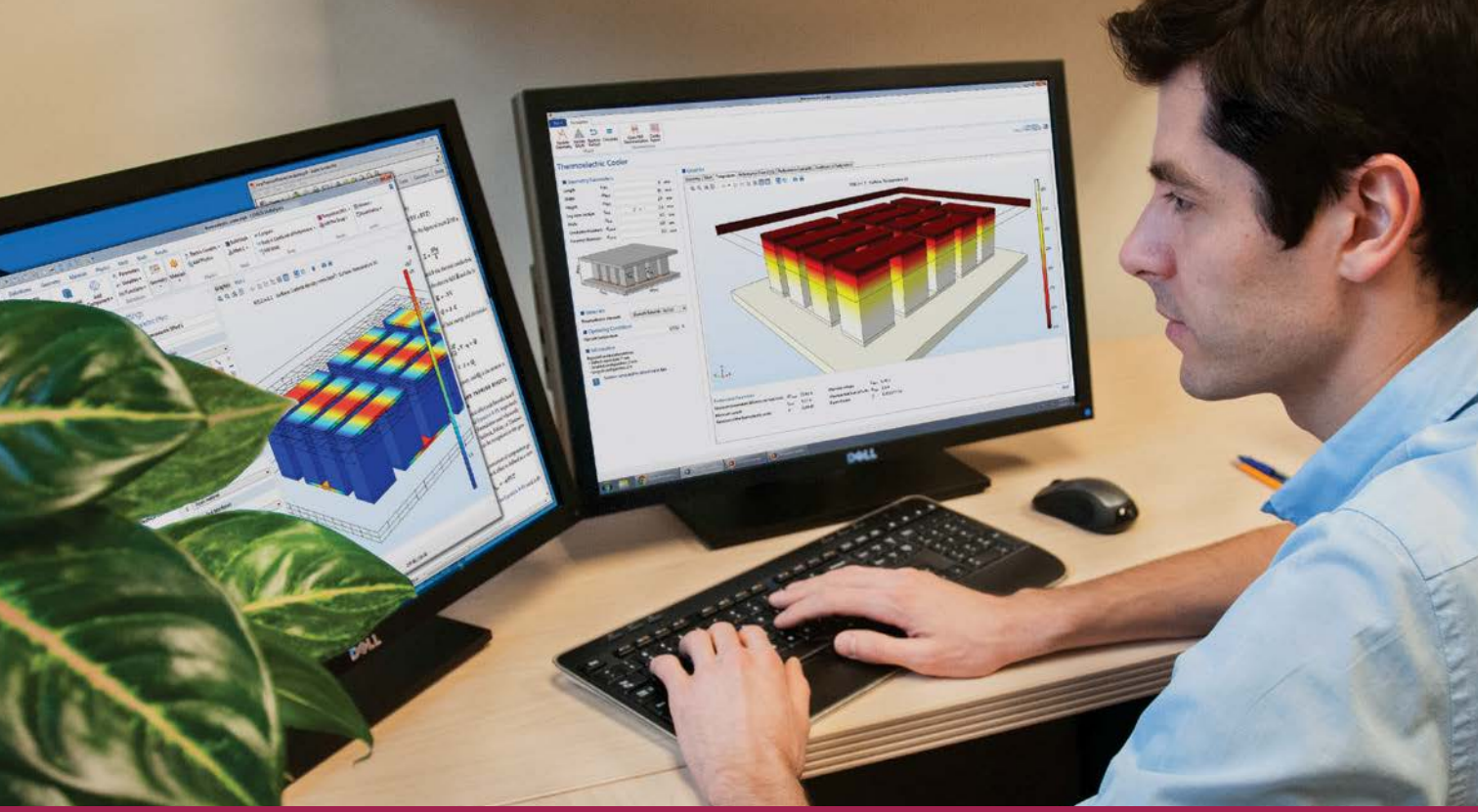

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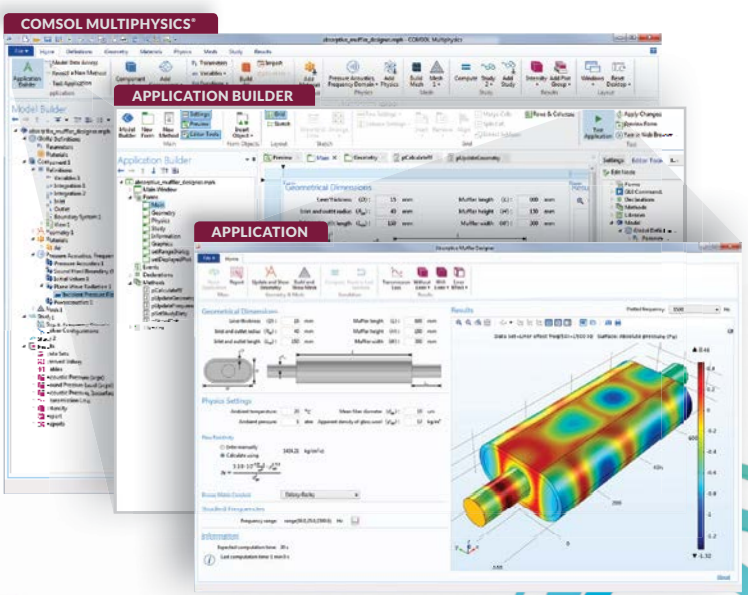

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Cadillac's 2017 XT5

Midsized luxury utility based on new GM C1XX architecture

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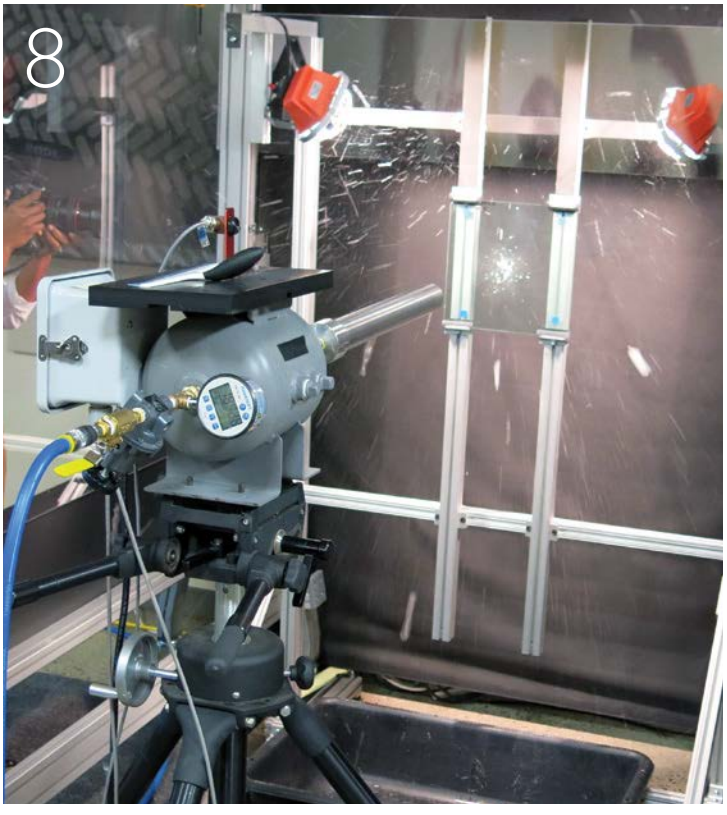
CONTENTS

FEATURES

ON THE COVER

Cadillac's all new 2017 XT5 midsized luxury utility is slated to replace the SRX and is underpinned by a clean-sheet vehicle architecture called C1XX. See page 28.



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Automotive Engineering®, February 2016, Volume 3, Number 1. *Automotive Engineering* (ISSN 2331-7639) is published 9 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, $30 each North America, $35 each overseas. Prices for nonmember subscriptions are $115 North America, $175 overseas. Periodical postage paid at Warrendale, PA, and additional mailing offices. POSTMASTER: Please return form 3579 to *Automotive Engineering*, P. O. Box 47857, Plymouth, MN 55447. SAE International 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 reproduce or 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. The *Automotive Engineering* title is registered in the U.S. Patent and Trademark Office. Full issues and feature articles are included in the SAE Digital Library. For additional information, free demos are available at www.saedigitallibrary.org.
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WHAT'S ONLINE

VIDEO

SAE Eye on Engineering: Delphi's new MDC

Automated vehicle technology is on the rise, but how do engineers keep electronics from becoming too complex and costly? In this episode of SAE Eye on Engineering, Senior Editor Lindsay Brooke looks at Delphi's new Multi-Domain Controller. The video can be viewed at https://youtu.be/kIdQUpcysa8. SAE Eye on Engineering airs in audio-only form Monday mornings on WJR 760 AM Detroit's Paul W. Smith Show. Access archived episodes at www.sae.org/magazines/podcasts.

MEDIA PARTNERSHIP

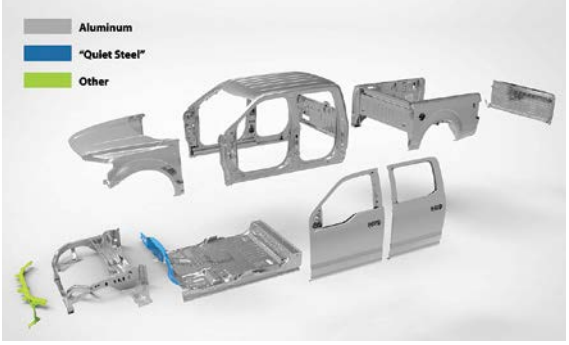
2016 Altair Enlighten Award adds new category to honor lightweighting efforts

Nominations for the fourth annual **Altair** Enlighten Award are now being accepted, with the 2016 award program including two distinct categories recognizing vehicle lightweighting: full vehicles and modules. The separate categories serve "to give full and proper recognition" to both vehicle manufacturers and the suppliers who help them to meet their increasingly aggressive weight targets.

