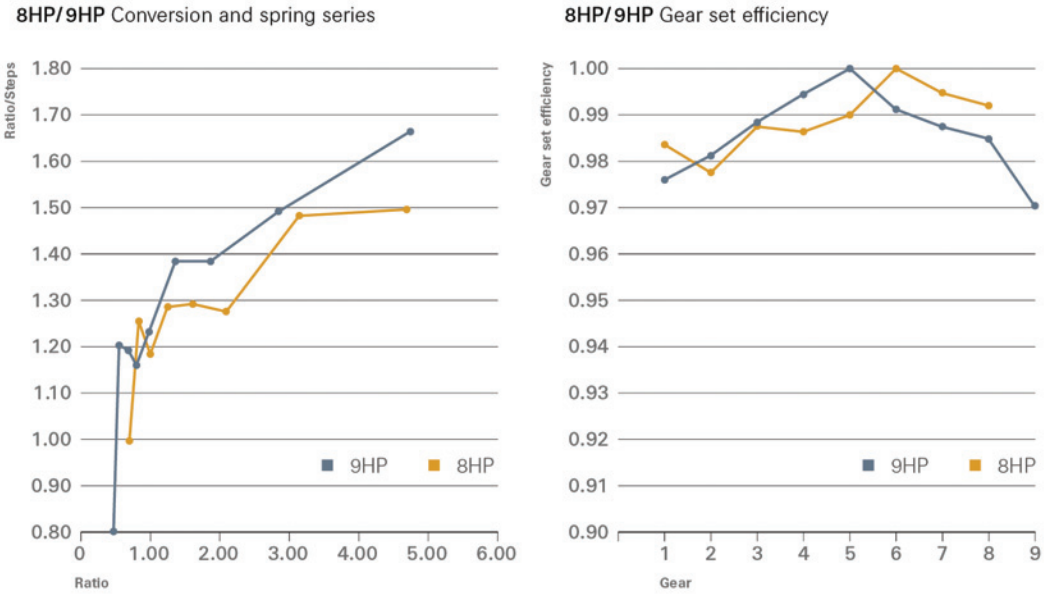
The 9HP's basic architecture consists of four planetary gear sets and six shift elements, with the two dog clutches, two multidisc clutches, and two multidisc brakes. The intermediate and final drive in the center of the gearbox enables a robust attachment for the gears. All shift operations over one or two gears can be executed by a switch of two shift elements.

A major design challenge in going to nine forward gear ratios was minimizing the overall package size of the fwd transaxle, the engineers said. The dog clutches help enable the packaging, as does directly nesting two planetary gear sets into each other so no more than three gear sets are arranged longitudinally. Gear sets 1 and 2 are stacked over one another. This required the ring gear of the inner gear sets to have a fixed link with the sun gear of the gear set above it.

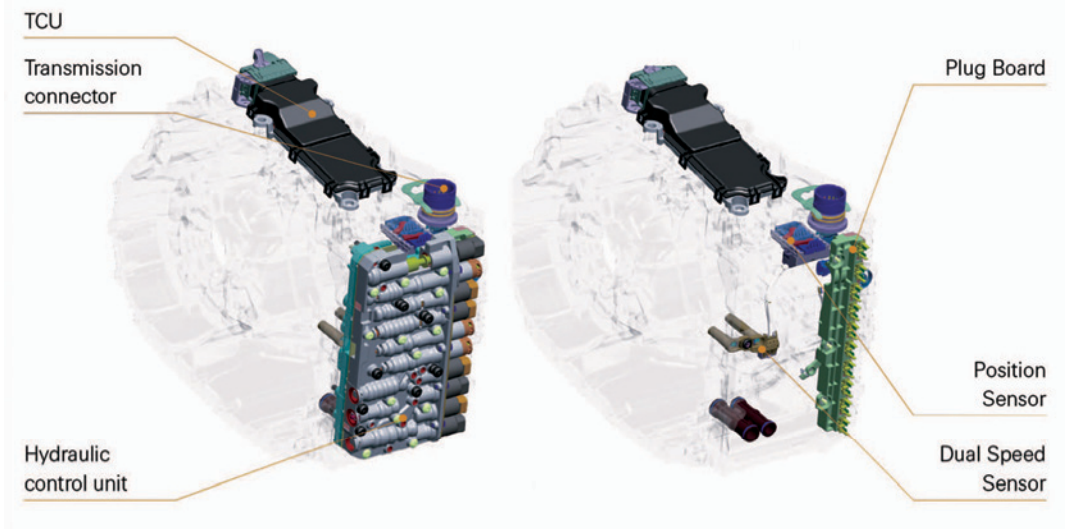
The decision to use dog clutches to help optimize the small gear-ratio steps meant choosing a shifting strategy that does not compromise functionality or shift quality, Ebenoch asserted. "So we only open the dog clutch during upshifts, because synchronization is not required in those events."

Compared with the mechatronic controls ZF uses on its eight-speed 8HP, the new nine-speed unit features hydraulic controls and a case-mounted electronic control unit (TCU) to optimize space. Compared with the 8HP controller, the 9HP's hydraulic controls unit has been significantly lightened (3.6 kg/8 lb) vs. 6.6 kg (15 lb). Its two die-cast aluminum housings contain the corresponding slide valve for triggering the shift element and lubricating or cooling the gear sets.

ZF engineers chose a torque converter as the starting element for its robustness, quietness, and high launch comfort—critical factors in the U.S. and Asia markets, said Ottenbruch. Depending on engine application, the torque converter will be paired with turbine- or twin-torsional dampers, or wet-disc start-up clutch, to minimize hydraulic losses in the launch phase.



Conversion and efficiency of the 9HP compared with ZF's 8-speed 8HP.



Two die-cast aluminum housings contain the hydraulic controls. Included are nine valve slides (including the parking lock actuation), six pressure regulators working on the pilot control principle, three on-off solenoids, and one interlock magnet for parking lock actuation. The actuator consists of closed-end pressure regulators, which engineers said significantly reduced leakage compared to the 8HP while delivering the same dynamics.

Start/stop capability designed in

When the engine is started, only one clutch is closed. This makes the 9HP start/stop capable—"an important consideration in our design planning," said Ebenoch.