The 2016 Altair Enlighten Award will recognize achievements in weight reduction across the entire automotive industry, from motorcycles to passenger cars, light trucks to commercial vehicles and buses. The award will be presented in collaboration with the **Center for Automotive Research** (CAR) at the 51st annual CAR Management Briefing Seminars in Traverse City, MI, August 1-4, 2016. **SAE International** and its flagship publication *Automotive Engineering* will again serve as the official media partner for the award.

"After three years, the Enlighten award and the automotive lightweighting industry have outgrown the original, single award program," Richard Yen, Vice President, Automotive at Altair, said in a statement. "Making the decision to add a second category to the award was the obvious and natural next step. The supplier base now contributes hugely to the vehicle lightweighting effort. It is therefore our pleasure to give suppliers of vehicle modules and systems their own, dedicated category and invite them to join the award and attract the recognition they deserve."

Applications for the 2016 Altair Enlighten Award must be received on or before May 20, 2016. Manufacturers and suppliers can access additional information about the nomination process at http://www.altair.com/enlightenaward/.

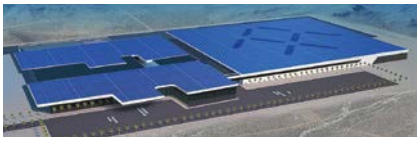


Ford won the 2015 Altair Enlighten Award for knocking 700 lb (318 kg) off its F-150 pickup (shown). In 2016 the award will recognize two winners, one for Full Vehicles and the other for Modules.

Most-viewed articles

The following are the top 5 most-viewed automotive-related articles of the month as of early January. Additional articles across all transportation sectors can be read at http://articles.sae.org/.

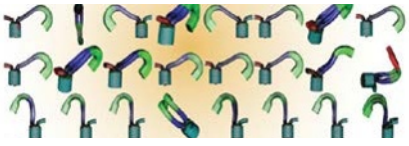
1 **China's new "automotive dragons" Faraday and Baidu target EV, autonomous leadership**
http://articles.sae.org/14508/



2 **Castrol's removable oil cell heralds 90-s oil changes, reduced friction and CO_2** http://articles.sae.org/14426/

3 **Citroën plans to go boldly on new suspension system**
http://articles.sae.org/14498/

4 **GM Powertrain gets more proactive with CAE**
http://articles.sae.org/14447/



5 **Surface Generation speeds composites throughput with one-shot stamp-forming process** http://articles.sae.org/14493/ or see page 12

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EDITORIAL

Careful about where you say 'vaporware' these days

At January's North American International Auto Show (NAIAS), Detroit's winter weather played its typical role, but decidedly not to script was the buzz that refused to go away: that despite several magnificent concept cars and formidable production vehicles on display in Detroit, many automakers and technology suppliers actually had revealed their vision of the "real" automotive future a week earlier at the Consumer Electronics Show (CES).

In effect, many insisted that not only has CES amplified its profile to the point that it rivals any of the auto industry's international shows, but that CES has quickly eclipsed "traditional" auto shows as the place to get the first glimpse of bleeding-edge automotive technology.

For now, though, I still get the whiff of slightly more flash than substance with CES, particularly in terms of how the auto industry cadences new technology. For example, **Faraday Future**, the mysterious and much-discussed electric-vehicle startup that's either vaporware or the next-and-even-better **Tesla**, rests its production-vehicle future on a "skateboard" modular vehicle architecture that looks an awful lot like a reboot of **General Motors**' same vision for a scalable EV platform that dates to 2001.

I purposefully used the term "bleeding-edge" above because by definition it implies risk that the auto sector, for a variety of reasons, can't afford to assume. That's one reason why GM's skateboard idea didn't get too far—it was a stretch well beyond what early 2000s technology could support. Risk considerations seem to trouble the consumer-electronics sector much less—understandable given the industry's relatively minor interplay with regulators and the comparatively low cost of most consumer-electronic devices and technologies. Then there's the demonstrated willingness of consumers to endure all manner of "beta" glitches from their bleeding-edge devices.

Nonetheless, the automotive component of CES has accelerated beyond any rational projection. The "why" is simple: the breakneck development of autonomous-driving technology. Without the society-imploding implications of autonomous vehicles (AVs), automakers and suppliers probably wouldn't have much of notice at CES beyond oversized dashboard screens with still-frizzy versions of **Android** Auto and **Apple** CarPlay. Instead, this year's CES championed concept-car reveals of serious import, such as **Volkswagen**'s BUDD-e and—make your own believability determination—Faraday Future's FFZERO1 concept. There was a raft of production or near-production innovations from major suppliers such as **Bosch**, **ZF**, **Harman**, and **Continental**, all of which went arm-in-arm with an array of electronic enablers from developers such as **QNX Software**, **Broadcom**, and **Nvidia**.

Look, GM used CES—not the Detroit show—to stage the first (albeit brief) public drives of the **Chevrolet** Bolt electric vehicle, surely one of the company's most pivotal models of the last 50 years. That says all you need to know about how the automotive sector has acknowledged the impact of CES. And it demonstrates the links between the automotive and consumer-electronics industries are rapidly tightening. Development of autonomous technology has stampeded from being a closely-watched concept when pushbutton start was the hot ticket just a few years ago to virtually the only automotive technology anybody means right now when they say, "automotive technology."

Outside the realm of public relations and promoters, few probably care whether auto shows or CES ends up the more prominent. But the auto-show-versus-CES dialogue is something of a microcosm for the inexorable but still slightly uneven technical meshing of the two worlds. For now, I believe the auto industry's ushering to the future, itself not always immune to hype, remains at least a little more grounded. Let's revisit this, though, when Apple unveils its first concept car.

Bill Visnic

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ELECTRONICS

CES rollouts extend connectivity, app integration

Harman's connectivity offerings give drivers plenty to do when they're not driving.

The tightening links between autos and consumer electronics were in evidence at the 2016 Consumer Electronics Show in Las Vegas as several automakers and suppliers unveiled infotainment technologies. Connectivity and simplified app integration technologies were among the many transportation offerings at the monstrous show.

Vendors throughout the industry unveiled connectivity products. An amplifier was among **Harman**'s connectivity offerings. It uses a customized microcontroller to provide connectivity, noise cancellation, equalization, and surround sound. That trims size and complexity significantly.

"The Summit Connected Amplifier is the first system based on our system-on-chip technology," said John Fitzgerald, Senior Vice President of Harman's Branded Audio Division. "Its functionality would traditionally require four to five digital signal processors and a microprocessor."

Toyota unveiled a connected vehicle framework based on a Data Communication Module that will become a globally uniform technology by 2019. This standardized architecture will replace a handful of technologies now used in various regions.

In one of many phone-related moves, Toyota also teamed with **Ford** in hopes of making Ford's open source SmartDeviceLink (SDL) a standard technology for apps. SDL makes it easier to create smartphone apps that match each company's in-car system characteristics and interface, much like Apple CarPlay and Android Auto.

Suppliers **QNX Software** and **UIEvolution** also announced SDL support. While multiple players adopted Ford's open-source technology, Ford expanded its app connectivity options by opting to deploy **Apple** CarPlay and **Android** Auto on its 2017 vehicles.

Broadcom supported another app-related technology, announcing a near field communication (NFC) controller. NFC is the smart-phone technology that lets users swipe phones to make payments and perform other actions. In vehicles, it could simplify Bluetooth pairing and let drivers transmit information from phones to the vehicle's navigation system.

"When you're driving and want to launch an address, you want to be able to just wave the phone past the nav system, not keep positioning it so the coils are aligned," said Richard Barrett, Director of Automotive Connectivity at Broadcom. "We've doubled the drive current coming into the coils, which means you don't have to be as close for the two coils to start sharing information."

NXP made a loosely related CES announcement. After unveiling an automotive-grade NFC chip in March, NXP extended its commitment with NFC technology targeted for smart-home systems.

Market researchers say NFC usage is skyrocketing. Shipments of NFC-enabled phones were projected to increase to 756 million in 2015, up more than 70% from 2014, according to **IHS** Technology.

"This is just starting to be pervasive in mobile phones," Barrett said. "The vehicle industry is beginning to roll it out. 2019 and 2020 is when it will be more prevalent in cars."

Harman also broadened its software offerings, teaming up with **Microsoft** to put the Microsoft Productivity Suite on some of Harman's infotainment systems. Drivers will be able to set up **Skype** calls, schedule meetings, and listen to e-mail or texts. Microsoft tool users will also be leveraging the cloud.

"This spans embedded through cloud-based technologies; it can go through a smart phone or use embedded connectivity," said Phil Eyler, President of Harman's Connected Car Division. "This is not exclusively embedded."

Terry Costlow

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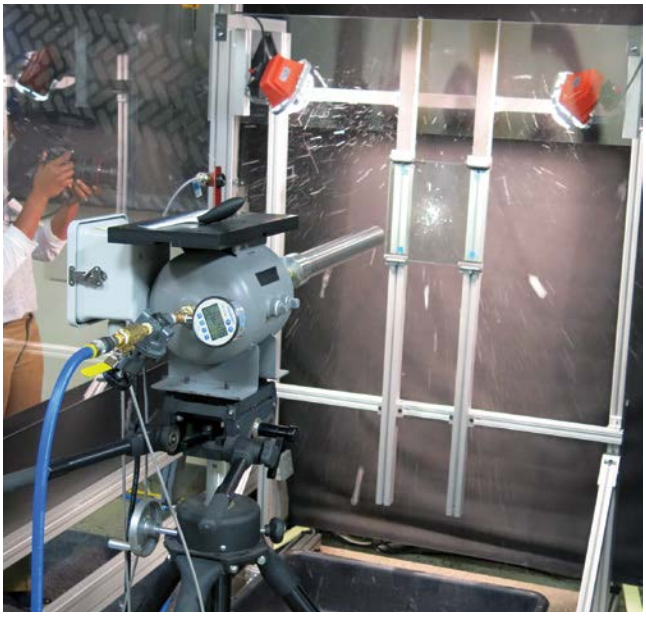
MOTION AND MOBILITY

BODY

Ford looks to spread Corning's new lightweight Gorilla Glass beyond the 2017 GT



Ballistics test demo at Ford replicates a 55-mph hailstone strike on a piece of Gorilla Glass for Automotive without damage to the glass. (All photos by Lindsay Brooke)

Paul Linden, Ford's Advanced Mechanisms Body Exterior Lead and glass technology veteran, noted that all application testing of the Gorilla Glass program for the GT was completed in four months.

While many supercar enthusiasts have "gone ape" over the **Ford** 2017 GT, the program development engineers have done the same for a new lightweight glazing solution.

Called "Gorilla Glass," the three-layer laminate is claimed by its supplier, **Corning** Inc., to deliver more than five times the strength, pound for pound, of conventional automotive glass while offering significant mass reduction. In the case of the GT, more than 12 lb (5.4 kg) was saved by using Gorilla Glass in three areas: the windshield (first use for a production vehicle), the rear window, and in an acoustic separator in the rear bulkhead. It also helped reduce the car's center of gravity by 3 mm (0.12 in).

Ford engineers are delighted with the performance of the new glass and are looking to increase its vehicle applications beyond the GT.

Introduced in 2007 as a thin, durable screen material for smartphones and tablets, Gorilla Glass is currently used on 4.5 billion mobile devices from a variety of global consumer-electronics brands. Since then Corning has been developing an automotive-grade variant that is produced using a twist on the ion-exchange process used in alumina silica glass manufacturing. **PGW** (Pittsburgh Glass Works) also played a role in the material's development.

Ford's Fusion MMLV (Multi-Material Lightweight Vehicle) concept car debuted Gorilla Glass in 2014 in its windshield and side windows, delivering a 30% reduction in glazing weight, the companies claim.

The GT windshield is a tri-layer laminate comprised of a 0.7-mm (0.028-in) -thick inner layer of Gorilla Glass for Automotive, a 2.1-mm (0.08-in) outside layer of annealed soda-lime glass, and a 0.76-mm (0.03-in) resin foil interlayer. The Corning product enables the glass layers to be up to 50% thinner than conventional vehicle glass.

Work for the supercar application began in late 2014. "It was an accelerated development program," observed Paul Linden, Ford's Advanced Mechanisms Body Exterior Lead. "We completed all our application testing in four months. The AR (application readiness) approval process typically takes us up to two years. My boss Ali Jamul put the team together and gave us the budget to build and test the vehicles. We went into this thinking it was a win-win, which it is, so we pulled out all the stops."

As the GT program itself was also on a fast track, Jamul's team completed its testing regime, including overlap, back-to-back, and rollover, on the vehicle's critical path.

The new lightweight glazing technology offers opportunities across Ford's global vehicle line, noted Hau Thai-Tang, Ford's Group Vice President, Global Purchasing. He said a typical passenger vehicle has about 50 ft^2 (4.6 m^2)—about 80 lb (36 kg)—of glass. A Ford Explorer with sunroof is laden with about 200 lb (91 kg), so a significant reduction in glazing-system mass has a "cascade" effect on surrounding body structure, such as A-pillar cross section, windshield headers, and the upper cowl.

"The big thing for us in designing bodies is looking at not only static stiffness but also dynamic stiffness," explained Thai-Tang, a veteran vehicle engineer and accomplished race-car driver. "Dynamic stiffness is the square root of k/m, so the lighter you can make the body-in-white system for the same equivalent torsional stiffness, the more you can drive up the

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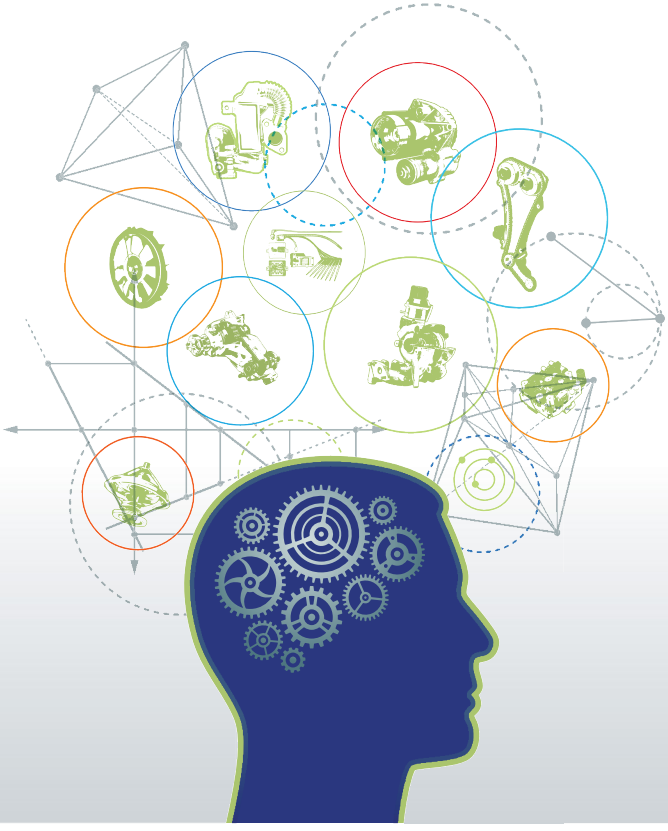

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Ford's 2017 GT is the first production car to use Corning's new glazing technology in a windshield application. Will SUVs be next?

dynamic stiffness. And that's where we're seeing the improvements with this glass technology."

He said that in the GT application, the advantage of Gorilla Glass comes from more than the stiffer material. "It's also a function of the windshield or window's shape; the GT's windshield has a lot of curvature," he told *Automotive Engineering*. "That was part of the answer to the different thicknesses of the laminate. We have some built-in tension in the glass system that adds the stiffness. But the main thing is we're driving the mass down so the dynamic stiffness, the 'k' factor, increases."

Panoramic sunroofs, which place significant glass mass far above a vehicle's center of gravity, "are a huge potential application for this technology," Thai-Tang said. "It's clearly a big area we're looking at."

Gorilla Glass for Automotive also provides optical advantages compared with conventional float glass. It has no optical draw lines, making it ideal for extremely "fast" (low angle) windshield applications as in the GT.

"A lot of times we can't execute what our designers want because of the glass distortion," noted Thai-Tang. "Distortion is also a factor when you introduce HUDs [head-up displays], LiDARs, and radars. As we bring in more autonomous driving technologies, you can imagine a day where we project images and information onto the glass. In an autonomous vehicle the elimination of optical distortion becomes an important factor."

The GT racecars being prepared by Ford and **Multimatic** will use Gorilla Glass in the 24 Hours of LeMans in June, he confirmed. While the car's headlamp lens covers will remain polycarbonate initially, Ford engineers are looking at other applications including the interior.

"Instead of just having an information screen you can have a full center console that is a Gorilla Glass surface," he asserted. "All the things being done in the consumer-electronics space for tablets and phones is applicable in vehicles. We want to pair the Corning technology with not only the exterior guys but also the interior designers. But you won't see us use Gorilla Glass on a refresh—the thinner glass will drive new door and body structures."

The new exterior-glazing system requires no change to the vehicle assembly process; the Gorilla Glass components are installed using conventional robotics and urethane-bonding system. Corning produces the glass at its Harrodsburg, KY, plant.

Lindsay Brooke

TESTING

New 40%-scale wind tunnel increases GM's aero-development capacity

Senior Aerodynamicist Nina Tortosa demonstrates GM's new reduced-scale wind tunnel using a 40%-scale Chevrolet Cruze. (All photos by Lindsay Brooke)

Reducing aerodynamic drag by 12 counts (reducing Cd by 0.0012) is equal to gaining about 1 mpg in vehicle fuel efficiency—"and our goal is to eliminate as many counts as we can," said Scott Miller, **General Motors**' Director of Global CO_2 Strategy, Energy, Mass, and Aerodynamics, at the recent opening of his company's new reduced-scale wind tunnel at the GM Technical Center in Warren, MI.

The new 32,000-ft^2 (2973-m^2) facility represents a $30 million investment for improving vehicle efficiency and reducing greenhouse gas emissions through greater aerodynamic design, testing, and validation. "Every vehicle we develop is measured in terms of dollars-per-gram of CO_2 emissions per mile," Miller noted.

Designed by **Jacobs Engineering**, the new wind tunnel uses a belt-type moving ground plane to simulate full driving conditions on 40%-scale clay models up to an indicated 155 mph (250 km/h). The aim is to accurately capture aerodynamic forces and moments including drag and side-force data, individual tire contact-patch downforce data, and the influence of rotating wheels.

Moving ground plane simulations better optimize the vehicle underbody and wheel design, the GM engineers said.

Using reduced scale models enables faster, less expensive surface changes per shift, with higher fidelity results and greater repeatability, said Miller. "One pound of clay on a 40% model is equal to 16 pounds of clay on a full-scale model," he noted.