The 9HP can support the start/stop function without the hydraulic impulse oil storage (ZF brands it HIS) used to actuate the clutches in the 8HP series. Since in a repeat start only one friction switching element is closed, the reaction times are rapid even without HIS, Ebenoch noted.

ZF developed the 9HP's control software in-house. Its modular design enables an adaptive shift strategy as well as capability to integrate the OEM customer's application-specific control program.

Hydraulic pressure is provided by an axially parallel vane cell pump that is chain-driven from the torque converter impeller hub.

Gears six through nine can be overdrive ratios depending on engine and final drive selection, although ZF engineers recommend OD on the two highest ratios only. The impressive 9.84 total ratio spread thus significantly contributes to the 9HP's potential to significantly improve fuel economy. Like the 8HP, the new nine-speed has a harmonic step range, its gear set efficiencies rising above 97% in all gears.

Besides its efficiency benefits compared to six-speed DCTs, ZF management also believes its new nine-speed has CVTs beat.

"You won't find a CVT with the ratio spread of our 9HP," Ottenbruch asserted. "And their basic disadvantage is they require power to transmit power. I believe engine technology has overtaken the CVT for passenger vehicle use."

Meantime, the 9HP's nine-month road test schedule continues. "The control software and the dog clutches must be 100% reliable, and our manufacturing processes, too," said Ebenoch. "It's the first time we're launching an all-new product in the U.S."

He said the 120-180 engineers and technicians involved with the nine-speed's design and development make it an expensive program, "and there's still much work to do." AEI

TECHNOLOGY CROSSES INDUSTRY BORDERS

Between the commercial- and military-vehicle markets, knowledge sharing and tech transfer benefits both in areas such as vehicle electrification and alternative fuels.

by Terry Costlow

Collaboration has become a watchword for the many aspects of vehicle development projects over the past years as cost-strapped vehicle makers added complex electronic features and functions to vehicles. Military developers also are planning to use even more of these linkups as military budget cuts loom.

Military design teams have been increasing their use of commercial-off-the-shelf products and modules for years, often working closely with vehicle providers and their suppliers. These efforts are expected to increase as rising debt curtails investments by the U.S. **Department of Defense**. As the funding climate has changed throughout this year, military speakers have increasingly begun presentations with a mention of reduced resources.

This trend was evident at the **SAE** Commercial Vehicle Engineering Congress in Rosemont, IL, in September. Budget cuts were mentioned twice before all the introductions were finished during a Blue Ribbon Panel titled "Commercial Vehicle Integration for Military & Homeland Defense Applications."

Collaboration is key

Collaboration is one of the strategies that military leaders plan to use to help make sure U.S. forces have access to well-equipped vehicles that help them complete missions safely. These leaders are keenly interested in working closely with commercial-vehicle suppliers and the companies that make equipment used on military vehicles.

"We want to interact with as many industry partners as we can," said Lieutenant Colonel Graham Compton, the **U.S. Army**'s Product Director for Non-Standard Vehicles. Non-standard vehicles are typically those that are designed primarily for commercial markets but are altered to fit military environments.

The focus on teamwork is taking several different tracks. While they turn outward to commercial suppliers, military agencies are also forging alliances with fellow members of the military.

In past periods of belt tightening such as the one that came as the Cold War faded out, military commanders often battled each other for a share of the remaining funds. That seems to have changed in the current environment as members of the armed forces join forces to make better use of the available funding.

"What happened during the drawdown of the 1990s is that everything was siloed and one group would fight another for resources," said Brigadier General Michael A. Stone, Assistant Adjutant General, Department of Military and Veteran Affairs, Joint Force Headquarter. "In the current environment, there's much more collaboration."

Stone, who is an officer in the Michigan National Guard along with his role in Joint Forces, noted that this spirit of cooperation extends beyond the military and its suppliers. He added that universities and a range of government agencies are also being tapped.

He cited a project that uses National Guard facilities that have seen less usage since the military cutbacks of the 1990s. These buildings are being used for the test and development of unmanned vehicles that are seeing increased usage in modern warfare.

"We're working towards getting a robotics test lab," Stone said. "I would never have dreamt five years ago that we'd be partnering with universities, but now I do a lot of conference calls to set up our program. We're even collaborating in the public sector, working with the governor of Michigan and the mayor of Detroit."

University partnerships are also becoming more common for the businesses that provide military vehicles. Collegiate research teams are often tasked with long-term research projects, and they are also being used to develop improved manufacturing and test processes. "Our university partnerships also continue to expand," said Lennart Jonsson, CTO for **Eaton** Corp.





Far left: Many challenges must be overcome before hybrid vehicles such as the U.S. Army's Clandestine Extended Range Vehicle see broad usage in the field.

Left: "We want to interact with as many industry partners as we can," said Lieutenant Colonel Graham Compton.

Working together not always easy

Though partnerships and joint projects can provide big benefits, panelists noted that those gains don't come without considerable effort. Tight relationships require some work up front to set guidelines.

Once the programs are in place, team members must balance needs between the shared project's goals and the larger goals of the company or agency they work for. That's especially true for companies that are providing innovative technology.

"It's a big challenge to collaborate on things and be successful," said Gary Schmiedel, Executive Vice President of Technology at **Oshkosh** Corp. "You need to balance the pressure to collaborate and still manage your intellectual property."

As companies in all slices of transportation increase collaboration, they are looking at related ways to trim costs. One of these is by using common hardware and software interfaces such as AUTOSAR that make it easier for design engineers to use existing modules rather than creating their own solutions.

"Interoperability is extremely important," Jonsson said. "We as manufacturers have to do more to create open standards."

While many issues associated with partnerships are universal, some of these considerations are specific to linkups with military organizations. One of these aspects is the time frame for military vehicles, which can be in development for years and have very long lifetimes once they move into production. Another is the need to protect the technical secrets that keep America's armed forces ahead of their adversaries.

"Program times are much longer and military operations are regulated by International Traffic in Arms Regulations (ITAR)," said Robert F. Combs, Director of Military Applications at **Allison Transmission**.

Another is the amount of paperwork and bureaucracy that can be involved with publicly funded programs. The regulations that govern government expenditures have been growing for years as legislators have attempted to avoid all sorts of financial issues such as bribery and overcharging.