The model is placed on a turntable setup with capability for 30° maximum yaw in both directions. There is also a boundary-layer suction function and capability for ride height adjustment. Wind speeds generated by the fan powered by a 1100-hp (820-kW) AC electric motor can accelerate the model to a simulated 250 km/h within 30 s, noted GM Senior Aerodynamicist Nina Tortosa. The fan is fitted with wood-carbon fiber composite blades.

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One of GM's new 40%-scale model vehicles, a Chevrolet Silverado, at the new wind tunnel facility in Warren.

Ghafari, a global architectural and engineering firm, designed the wind-tunnel building. As the new facility goes on line, GM will take its full-scale tunnel off line for extensive upgrades in early 2016. They include addition of a moving ground plane and full acoustics capabilities. Completed in 1980, the "big" tunnel was the first full-scale aerodynamic wind tunnel in the U.S. designed specifically for testing full-size automotive vehicles. Jacobs Engineering is performing the upgrade work. While the tunnel is out of commission, GM will use the **Lockheed Martin** tunnel in Georgia for its full-scale aero work.

During a media tour of the new reduced-scale tunnel facility, GM aerodynamics engineers showed the first example of its new 40%-scale model vehicles—a **Chevrolet** Silverado pickup that

GM's CO_2 Strategy boss Scott Miller talks about his company's growing aerodynamics development resources and their impact on vehicle efficiency.

Accurate detail abounds in the CNC machined suspension and brake systems on the 40%-scale Silverado.

Highly detailed scale model underbody (view from rear of Silverado with spare tire in foreground) created using GM's 3D printing capabilities.

was impressively detailed. The models, which cost approximately $450 each to build in house, are constructed using GM's stereolithography/additive manufacturing machines along with CNC machining. The model truck features highly accurate underbody detail, working suspension systems, and spinning wheels, causing equally high fascination and covetous stares among the assembled reporters.

Lindsay Brooke

DESIGN FOR MANUFACTURING

Surface Generation speeds composites throughput with one-shot stamp-forming process

Surface Generation is working with research group **WMG**, an academic department of the **University of Warwick**, and **AGC AeroComposites** to develop new composite press-forming processes for automotive and aerospace manufacturers.

Surface Generation, a U.K.-based provider of advanced carbon-fiber processing technologies, is developing new press-forming mold faces that incorporate its patented PtFS (Production to Functional Specifications) technology for the production of high-performance thermoplastic composite components. By integrating Surface Generation's active thermal management technologies into the mold face itself, WMG and AGC are able to continuously adapt heating and cooling levels for each mold area and process stage in real time. The companies believe that this enhanced capability will improve both the quality and throughput of compression molding applications.

"PtFS provides automotive and aerospace manufacturers with a new level of sophistication in compression molding," said Ben Halford, Chief Executive at Surface Generation. "The ability to dynamically control the heat applied to each mold area throughout the cure cycle means manufacturers can quickly and cost-effectively upgrade existing production lines for thermoplastic composites and significantly reduce their cost of production. As part of an integrated production line PtFS makes it possible for manufacturers to achieve one-minute Takt times for thermoplastic components."

"PtFS is a rapid heat/cool process which uses multiple independently heated and cooled cells to locally control mold tool temperature through the applications of forced air heating and cooling to the back of mold faces using multiple circuits arranged in arrays," Halford explained to *Automotive Engineering*. "It is unique in that it is a complete blend of

Surface Generation is developing new press-forming mold faces incorporating its patented PtFS technology for the production of high-performance thermoplastic composite components.

"Recent developments make it possible to achieve significant production and efficiency improvements using PtFS with die casting, hot sheet metal forming, and even glass processing at 850°C," said Surface Generation's Ben Halford. "We have a third wave of research projects under way with applications running 1000°C to allow us to superplastic form titanium."

hardware and software which acts together to manage thermal control of the mold. By creating a physical representation of the digital control environment in the mold face, PtFS is able to manipulate everything in software."

This approach allows the optimized delivery of energy in targeted areas, resulting in increased precision, reduced cycle time, and lower energy consumption. "The mold face can match melt temperatures even for PEEK and glass at 850°C, allowing users to process any material with one thermal control solution," Halford noted.

"PtFS currently offers precise surface control to within 0.5°C of a desired target at temperatures of up to 850°C. This is three times more precise than Induction processes and twice as accurate as Rapid Heat Cycle Molding," according to Halford. "During a recent compression molding PEEK trial, PtFS cut cycle times by 95%, the amount of energy used by 90%, and required press pressure by 75%. The reduction in pressure makes it possible to use smaller machinery and up to 85% less floor space in the factory."

The work is in support of the Composites Innovation Cluster's Thermocomp project, which aims to develop short cycle time, high-volume manufacturing processes that can be used to produce carbon-fiber-reinforced thermoplastic components in the transportation industries.

Surface Generation has been developing PtFS since 2008 and continues to iterate the process to work with different materials, Halford shared. "Recent developments make it possible to achieve significant production and efficiency improvements using PtFS with die casting, hot sheet metal forming, and even glass processing at 850°C. We have a third wave of research projects under way with applications running 1000°C to allow us to superplastic form titanium."

"A major barrier to mainstream adoption of novel, aligned fiber-reinforced thermoplastics within the automotive sector is the difficulty of economically achieving short cycle times within a high-volume production environment," Geraint Williams, Project Manager at WMG, said in a statement. "Surface Generation's PtFS technology has the potential to meet this challenge by eliminating process stages and enabling manufacturers to rapidly form composite components using a one-shot stamp-forming process."

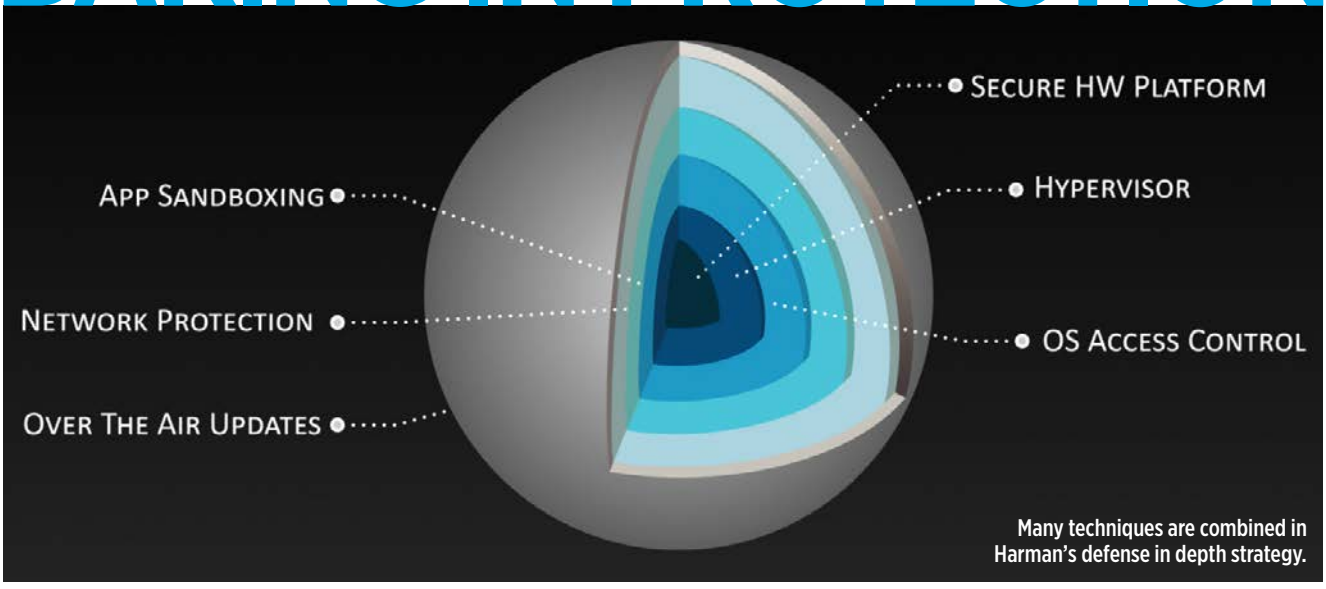
Side impact test article produced as part of the Thermocomp project.

Commenting on the aerospace industry, Dave Conway, Materials Technology Director at AGC AeroComposites, said: "Aerospace manufacturers recognize that every gram counts when it comes to building lighter, more fuel-efficient aircraft, but traditional press forming processes are not economically viable for producing even medium-volume complex shaped parts. By incorporating its...PtFS process into conventional press forming processes, Surface Generation has opened the door to a... new era in aerospace manufacturing."

PtFS is already used for production in aerospace and consumer electronics. "Our PtFS Multiplexing system, which uses a unique transfer process with a pressure containment cassette that allows mold faces and laminates to be held at pre-defined loads inside and outside of the press, is expected to be deployed in mid-2016 for consumer electronics and mid-2017 for automotive," Halford said.

Ryan Gehm

BAKING IN PROTECTION



Many techniques are combined in Harman's defense in depth strategy.

With vehicles joining the Internet of Things, connectivity is making cybersecurity a must-have obligation for automotive engineers, from initial designs through end-of-life.

by Terry Costlow

Consumer demands for connectivity open the vehicle up to the dark side of the Internet, making cybersecurity an important design requirement for vehicle providers. Automakers have several unique challenges as they attempt to provide connectivity in vehicles that have burgeoning amounts of software that must remain secure and efficient over long vehicle lifetimes.

Throughout the industry, there's a race to leverage safeguards used in other industries in ways that meet automotive safety and reliability requirements. A number of tools will be employed, many using over-the-air (OTA) updating to fix vulnerabilities and adapt to changing threats.