At large companies, teams typically include at least a member or two who have worked with these regulations. But many innovations come from small companies that don't have much experience with government requirements. Military agencies that encourage these small companies to bid on

Tech transfer is focus of December webcast

Automotive Engineering International will hold the fourth in a series of special topical webcasts on Dec. 15, 2011. The title of the webcast is "Technology Transfer: Sharing Knowledge between Commercial and Military Vehicle Sectors."

The panelists are Rod Heiple, Associate Director, **Alcoa Defense**; Gary Hunter, Director of Research and Development, **AVL Powertrain Engineering** Inc.; and Peter King, Executive Director of Business Development for **Roush CleanTech**.

Among the topics to be addressed are the trends of improving fuel efficiency and moving away from such a large dependence on traditional petroleum-based fuels, namely diesel—issues affecting not only on-road commercial vehicles but military vehicles employed in theater as well.

A variety of technology paths are being pursued to accomplish these goals, and they are not exclusive to just one segment. For example, lightweighting strategies increasingly employed in on-road commercial and passenger vehicles should interest engineers—and end customers—in defense because of the potential savings in fuel costs and the capability for higher payloads.



Rod Heiple



Gary Hunter



Peter King

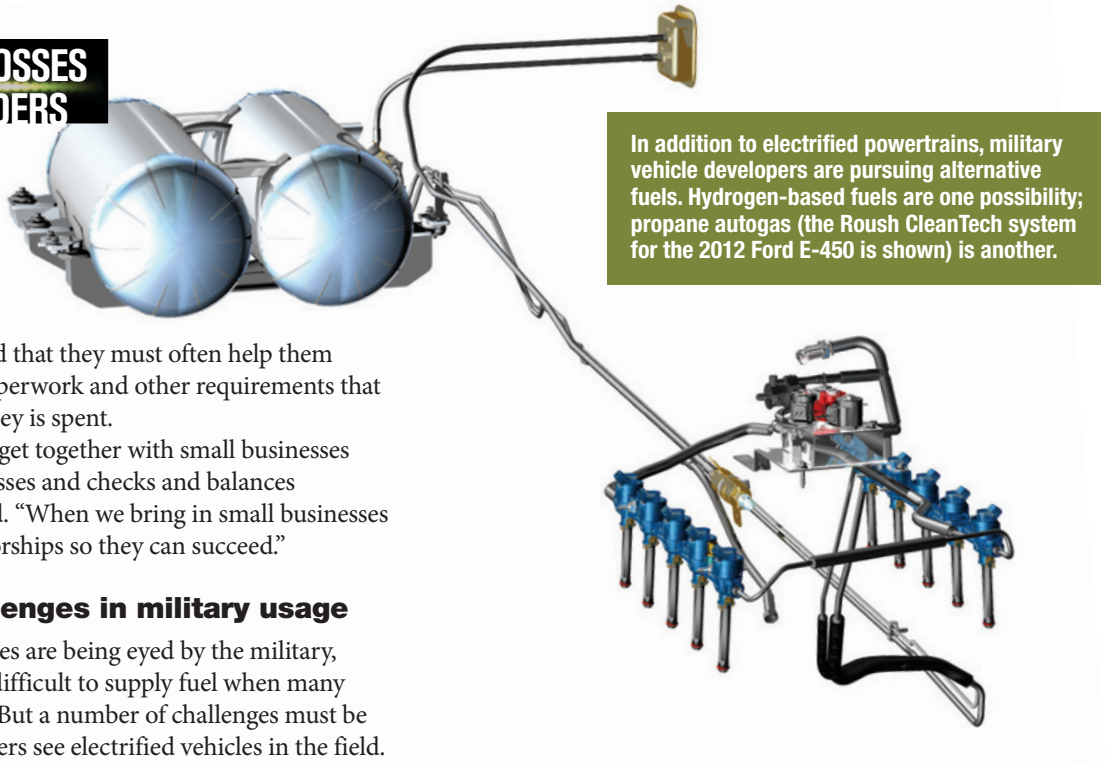
Panelists will present key cross-industry trends such as these and more—including the move toward vehicle electrification and other advanced powertrain solutions, and the increasing use of alternative fuels. They will also provide real-world success stories of technology transfer.

Attendees are invited to interact with the experts during the Q&A portion of the webcast.

Ryan Gehm

Sponsored by

Integrity
A PTC Product



In addition to electrified powertrains, military vehicle developers are pursuing alternative fuels. Hydrogen-based fuels are one possibility; propane autogas (the Roush CleanTech system for the 2012 Ford E-450 is shown) is another.

government contracts find that they must often help them maneuver through the paperwork and other requirements that come when taxpayer money is spent.

"It's a real challenge to get together with small businesses that don't know the processes and checks and balances developed," Compton said. "When we bring in small businesses we need to provide mentorships so they can succeed."

Hybrids face challenges in military usage

Hybrid and electric vehicles are being eyed by the military, which has often found it difficult to supply fuel when many vehicles are on the move. But a number of challenges must be overcome before warfighters see electrified vehicles in the field.

The U.S. military has developed demonstrator vehicles and many transportation companies have produced vehicles that augment internal-combustion engines (ICEs) with electric or hydraulic power. But broader adoption appears to be a fair ways out in the future. When the topic of hybrid and electric vehicles came up during the Blue Ribbon Panel at SAE's Commercial Vehicle Engineering Congress, panelists cited a number of issues that must be resolved before electrified powertrains see use in most military environments.

Military and commercial representatives said there's definitely interest, since delivering fuel is an expensive and sometimes hazardous aspect of military operations. Panelists from the commercial side noted that as interest in electrification increases, they are forging partnerships to help develop electric subsystems.

"We're refocusing our effort on power management, partnering with companies that give us complementary technologies," said Eaton's Jonsson.

Designing components and subsystems for military vehicles always requires more ruggedness, but other parameters are also far more demanding. Most vehicles now carry many different antennas for communications and they have a wealth of other electronic equipment that drives up the overall power consumption, boosting the demand for battery power.

"For military missions, vehicles require a lot of onboard power, from 40 to 90 kW to run all the accessories," said Allison's Combs.