Pathways for hackers come when vehicles join the Internet of Things, and security defects in software provide vulnerabilities that hackers can exploit. That's a challenge being addressed by suppliers of semiconductors through systems.

"One challenge is the sheer amount of software on a chip," said Amrit Vivekanand, Segment Marketing Manager at **Renesas Electronics America**. "The more software you have, the more potential there is that weaknesses can be exploited."

Software defects are being reduced, but debuggers can't catch them all. Cars run far more software than most embedded systems, so even rare security faults add up to significant vulnerabilities.

"In high-quality software, there's roughly one defect for every 10,000 lines of code," said IP Park, **Harman**'s CTO. "If you've got 100 million lines of code in a car, you've already got 10,000 defects in your system. It's almost impossible to get rid of all of them."

Throughout the industry, there's an emergent effort to protect vehicle electronics. Last fall, **Intel** set up the Automotive Security Review Board, which it says will encompass top security industry talent across the globe. Researchers will perform ongoing security tests and audits intended to codify best practices and design recommendations for advanced cybersecurity solutions. Intel designed a test platform and created a security white paper.

"We will provide a platform to be hacked, or more politely said, tested," said Intel Automotive Solutions Division General Manager Elliot Garbus. "As we find vulnerabilities, the white paper will be updated."

E pluribus unum

Automakers will be able to leverage expertise from many entities to create their proprietary protective schemes. Military and telecommunications companies have focused on cybersecurity for years, creating standards and techniques that can easily be adapted to automotive systems. In vehicles, one of the key issues is to securely detach connected infotainment systems from the other electronic modules.

Operating system providers like **QNX Software** and **Green Hills Software** use partitioning to ensure that a problem with an app on the infotainment system won't impact any other functions. Other vendors such as **Wind River Systems** uses hypervisors to prevent any unwanted interactions or cycle stealing between modules.

"A hypervisor splits functions into separate operating systems," said Oren Betzaleli, Automotive Business Manager at **Redbend**. "It isolates down to the hardware

BAKING IN PROTECTION

level; nothing is shared."

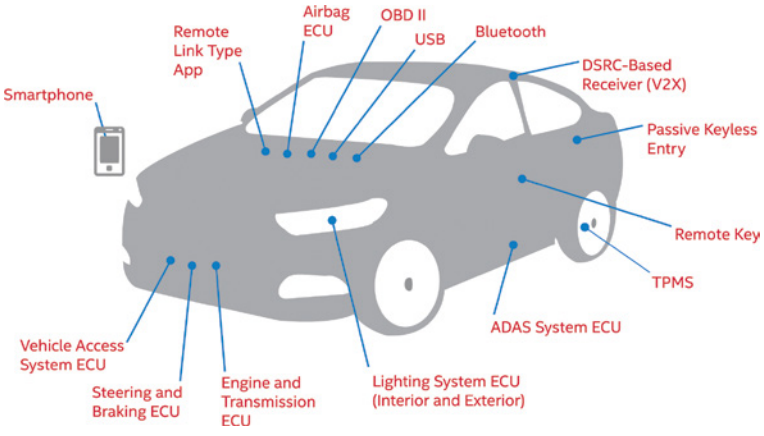
Gateways can also block messages from moving deeper into vehicle systems. Regardless of safeguards being used, security software must be continuously updated to close newly discovered vulnerabilities and adapt to ever-changing threats.

"Putting in a gateway largely isolates the rest of the car, but the problem is that you need to pass messages between modules," Vivekanand said. "OTA updating is a big factor."

Keep it fresh

OTA will let OEMs upgrade software without requiring owners to take vehicles into shops. That's not popular with dealerships, but many observers say that eventually, automotive firmware will be updated much like on mobile phones.

IHS Automotive says that the OTA-capable vehicle fleet will grow from barely more than 200,000 units in 2015 to more than 96 million by 2022. While security is a critical driving force, cost reductions are also fueling adoption. IHS estimates that global OEM cost savings from OTA updates will grow to more than $35 billion in 2022.



Intel's Automotive Security Review Board aims to help foster best practices for security.

While many proponents say that OTA is a necessity in the battle against malware, automakers haven't exactly been racing to roll it out. There are myriad challenges for technologists, and the potential that a single bit error could cause major liability issues brings

Protection comes from many sources

As automakers gear up for the cybersecurity challenge of connectivity, they can leverage a wealth of experience from many other fields. Myriad industry groups have created standards and best practices that form the foundation for safe and secure communications.

"Carmakers and their suppliers are already using modern security practices from the mobile and information technology world," said Walter Sullivan, Head of **Elektrobit**'s Silicon Valley Innovation Lab. "Threat modeling and analysis, encryption with the latest algorithms, digital certificates, secure communication protocols like Secure Sockets Layer, and other approaches are all standard practice today. There is a lot of work going on around firewalling vehicle networks, hypervisors for application and CPU isolation, and much more."

The industry is also utilizing aspects of broader documents like **ISO/IEC** 15408 Common Criteria, ISO/IEC 27001 and 27002, and **National Institute of Standards and Technology** SP 800-90 specification. There seems to be little reason for automakers to create their own standards.

"We probably won't see automotive industry standards," said IP Park, **Harman**'s CTO. "Security standards are well established; we don't need to create something from scratch. Connected cars will not be standalone devices, they'll be part of the Internet of Things."

Leveraging proven techniques helps automotive companies develop strategies that work for them. Staying up to date and compatible over a vehicle's lifetime is a central factor.

Proven techniques from other fields including Secure Sockets Layer are being used to protect vehicles against malicious attacks. (Elektrobit)

"To make the car 'updateable,' the architecture needs to be thought out strategically," said Oren Betzaleli, Automotive Business Manager at **Redbend**. "OEMs can't have three or four updating techniques updating three or four systems in cars. They also need one catalog of software; they can't have version 5 of the infotainment software running with version 6 of the ADAS software, especially if they come from different suppliers."

Dealing with equipment from multiple suppliers is an important factor for automakers. Cybersecurity strategies rely heavily on defense in depth, ranging from encryption in microcontrollers to schemes used in modules and networks. All these elements must work together, without negatively impacting each other. That requires a common approach implemented by all suppliers.

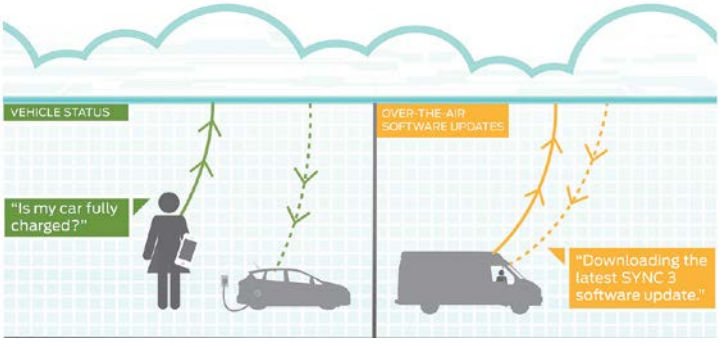
"It's important for OEMs to coordinate with suppliers to make sure the entire system is aligned in regards to security," Park said. "OEMs may pick one Tier 1 as the owner of the security space. We're starting to see this happening, where that Tier 1 work with some sort of in-house coordinator."

Over-the-air (OTA) updates are a central challenge for automakers, who face more challenges than phones, PCs, and other gear that's routinely updated. For example, software can't be updated while vehicles are being driven, but updates sent to idle vehicles can't drain the battery. Some observers feel that automakers may coalesce around a single strategy for updating firmware.

"Eventually, the industry may standardize on an OTA technology," Park said. "The mobile industry does this through the **Open Mobile Alliance**."

Terry Costlow

Most OEMs are moving towards over-the-air updates that use the infotainment systems' connectivity, according to Red Bend.



Ford and Microsoft teamed to develop over-the-air updating for Sync 3.

corporate attorneys into the discussion.

"There's been a reluctance to move towards OTA updating, which is needed to address evolving security threats," Garbus said. "**Tesla** has embraced it, but that's certainly not the case at most automotive OEMs."

However, there are signs of change. For example, **Ford** teamed with **Microsoft** in March 2015, to create the Ford Service Delivery Network, which will deliver over-the-air software updates for Sync 3. OTA specialists say that interest is definitely rising.

"It's only been the last few years that OEMs have understood the benefits of OTA," Betzaleli said. "Three years ago, they showed minimal interest. But we're involved with nearly everyone now."

April cybersecurity webinar

Connectivity is making cybersecurity a must-have obligation from initial designs through end of life. Automakers and suppliers have several unique challenges as they attempt to provide connectivity in vehicles that have burgeoning amounts of software that must remain secure and efficient over long vehicle lifetimes. Throughout the industry, there's a race to leverage safeguards used in other industries in ways that meet automotive safety and reliability requirements. A number of tools will be employed, many using over-the-air (OTA) updating to fix vulnerabilities and adapt to changing threats. The *Automotive Engineering* editors will continue the conversation in April. See http://www.sae.org/magazines/webcasts/ for more info.

Microcontrollers from Renesas and others now include many peripherals that help system designers protect and update growing volumes of software.

Trusted OTA updates

Security systems rely on defense in depth, using layered safeguards to ensure that malware can be blocked or detected if it gets through one defensive element. In the vehicle, the hardware side of security begins with microcontrollers.

Chipmakers provide encryption modules that help prevent outsiders from sending communications over vehicle networks. These chips also have secure sections where they store the keys that help certify authenticated communications. That's important when programs are being updated so malware does not alter any programs.

"Hardware provides the root of trust," Park said. "Without it, OTA can't be trusted."

Making sure that updates are authentic is critical for any OTA technique. Hackers intent on harming a driver or extorting funds from an automaker may try to intercept signals at any phase of their lifetime. Constant checking will be mandatory.

"Every sub-package will be verified when it's received by the ECU, which will also ensure that what was sent was the same as what was received," Betzaleli said. "That ensures that nothing has been altered or hacked."

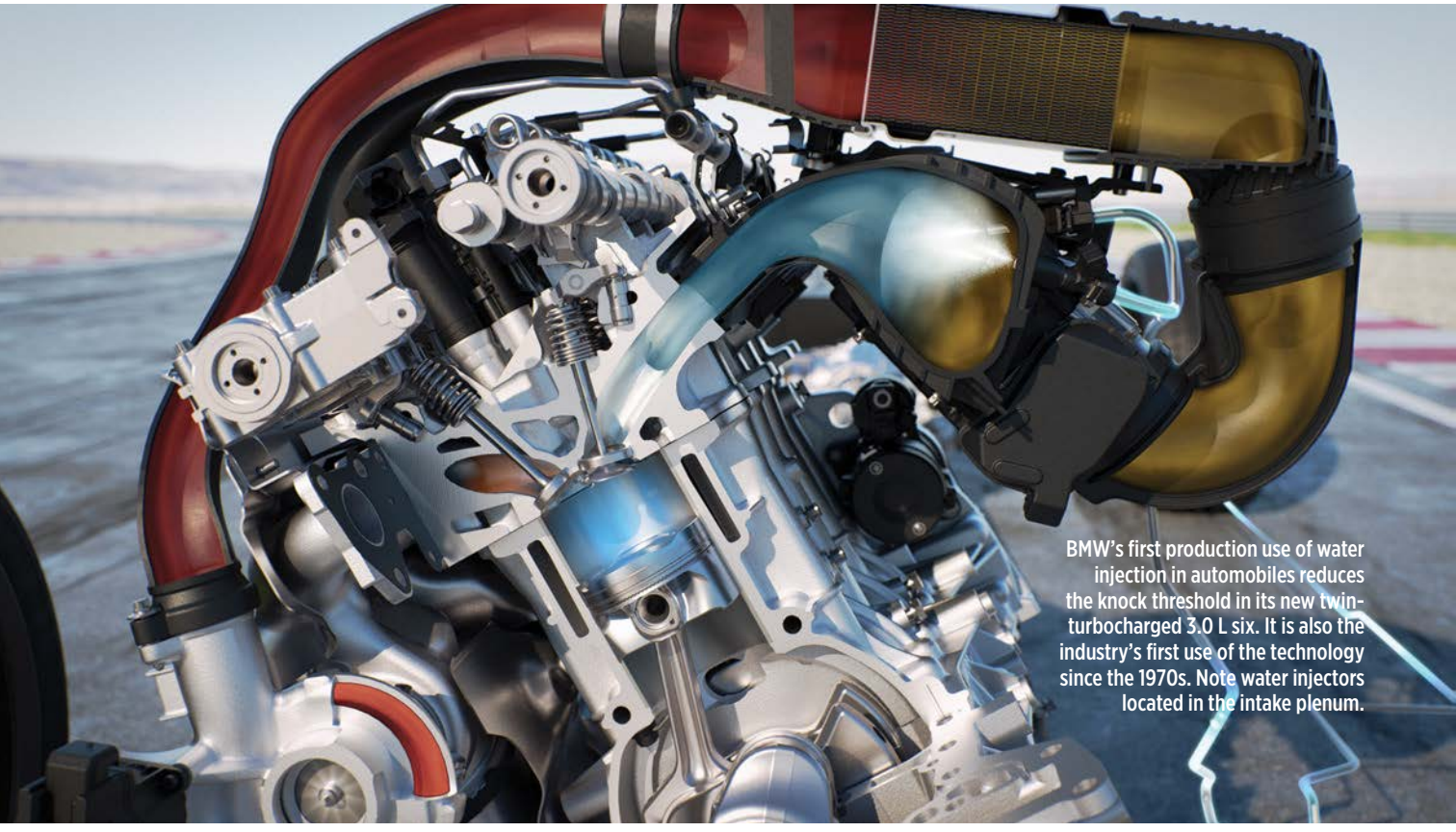
Security is only one facet of this. OTA upgrades must do no harm. Downloads will typically occur when the vehicle is turned off, making battery power something of a concern. Additionally, cell phone users might accept a restart or some other step, but car owners probably won't be as forgiving.

"In general, beyond security, the challenges all relate to ensuring that the update arrives into the vehicle complete, that the vehicle is in a safe state for an update to be applied when it arrives, and that the vehicle is left in an operational state when the update is finished," said Walter Sullivan, Head of **Elektrobit**'s Silicon Valley Innovation Lab. ■

NEW ENGINES 2016

Highlighting the design, engineering, and technologies inside some of the most competitive new gasoline and light-duty diesel ICEs.

by Lindsay Brooke, Stuart Birch, Kami Buchholz, and Paul Weissler



BMW's first production use of water injection in automobiles reduces the knock threshold in its new twin-turbocharged 3.0 L six. It is also the industry's first use of the technology since the 1970s. Note water injectors located in the intake plenum.

Engine history bonus question for 100 points: What technology has been shared by the P-47 Thunderbolt fighter plane, **Oldsmobile**'s 1962 Jetfire V8, the **Saab** 99 Turbo, and the 2016 **BMW** M4 GTS?

Answer: Water injection, a proven technique for raising the knock threshold, enabling a higher compression ratio for more power output over a wide operating range. Water injection is particularly effective in highly boosted engines, hence BMW's adoption of it in a limited-production run of M TwinPower 3.0-L Turbo inline six units powering the track-day-focused M4 GTS.

BMW's engineering logic says that in turbocharged engines, the intake air is heated in the turbo compressor to as much as 160°C (320°F). But the effectiveness of intercoolers in reducing the pressurized intake-air temperature is limited by system size, configuration, and vehicle aerodynamics. So simply increasing boost pressure to raise engine power is not viable, as it would exceed the knock threshold.

Enter water injection where, in the case of the M4 GTS application, a fine mist of H2O is injected at 145 psi (10 bar) by three dedicated injectors into the intake plenum. This reduces the intake air temperature by an additional 27°C (80°F) beyond the intercoolers' capability, allowing spark timing to be advanced and more efficient, lower-temperature combustion to be realized. The engine is calibrated for minimum 95 RON gasoline.

Water injection adds complexity and cost, as BMW realizes. In the M4, the water injection module consisting of a 1.3 gal plastic water tank, a pump, sensors and valves resides in a compartment under the trunk. Water supply lines connect to the engine's intake plenum. The quantity of water injected varies depending on load, rpm, and temperature; track-day flogging may require the water tank be topped off at each refueling, while normal street driving extends the interval to about every fifth refueling, according to BMW engineers.

Boosted engine, high compression ratio, and water injection help make BMW's new street-legal M4 GTS a track-day star. Note complexity of the H2O injection system in the bottom image.

The BMW M water injection system, developed in collaboration with **Bosch**, uses an expanded engine ECU and a unique self-diagnosis system. If the water tank runs dry, or the system malfunctions, boost pressure and spark timing are adjusted so the engine continues to operate safely. And in everyday use, each time the engine is switched off, the water supply line automatically drains into the tank to prevent icing in freezing temperatures. (The early H2O-injected aero engines used a mixture of water and glycol for anti-icing measures.)

Besides its knock-mitigation capabilities, the BMW M4 GTS engine brims with technology for reduced mass, greater throttle response, and low friction. Its closed-deck cylinder block is engineered for increased rigidity, enabling higher cylinder pressure. The cylinder bores feature a twin-wire arc-sprayed ("plasma") coating that reduces weight versus a lined block. The twin turbochargers are single-scroll types, and the 24 valves are actuated by Valvetronic variable lift control and Double-VANOS continuously variable camshaft timing. The result is a claimed 493 hp (368 kW) at 6250 rpm, and 442 lb·ft (599 N·m) at 4000-5500 rpm.

Porsche's 3.0-L turbo Boxer rebellion

Porsche joins the downsized-and-boosted trend in 2016, with an all-new turbocharged 3.0-L horizontally-opposed "boxer" six replacing naturally-aspirated 3.4-L and 3.8-L engines in the 911 Carrera and Carrera S. Known internally as 9A2, this is an entirely new architecture targeting increased efficiency and lower CO_2 emissions with added power.

The 3.0-L as fitted to the Carrera gets an extra 20 hp (15 kW), with peak output now at 365 hp (272 kW). The Carrera S engine also gains 20 hp, for 414 hp (309 kW) total. Peak torque also is increased by 44 lb·ft (60 N·m), to 331 and 368 lb·ft (450 and 500 N·m) on the respective models, available from 1700 to 5000 rpm.

The new boxer uses one **BorgWarner** turbocharger per cylinder bank. The hotter S version of the 3.0 L features modified turbine compressors, a specific exhaust system and tuned engine management. The mono-scroll, fixed-vane turbos use a vacuum-operated wastegate system to manage boost pressure, set at 13 psi (0.9 bar) in the Carrera and 16 psi (1.1 bar) in the Carrera S. Compression ratio on both variants was reduced 12.5:1 to 10.0:1, and both are rev-limited to 7500 rpm.

The Carrera and S will not carry "Turbo" badges; that will remain the province of the super-high-performance 911 GT, according to the company. Besides improved acceleration and top speed, the turbo engine enables the Carrera models to achieve lower fuel consumption and emissions: the S with PDK transmission has a combined figure of 7.7 L/100 km, an improvement of 1.0 L/100 km. Claimed CO_2 emissions are 169 g/km for the regular Carrera, 174 g/km for the S.