Providing that much power while also moving a vehicle along its route takes a lot of battery power. Most vehicle and battery suppliers feel that major improvements in battery technologies need to occur before plug-in electric vehicles can begin to compete at the same level as ICEs.

"Lithium-ion batteries aren't yet completely ready for things like plug-in hybrids where you really utilize the battery's full capabilities," Jonsson said. "Developments in the commercial space can really help build up a knowledge base before we go into more demanding military markets."

A key obstacle for hybrids and electric vehicles is their complexity. Most military technicians are unfamiliar with the many components added for electric powertrains, so significant amounts of training must occur before they can move into the mainstream for military vehicles.

Deploying hybrids in war zones also underscores the need to stockpile spare parts in addition to increasing training. That's especially true as the U.S. exit strategy for Afghanistan proceeds and locals take over vehicle maintenance.

"We do our own maintenance, so adding a new technology can be very, very expensive in areas like Afghanistan," said Lieutenant Colonel Compton. "The literacy rate for Afghanis is around 20%; something as simple as filling out a requisition form won't work there.

While very few other environments will have that limitation, product developers are always striving to simplify maintenance. In most military theaters, reducing downtime and the amount of training needed for each vehicle are important factors. That's driving a trend toward plug-in componentry.

"Certainly a large degree of training needs to take place with hybrids," said Oshkosh's Schmiedel. "It's well within our capability to build products based on removing and replacing modules."

At the same time, design teams are working to add features that help users and technicians understand what's broken and how to fix it. They're also working on prognostics, which will predict when failures may occur so preventive action can reduce overall downtime.

"Diagnostics and prognostics are becoming increasingly important," Jonsson said. "Modularity is also very important."

While electrified powertrains inch into military markets, developers are already looking at other alternative fuels. Some vendors feel that the shift to electric vehicles will help clear the pathway for a transition to hydrogen-based fuels.

"Fuel cells remain elusive," Schmiedel said. "As we start embracing electrification, we can set the infrastructure for moving to fuel cells when the time is right." AEI



Cutting the cost of carbon

Automakers streamline production to reduce the price premium for lightweight carbon fiber.

by Dan Carney

The 2011 Frankfurt Motor Show was a virtual carbon fiber industry expo, as automakers rolled out numerous concepts heavily featuring carbon-fiber-reinforced plastic (CFRP) components.

The appearance of carbon fiber in supercars such as the **Lamborghini** Aventador or **McLaren** MP4-12C is no surprise, but automakers are increasingly aiming to exploit the lightweight material's advantages in small fuel-saving models.

BMW rolled out the prototype of its planned limited-production i3 battery-electric model that is built on a carbon-fiber tub. Meanwhile, **Audi** explored the potential to reduce unsprung mass in its urban concept, which showcased **Formula One**-style open-wheel design using exposed carbon-fiber suspension components.

The industry certainly appears to be embracing this costly technology, so the question now is whether mainstream production models can really use carbon fiber on a large scale, or whether such materials will be restricted to high-dollar, high-performance machines.

Market research company **Lucintel** predicts the North American market for automotive composites will grow to nearly $1.6 billion by 2014, indicating market growth that is slightly faster than the growth of the GDP over that time. The company cites the need for automakers to increase fuel efficiency, as well as advances in carbon-fiber manufacturing and fabrication techniques as reasons why this industry segment will grow faster than the overall economy.

During the same period, the market for automotive carbon fiber in Europe will expand to more than $1.8 billion, according to Lucintel's forecast.

Carbon-fiber supplier **Zoltek** is bullish on automotive carbon but points out that if the entire carbon-fiber manufacturing industry reaches 400,000 t (441,000 ton) of production in 2017, that it will then only equal one-tenth the annual production of fiberglass products.

While the auto industry's production processes are the most efficient of any industry served by carbon fiber, the manufacturing and assembly costs using the material still make it prohibitively expensive for many applications, pointed out Rolf Johns, Vice President of Prepreg Operations at

Above: The McLaren MP4-12C sports car is built on a carbon-fiber tub, which is unusual even for its high-end market segment.

Below: SGL Automotive Carbon Fibers, a joint venture between carbon supplier SGL Group and BMW, produces these spools of carbon threads and ships them to BMW's Wackersdorf, Germany, plant to be made into fabric.



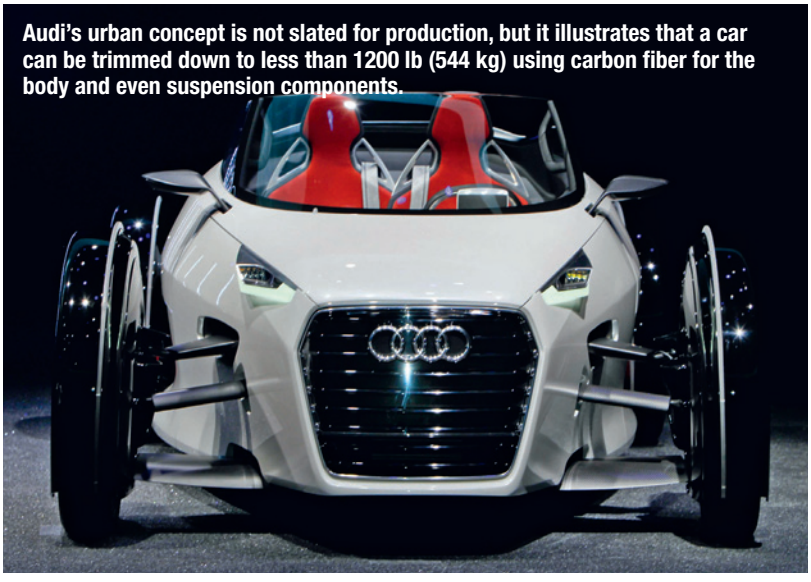
Cutting the cost of carbon



The i3 Concept car demonstrates BMW's plans for a battery-electric "mega-city" car using carbon-fiber construction to reduce weight.



Using carbon fiber can help save money because it can permit use of a smaller battery pack, according to Dr. Joerg Pohlman, the managing director representing BMW in the SGL Automotive Carbon Fibers joint venture.



Audi's urban concept is not slated for production, but it illustrates that a car can be trimmed down to less than 1200 lb (544 kg) using carbon fiber for the body and even suspension components.

Zoltek in a presentation to the **Society for the Advancement of Material and Process Engineering** (SAMPE). "If carbon fiber was free, it would still be too expensive," Johns noted dryly. Despite the cost, the auto industry will eventually be the largest application of carbon-fiber materials, he predicted.

It is exactly such costs that BMW is targeting in its partnership with **SGL**. By attacking cost at every stage of carbon-fiber supply, manufacturing, and process, the company hopes to bring carbon-fiber cost into a realistic range for use in a limited-production specialty car such as its i3 concept.

BMW is also targeting a high level of automation in the i3's manufacturing process, which should reduce its cost compared to labor-intensive supercars such as the McLaren MP4-12C.

"Carbon-fiber production is very labor-intensive," acknowledged McLaren Automotive Managing Director Antony Sheriff. McLaren has developed a process that produces the entire tub from one mold, streamlining the MC12's production. While the McLaren F1 of 1992 required 100 h of labor for its carbon-fiber construction and the **Mercedes-Benz** SLR McLaren of 2003 needed 33 h of labor, the new MC12 requires only 8 h of hand assembly, said Sheriff.

For production of the i3, BMW is involved with nearly every step of the carbon-fiber process, coordinating and streamlining for maximum efficiency. The company buys the rayon precursor material from **Mitsubishi**, shipping it to the **SGL Automotive Carbon Fibers** joint venture plant in Moses Lake, WA. There, SGL carbonizes the precursor material, turning out spools of carbon-fiber yarn using cost-effective hydroelectric power that is abundant in that region.

As part of BMW's desire to produce a carbon dioxide-neutral car, the company observed that the energy-intensive carbonizing process typically releases a lot of CO_2. The company wanted to avoid that, and needed to avoid the interruptions in power supply inherent in solar or wind power, leaving hydropower as its only CO_2-neutral option. Nuclear power was evidently not considered a sufficiently green option, so the plant was located in Moses Lake, where it draws on electric power that is much cheaper than that available in Germany, running the plant around the clock.

This green agenda handicaps BMW's effort to some degree, remarked Johns in his presentation to SAMPE. He identified this as "unnecessary objectives that may take away from its success."

Carbon's extra expense can be partially justified by the benefits carbon-fiber



McLaren introduced carbon-fiber chassis construction to Formula One with the introduction of the MP4-1 in 1981, paving the way for the eventual development of the MP4-12C road car, which is also built on a carbon-fiber tub.

construction can contribute, explained Joerg Pohlman, Managing Director of SGL Automotive Carbon Fibers. Less vehicle mass means a longer driving range with less battery capacity, he pointed out. Because batteries are very expensive, using carbon fiber can help save money because it can permit use of a smaller battery pack. "It is an easier business case to make because you are going to need fewer batteries," he noted. "You can save money there."

Smaller battery packs are not only cheaper, but lighter, too, creating one of those virtuous cycles in which an effect strengthens itself. A 100-mi (161-km) driving range typically requires a little more than 20 kW·h of battery capacity, and each of those kW·h weighs about 10 kg (22 lb), Pohlman said. With reduced vehicle mass, a smaller battery is possible, further reducing the vehicle's weight and in turn permitting lighter brakes and suspension components.

And the carbon-fiber structure itself may be lighter than expected. While conservative estimates peg carbon's weight savings at 50% compared to steel and 30% compared to aluminum, BMW's i3 project is doing much better than that, he said.

"There are parts where you can replace a steel part at one-third the weight," he said. Pohlman declined to pinpoint which parts offer the potential for so much weight savings.

Such intensive attention to mass reduction allowed Audi to trim the weight of its urban concept to just 1058 lb (480 kg) using a carbon fiber-aluminum mix for both the body shell and the suspension components.

The urban concept's exposed suspension looks vulnerable to damage and its carbon-fiber construction looks fragile, but the material's durability in that application is excellent, reported Pohlman. The benefit of its lighter mass is magnified when used in unsprung applications, he added.

"In parts that are unsuspended you would have a positive effect on driving comfort and on fuel consumption," he said. "For fuel consumption I would imagine an even higher effect than if you took that same kilogram out elsewhere in the vehicle."

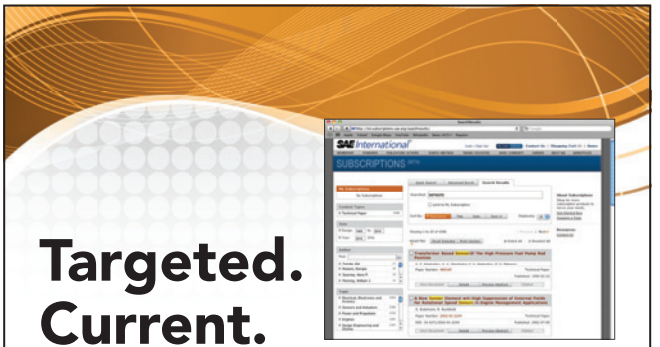
In the case of the urban concept, the low mass and minimal aerodynamic drag contribute to a driving range of 45 mi (72 km) on a 7.1-kW·h battery pack, which extrapolates to a 15.8-kW·h pack for a 100-mi range. That compares to batteries of about 25 kW·h for a comparable range in current battery EVs.

Zoltek's Johns says that future volume production vehicles could feature 200 lb (91 kg) of carbon fiber each, which in a vehicle with annual sales of 250,000 units would total 50 million lb (22.7 million kg). That's half of the world's carbon-fiber capacity today, he pointed out. "Is the carbon-fiber industry doing enough to develop this demand and address this potential supply shortage?" he wondered.