The move to turbocharging required a new engine airflow system for combustion and intercooling in this industry-unique rear engine application, with combustion air entering the car body in the center

Output-side view of Porsche's all-new 9A2 twin-turbo boxer six. The company's upcoming new turbocharged boxer four-cylinder shares design elements from this unit.

of the rear spoiler and flowing through ducts to the induction manifold and twin intercoolers. The 3.0-L's Continental-supplied, centrally-located injectors are fed by two fuel pumps, one per cylinder bank, operating on a system pressure of up to 3626 psi (250 bar). Variable exhaust-camshaft timing facilitates precise control of the charge exchange process. On the intake side, Porsche's VarioCam Plus adjusts both valve lift and opening duration.

The 9A2 engine features plasma-coated cylinder bores, its iron content helping to reduce ring-to-bore friction, according to Porsche engineers. Overall mass reduction was a focus of the development program; the two turbochargers and their intercoolers and related plumbing added 77 lb (35 kg) to the 911's powertrain, requiring extensive use of FEA to then remove 33 lb (15 kg). The crankcase uses a new design with thin-wall coolant galleries and different aluminum alloy to save 3.3 lb (1.5 kg). A reinforced-plastic oil pan replaced the old aluminum pan, saving 4.4 lb (2 kg). A new-design oil pump cuts 2.6 lb (1.2 kg).

The biggest single mass reduction is in the 911's exhaust system: 15.4 lb (7 kg). Reduced parasitics are addressed by the clutched water pump, which allows complete decoupling from the engine; this also helps the engine reach operating temperature faster. The A/C is also clutched.

The new boxers' power flows through a new dual-mass flywheel and twin-disc clutch.

Hyundai-Kia's new Kappa turbo triple

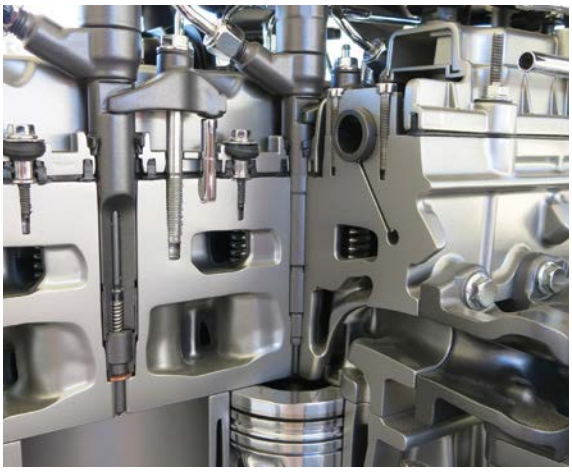
Powertrain engineers at **Hyundai**'s Namyang R&D complex developed the new 1.0-L T-GDi "Kappa" 3-cylinder engine to cover a broad range of products under both the Hyundai and **Kia** brands, in multiple global markets. The new triple debuted in late 2015 in the Europe-only Cee'd GT range, and is expected to power North American models (including Accent, Rio, Forte, Elantra, Soul and Veloster) over those vehicles' next product cycles, according to industry suppliers apprised of Hyundai-Kia's future product schedule.

Hyundai's new 3-cylinder "Kappa" family T-GDi will power a broad range of Hyundai and Kia models. The 1.0-L triple features separate water pumps for the cylinder block and head.

Key development bogies were led by the need to deliver power and torque equivalent to the current G4FC 1.6-L GDI unit but at lower rpm and with 10 to 15% lower fuel consumption. Initially there will be two European market output ratings: 99 hp (74 kW) and 118 hp (88 kW). Both versions deliver a rated peak 127 lb·ft (172 N·m) from 1500 to 4000 rpm.

High-pressure die casting (HPDC) the aluminum cylinder block provided mass savings, even though it uses iron liners; the fully dressed engine and manual transmission weigh 182 lb (82.4 kg), Kia claims. The block's ladder-frame construction adds to its structural stiffness. Additional weight savings comes from integrating the timing drive cover with the engine support bracket, and reducing the piston compression height. For reduced-friction operation with improved durability, the new triple's piston skirts are embedded with molybdenum disulfide, and piston oil rings are chromium nitrided, applied using physical vapor deposition (PVD) developed for Hyundai's Tau series engines.

The Kappa cylinder head breathes via straight intake ports, rather than the slightly curved port in the incumbent G4FC engine. Engineers explain that the straight port terminates in a shrouded intake valve configuration for improved tumble for more rapid combustion, improved knock suppression and greater



Cutaway of the aluminum DOHC cylinder head of GM's new 2.8-L Duramax diesel shows injector details, clamping arrangement. (Lindsay Brooke)

low-end torque. The engine is also fitted with an integrated exhaust manifold for faster catalyst light off.

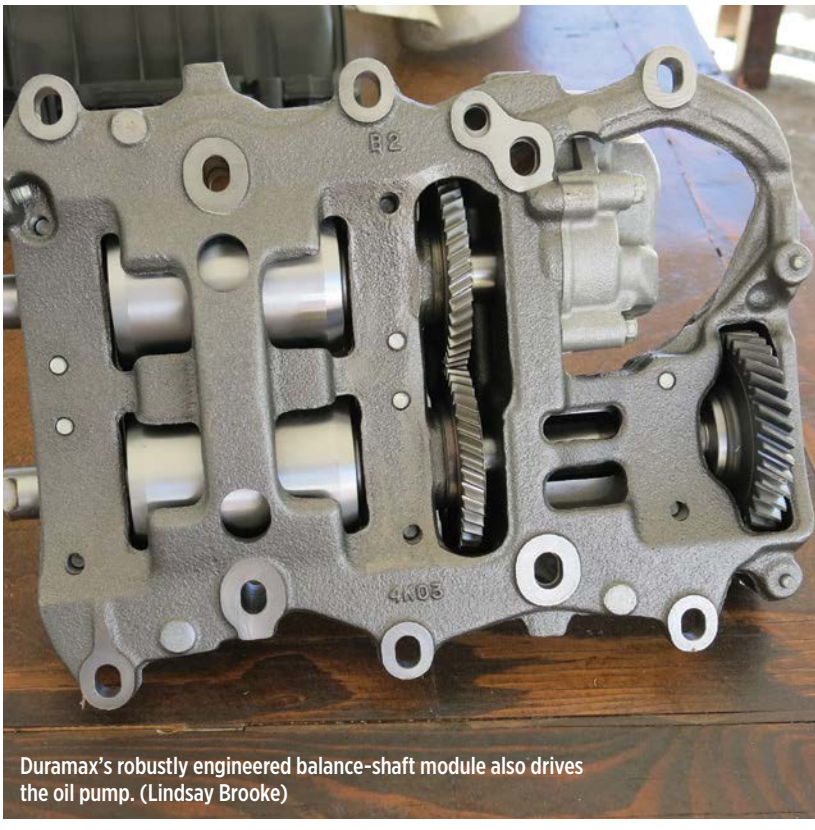
A single-scroll turbo is used in conjuction with an electrically operated wastegate. Each fuel injector features six laser-bored holes arrayed in a pyramid configuration for optimum dispersion in the combustion chamber. The injection systems operates at up to 2900 psi (200 bar).

Two thermostats allow independent cooling of the block and head. The head's thermostat opens at 190°F (88°C) to avoid detonation, while the block's opens at 221°F (105°C) to reduce mechanical friction.

GM brings 2.8-L Duramax diesel to midsized trucks

The official **EPA** fuel economy estimates—31 mpg highway, 22 city, and 25 combined—make the 2016 **Chevrolet** Colorado and **GMC** Canyon powered by **GM**'s 2.8-L Duramax 4-cylinder turbodiesel the most fuel-efficient pickups sold in North America. *Automotive Engineering* has put many road-test miles on the new midsized diesel trucks, in Michigan and California, and found it's easy to exceed 30 mpg on a highway trip sans load.

The new engine—part of the trucks' North American product plan since its inception—produces **SAE**-rated 181 hp (135 kW) and 369 lb·ft (500 N·m), giving the Colorado/Canyon towing capability of 7600 lb and 7700 lb (3447 and 3492 kg) in their respective 4WD and 2WD variants, topping a number of full-size spark-ignited competitors including the latest **Ram** 1500 V6 and naturally aspirated **Ford** F-150 3.5 L V6. The diesel is paired with GM's 6L-50 6-speed planetary automatic, with standard 3.42:1 final drive gearing that includes the G80 limited-slip/locking differential.