McLaren's Sheriff is bullish on the possibilities. "Our ultimate goal is that everyone is driving a carbon-fiber car," he exclaimed. **AEI**

Companies mentioned

Company	Page
3M	4
ACIS	6
Aisin	33
Albonair	6
Alcoa Defense	37
Alfa Romeo	11
Allison Transmission	37
Atmel	6
ATX	6
Audi	10, 39
Australian Gas Association	14
AVL Powertrain Engineering	37
BMW	39
Chevrolet	11, 27
Chrysler	33, 34
CNC Software	4
Continental	6
Daimler	24
Delphi	6
Eaton	36
Elsevier	6
Ensoft	6
Evonik Industries	16
Ferrari	6
Ford	6, 11, 18
Formula One	39
Genovation Cars	6
German Government's Ministry of Education and Research	16
GM Holden	13
Green Hills Software	15
HBM	4
Honeywell Turbo Technologies	10
Hyundai	13
IHS	33
Infotech Enterprises	6
Intel	15
International Motor Press Association	10
Jacob Plastics	16
Jaguar	22
Jatco	33
Jeep	24
Johnson Controls	16
Lamborghini	39
Land Rover	24, 33
Lincoln	11
Lord	4
Lucintel	39
Mahle	6
Mann+Hummel	13
Maplesoft	6
McLaren	39
Mercedes-Benz	11, 23, 40
Microsoft	15
MINI	34
Mitsubishi	40
MKS	6
Mobileye	6
Munro & Associates	44
NASA	44
National Academies	6
ND-Automotive	33
Nissan	6
NSERC	6
OnStar	15
Opel	27
Oshkosh	37
Porsche	12, 20, 33
PTC	30
QNX Software Systems	15
Roush CleanTech	37
SAE International	6, 28, 36
Sauer-Danfoss	6
SGL Automotive Carbon Fibers	40
Siemens PLM Software	6
Signet Research	29
Society for the Advancement of Material and Process Engineering	40
STMicroelectronics	6
Tata Technologies	6
Technical University of Aachen	16
Ticona	6
Toho Tenax Europe	16
Toyota	6, 26
Umicore	6
University of Waterloo	6
U.S. Army	36
U.S. Department of Defense	36
Vialle	13
Virginia Tech Transportation Institute	6
Volkswagen	11
Wind River	15
ZF	22, 32, 34
Zoltek	39



Targeted. Current. Convenient.

SAE Subscriptions are designed for companies, organizations, and individuals who routinely need comprehensive, current information on key topics

Current titles include:

Electronic Engine Controls
Emissions Technology
Sensors and Transducers
Occupant Protection and Crashworthiness Technology

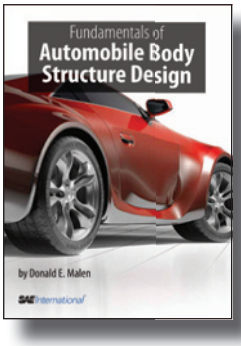
For a complete listing of Subscription titles
visit subscriptions.sae.org

SAE International

P111177

New book provides 'structural intuition' concepts for better automotive body design

By Donald E. Malen



This fundamental book will give the reader a solid understanding of the principles of automobile body structure design. It illustrates the effect of changing design parameters on the behavior of auto body structural elements. *Fundamentals of Automobile Body Design* will provide valuable insight to graduate and undergraduate students in automotive programs, entry-level body design engineers, and others looking to understand the influence of vehicle layout on body performance or the interaction of subsystems with the body.

ISBN: 978-0-7680-2169-1
List Price: $89.95
Product Code: R-394

ebook available

SAE International

Order today!
Online: books.sae.org/book-r-394
Email: CustomerService@sae.org
Phone: 1-877-606-7323 (U.S. and Canada only)
or 1-724-776-4970 (International)
Actual shipping charges will be applied.

P110214

Ad index

Advertiser	Page	Web Link
3M Automotive	9	www.3m.com/autoeng
Allegro MicroSystems Inc	21	www.allegromicro.com/promo829
ContiTech	3	www.contitech-online.com/aaw
Dana	Cover 4	http://auto.dana.com/b14
Dexmet Corporation	27	www.expanded-materials.biz
DSM Engineering Plastics	19	www.livingsolutions.dsmep.com
HBM-nCode	12	www.hbm.com/ncode
Indo-MIM	11	www.indo-mim.com
MathWorks	7	www.mathworks.com/accelerate
Melexis Inc.	17	www.melexis.com/lin
	43	www.melexis.com/Hall-Effect-Sensor-ICs/Linear-Hall-ICs/MLX90288-762.aspx
Omega Engineering Inc	1	www.omega.com
	43	www.omega.com/literature/wireless26
Panasonic Electric Works Co Ltd	Cover 2	http://www.pewa.panasonic.com/ev-relays
Panasonic Industrial Company	24	www.panasonic.com/bluetooth www.panasonic.com/rfmodules
Rittal Corporation	14,15	www.rittal-thesystem.com
	Cover 3	www.rittal-thesystem.com
SEA Limited	5	www.sealimited.com
Seissenschmidt AG	25	www.seissenschmidt.com
TAITRA	13	www.taipeiampa.com.tw www.autotronics.com/tw

Free Subscription to AEI
Go to: www.submag.com/sub/au

upcoming FROM THE AEI EDITORS

Nov. 7 SAE Vehicle Engineering Technology eNewsletter

Nov. 14 SAE Hybrid & Electric Vehicle Technology eNewsletter

Nov. 21 AEI Electronics Technology eNewsletter

Nov. 28 SAE Materials Technology eNewsletter

Dec. 5 SAE Vehicle Engineering Technology eNewsletter

Dec. 6 Automotive Engineering International digital
- Top Technologies of the Year

Dec. 12 AEI Powertrain Technology eNewsletter

Dec. 19 SAE Heavy-Duty Technology eNewsletter

Dec. 19 SAE Connected Vehicle Technology eNewsletter

Jan. 9 SAE Vehicle Engineering Technology eNewsletter

Jan. 16 SAE Hybrid & Electric Vehicle Technology eNewsletter

Jan. 17 Automotive Engineering International digital
- Electronics

Jan. 23 SAE Test & Measurement Technology eNewsletter

Jan. 23 AEI Electronics Technology eNewsletter

Jan. 25 SAE Powertrain & Energy Technology-Focused Digital Magazine (New for 2012)

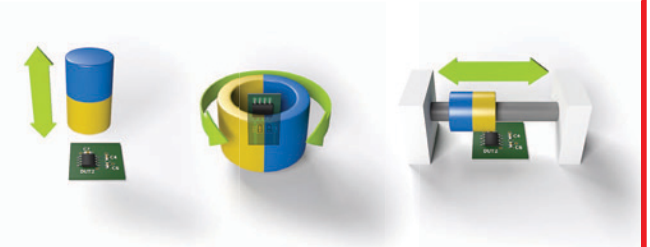
Feb. 7 Automotive Engineering International print
- Vehicle development and systems
- Alternative fuels
- Body & chassis

Feb. 21 SAE Vehicle Electrification Technology-Focused Digital Magazine

Tech-lit file

Melexis Dual Programmable Linear Hall Sensor Family Goes Surface-Mount

Melexis, the leader in Linear Hall IC sensors, announces a new series of three programmable surface mount linear Hall IC sensors. Both the MLX90288 ratiometric analog output and the MLX90291 125 Hz PWM output sensors are provided in an SOIC-8 SMD package. The third sensor, the MLX90292 is dual die redundant in a TSSOP-16 package with a digital output that uses the fast and safe 2-wire PSI-5 protocol, featuring a 2 kHz PWM mode.



Product URL: http://www.melexis.com/Hall-Effect-Sensor-ICs/Linear-Hall-ICs/MLX90288-762.aspx

DILBERT™ BLUE CAT® NEW HORIZONS® IN WIRELESS COMMUNICATIONS Version No. 26



Contains 68 full color pages of cutting-edge technology showcasing our top-selling Wireless Sensors, Transmitters and Receivers, Ethernet Web Based Measurement and Control Devices for Monitoring & Recording Data over the Internet. Wireless Solutions include Temperature, Pressure, pH, Humidity, Flow and Process applications for Test & Measurement, Automation and Industrial Manufacturing.

For more information, go to the OMEGA Engineering Inc. web site at http://www.omega.com/literature/wireless26

Classifies advertising

Business Management Analyst: Collect, analyze ongoing administrative and financial efficiency; evaluate data collected, provide suggestions/solutions for efficiency; conduct, evaluate internal quality controls w/company departmental managers; document collected data and prepare reports; coordinate any implemented changes. Bachelor of Business Administration. 2 yrs Exp. in management.

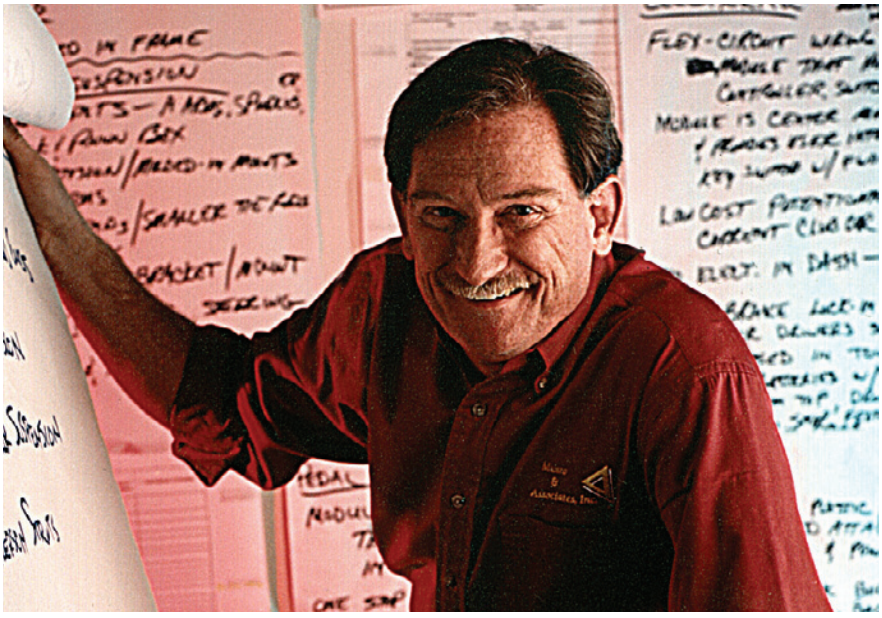
Send resume to:Dongwon Autopart Technology Alabama, LLC.12970 Montgomery Hwy. Luverne, AL 36049

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

Reaching higher

Will the car of the future fly?

I've read many articles about the future of the auto industry and I am amazed that the 100-year plans still include things like metal bodies, engines, and wheels. To me, that just seems absurd. All one has to do is reflect on the past 20 years and think about the new-found horsepower in your computer or the fact that everyone is completely connected 24/7.



Sandy Munro, CEO of Munro & Associates, Inc., wrote this article for *AEI*'s 100th anniversary. He is a catalyst, coach, and change agent who has helped some of the world's top manufacturers implement cultural change and lean design.

The automobile is improving with new innovations such as voice activation, automated parking, crash avoidance, lane detection systems, and the list goes on. Yet the automobile is treated as a commodity, an appliance. I benchmark cars for a living. In my opinion, they all have about the same quality, performance, and content with different styling. I think the market is ripe for a change.

Twenty short years ago who would have thought that cell phones, texts, tweets, etc. would take the place of that giant piece of Bakelite that your mom kept in the living room? So why do we think that the car of today will look or perform anywhere close to what we'll see 100 years from now?

One hundred years ago, most ships had a combination of steam and sail. One hundred years ago, planes were made of balsa wood and canvas, had two wings, and flew an average range of about 60 mi (100 km). One hundred years ago, more "folks" had horses than cars. Yet we predict the future will still be glued to the road using wheels.

Not me.

I had my mind change about 20 years ago in a Texas barn. There, I watched what looked like a combination cigar box and golf umbrella, coated with aluminum foil, lift off a hayloft floor and gingerly head out the door into the wild blue yonder. It didn't stay out long and crashed on its reentry, but it did fly. No wires, no magnets, no engines, nothing.

I have no idea how they did what they did; but their big problem was lightweight power and I couldn't help then. But now?

The great thing about technology is that what was impossible to comprehend or imagine yesterday is commonplace tomorrow. The bad news? I couldn't help then when they needed it. (Maybe I can now, so call me.) The good news? I was blessed by witnessing the technology for the car of the future.

I have seen two "anti-gravity" machines; **NASA** knew about both of them, but neither was practical. Should failure hold us back? The Wright Flyer was fragile and dangerous, just like the little craft I saw in Texas. But the good thing about



The easy chair of the future flies.

"inventive engineering" is that there's always a better way if you're willing to open your mind and work to find it.

So who will conceive the next big thing: universities, big auto companies, big aircraft companies? I don't think so. When a paradigm changes, it's always outsiders that lead the way. We need a few brave people like that pair of Dayton, OH, bicycle repairmen, or that toolmaker from Detroit, or those two guys who built a computer in their garage, or maybe a few guys in a Texas barn. We need to be shoved off our pillar of comfort before we can fly.

I want to be in that group of engineers—the ones that are resilient; that keep dreaming, inventing, and forging ahead; while simultaneously ignoring the Luddites and naysayers. Got a fantastic idea? Pursue it with passion! I predict that a year or two after the introduction of the first "anti-gravity car," we will all wonder why we ever bothered with the wheel. 100

Rittal – The System.

Faster – better – worldwide.

RITTAL XPRESS
STOCK > MOD > SHIP





Here today.

Here tomorrow.

The RittalXpress stocking program ensures next day shipping for more than 2,200 of our most popular Industrial and IT enclosures, accessories and climate control products. Visit www.rittal-corp.com/rittalxpress for a complete selection of in-stock products.

ENCLOSURES | POWER DISTRIBUTION | CLIMATE CONTROL | IT INFRASTRUCTURE | SOFTWARE & SERVICES

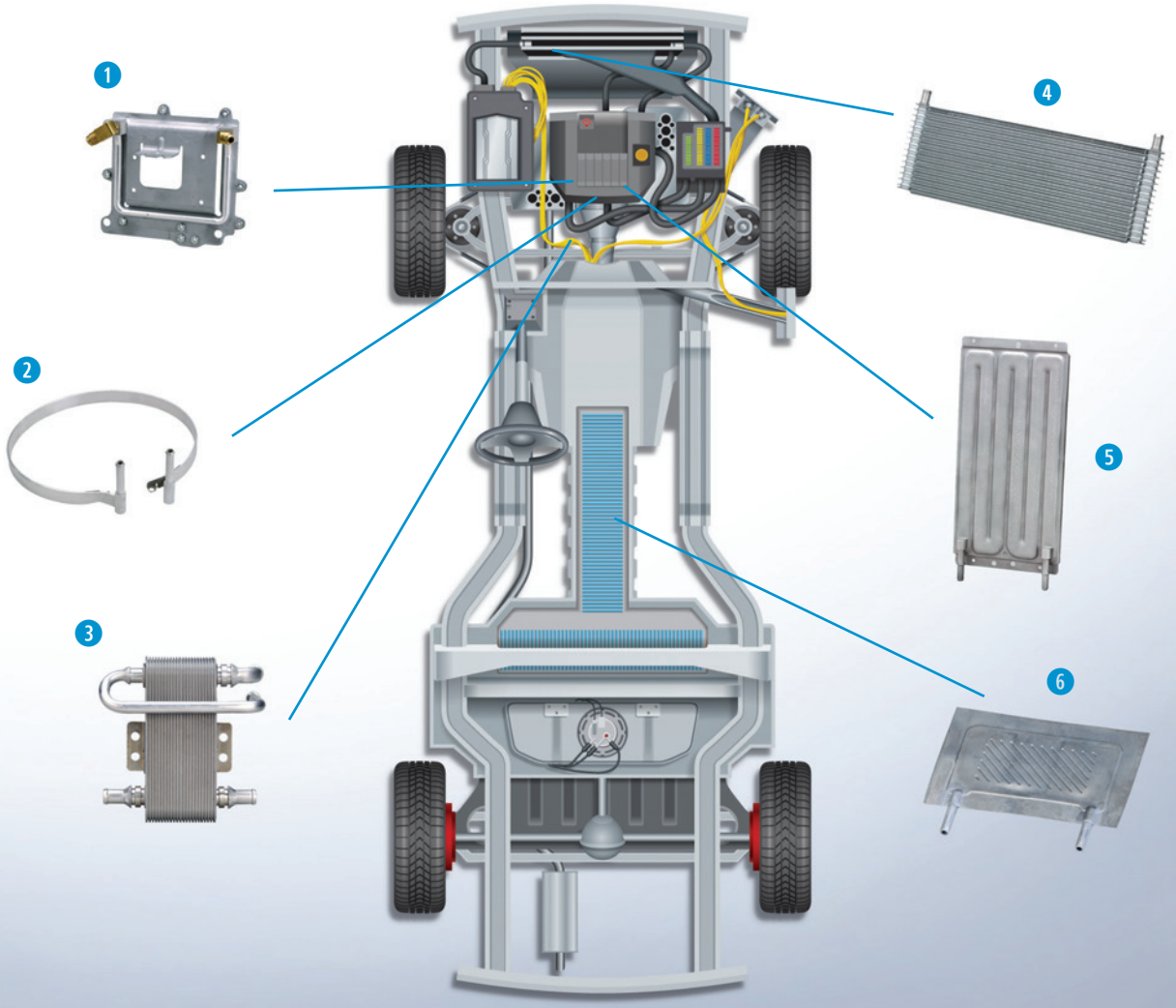
RITTAL

FRIEDHELM LOH GROUP

www.rittal-thesystem.com

Driving Innovation

With Durable Battery Cooling



1. **Engine Control Unit Cooler**
2. **Universal Stator Cooler**
3. **Hybrid and Electric Vehicle Battery Cooling Chiller**
4. **Sub-Cooled Loop Radiator**
5. **Electronic Cooling Plate**
6. **Interelement Cooling Plate**

CUSTOMIZED BATTERY COOLING TECHNOLOGY As a leader in thermal technologies, Dana works with global automakers to create custom hybrid cooling solutions for the unique and changing needs of today's advanced battery systems. Our hybrid cooling technology is manufactured with various types of lightweight aluminum and provides a multitude of benefits to the vehicle. The cooling technology is easily recyclable, which contributes to the overall environmental benefits of electric and hybrid-electric vehicles. For more information, call **1-888-670-DANA** or visit **http://auto.dana.com/b14.**

DANA

LONG®
Thermal Products

© 2011 Dana Limited