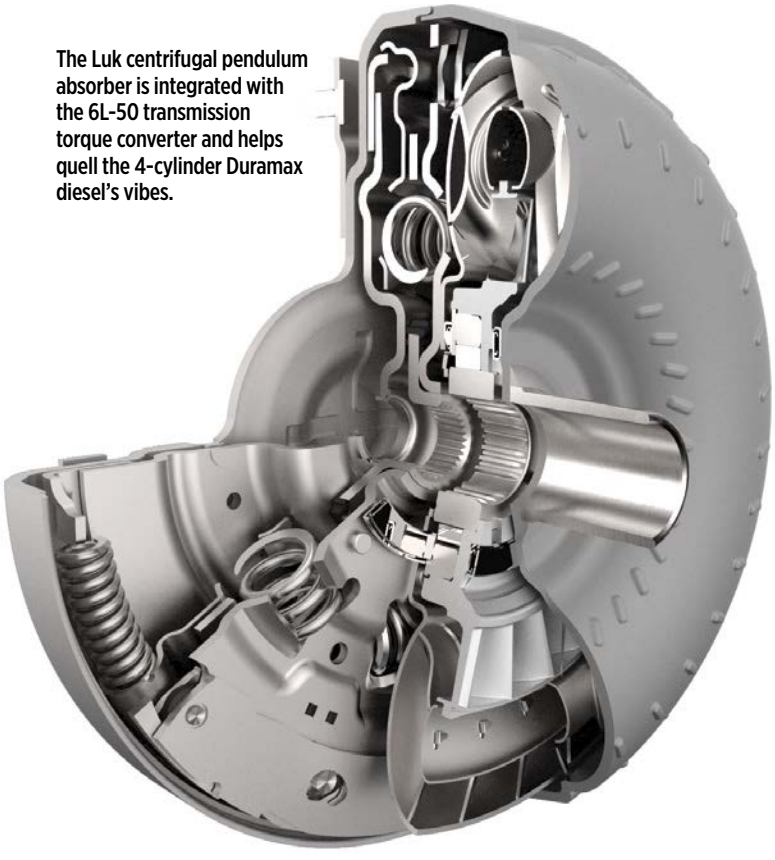


Duramax's robustly engineered balance-shaft module also drives the oil pump. (Lindsay Brooke)

A descendant of GM's previous diesel-development relationship with **Fiat**, the Thailand-built "mini Duramax" carries DNA from **VM Motori**—it's a cousin to the VM-sourced diesel briefly available in the **Jeep** Liberty, and has a 2.5-L variant for global markets. "The team spent more than three years developing the new 2.8 for use in the midsize trucks," explained Assistant Chief Engineer Scott Yackley. "There was a lot of detail work in not only making the engine emissions compliant, but also able to meet North American customer requirements for smooth and quiet operation."

The four-cylinder Duramax was launched in 2011, its architecture combining a cast-iron cylinder block and aluminum head, the latter secured with 10 head bolts. A laminated steel-and-aluminum "acoustic" oil pan is part of a comprehensive NVH attenuation package—twin balance shafts; unique fuel injection timing map in the **Continental** ECU; a centrifugal pendulum absorber (CPA); hydraulic engine mounts; and strategic insulation including three acoustic absorbers on top of the engine—for North America that is quite effective in making the diesel almost invisible to ears inside the cabin.

Yackley noted that engineers relocated the oil pump so it is now driven off of a balance shaft, measurably smoothing the pump's vibration profile. A segment-first technology he's proud of is the CPA, integrated with the torque converter and supplied by **Luk**. The CPA, a type of tuned mass absorber, contains a secondary spring mass that, when energized, cancel the diesel's amplitude of torsional vibrations. CPAs are currently used on BMW and Mercedes automotive diesels, an area in which Luk (part of **Schaeffler Group**) has deep experience.



The Luk centrifugal pendulum absorber is integrated with the 6L-50 transmission torque converter and helps quell the 4-cylinder Duramax diesel's vibes.

Nissan's all-new 3.0-L VR30DETT—the TT stands for twin turbo—is available in two performance ratings and is thus far an Infiniti-only power unit.

The **Honeywell** M12 EC-5 turbocharger is a variable-geometry machine operating at 35-40 psi boost pressures under peak loads. It features a new compressor wheel design optimized for performance and low noise, Yackley said. Exhaust exits through a long megaphone-shaped "venturi-cooled" tailpipe similar to those used on Duramax V8-equipped 2500/3500 trucks. There is no muffler on the diesel Colorado/Canyon, because the truck meets GM's pass-by noise standards. Yackley noted that sans muffler, the system produces less backpressure downstream of the DPF (diesel particulate filter).

Another segment first is the integrated, driver-selectable exhaust brake system, similar to that used on GM's HD diesel models. When the exhaust brake is engaged in Cruise mode, algorithms signal the cruise control system to maintain the desired downhill vehicle speed, keeping the driver from having to apply the brakes and exit cruise control to maintain speed. In non-cruise mode, the transmission and the exhaust brake deliver the correct amount of braking to assist in vehicle control, regardless of vehicle load.

A somewhat controversial design/engineering decision is the diesel's timing belt, rather than a chain, which Yackley claimed is suitably robust for a 150,000 mi (241,000 km) service life before replacement. The choice of a belt has GM diesel fans buzzing on various Internet blogs.

Cold-start was another focus for Yackley's team. The Duramax employs a ceramic-tip glow plug in each cylinder to pre-heat the combustion chamber, along with a larger output starter and bigger-amp-hours battery. A block heater kit is available for extreme-cold conditions.

Fully dressed, the Duramax weighs about 510 lb (231 kg), according to Yackley. With its full emissions suite including cooled EGR module, diesel oxidation cat, SCR, and particulate filter, the diesel option is 250 to 300-lb (113 to 136-kg) heavier than the GM 3.6-L all-aluminum gasoline V6 also available in the trucks, and about 430 lb (195 kg) heavier than the spark-ignited 2.5-L inline four base engine.

As an integrated package, the 2.8-L Duramax and Colorado/Canyon are impressive despite the diesel's $3700 option price. Broad torque delivery, a responsive throttle, minimal turbo lag at low rpm, and a nearly perfect match of transmission and final gearing make the trucks unique and desirable, and not just for diesel enthusiasts.

Nissan VR30DETT: new 3.0-L twin turbo

The first **Nissan** twin-turbo V6 to power an **Infiniti**-brand model debuts in the 2016 Q50 Red Sport 400, a special high-performance sedan aimed at **BMW**'s M5.

Based on Nissan's VR-series V6 launched in 3.8-L form on the 2007 GT-R, the new direct-injected engine is designated VR30DETT. It will be available with two performance ratings: 400 hp (298 kW) and 350 lb·ft (475 N·m), and 300 hp (224 kW) and 295 lb·ft (400 N·m). Both engines make peak power at 6400 rpm, with peak torque available from 1600-5200 rpm.

The aluminum 60° cylinder block features "square"

86 x 86-mm (3.39-in) bore and stroke dimensions, with thermal-arc-sprayed bores. The technology, also known as "plasma coating," is claimed to reduce ring-to-bore friction by 40% and saves 3.8 lb (1.7 kg) compared with the outgoing VQ-series V6, Kyle Vargason, Manager of Infiniti Product Planning, told *Automotive Engineering*.

The all-new aluminum cylinder heads were thoroughly redesigned for boosted DI duty. They incorporate integrated exhaust manifolds, with close-coupled catalytic converters and compact twin direct-mount IHI turbochargers with twin air-to-water intercoolers. The cast-in manifolds allow the cats to reach operating temp twice as fast as those of the old VQ engines. They also result in an 11.7-lb (5.3-kg) mass reduction versus separate manifolds.

An optical turbine speed sensor allows the twin-turbo system to perform up to 220,000 rpm at steady condition and up to 240,000 rpm at transient condition, said Vargason. He explained that the optical sensor, along with an electronically-controlled-and-actuated wastegate, provide a higher degree of boost control and improved response in transient conditions. Also helping to increase engine response time is a new electronic intake cam phaser.

To reduce weight, the lower oil pan, cam covers, and intake manifold are molded using an organic-derived reinforced plastic resin. As installed in the Q50, the new VR30DETT weighs in at 486.3 lb (220.6 kg) fully dressed. The turbocharger/intercooler system (which Nissan calls the CAC) accounts for 56.9 lb (25.8 kg). Sans CAC, the 3.0-L V6 weighs 39.1 lb (14.1 kg) less than the 3.7-L VQ-series V6 it replaces.

Moving to direct injection helps increase fuel economy by 6.7% versus the 3.7-L, Nissan engineers claimed. The VR30DETT is manufactured at the Iwaki, Japan, engine plant.

First production Turbo engine for Honda

It's remarkable that 2016 marks the first-ever appearance of a turbocharged engine in a **Honda**-badged production car. Prior to the 1.5-L DOHC I-4 in the all-new Civic, Honda offered turbo bikes with electronic port fuel injection (the CX500 and CX650 V-twins) in 1982-83, and a few years later was winning Formula 1 races (and the 1988 F-1 Constructor's title) with its dominant turbo V6.

But despite being a latecomer to the downsized/boosted trend for passenger vehicles, the new Civic engine brings proven technology and formidable performance. Equipped with direct injection and a low-inertia single-scroll Mitsubishi TD03 intercooled turbo machine with electric wastegate, the DOHC engine is SAE rated at 174 hp (130 kW) at 5500 rpm, and 162 lb·ft (220 N·m) available between 1800 and 5500 rpm. Honda is touting EPA fuel economy estimates of 31 city/42 highway/35 combined mpg.

Honda's new 1.5-L turbo I-4 employs a small-bore MHI turbo and a new cylinder-machining process.

The new Turbo engine's base architecture follows established Honda practice using a die-cast aluminum cylinder head and block, and undersquare (73.0 x 89.4 mm) bore/stroke dimensions. The block features cast-iron cylinder liner that are "plateau" honed using a two-stage machining process to help reduce piston-to-bore friction and improve long-term wear characteristics. The block houses a micropolished, forged-steel crankshaft and con rods. The rods use fracture-split "cracked" bearing caps, and drive a new-design lightweight piston that employs a moly-coated skirt and low-friction ion-plated rings.

Both piston crown and intake port geometries are designed to promote a high-tumble inlet charge that helps optimize combustion efficiency. Pumping losses are minimized, and torque is increased, by the engine's independent variable valve timing that has authority over both intake and exhaust camshafts. Note that the new Turbo engine does not employ Honda's i-VTEC system which also controls valve lift as well as timing. (The new Civic also is available with a 2.0-L naturally-aspirated, oversquare, port-injected I-4 featuring i-VTEC.)

To help manage the thermal challenges of the boosted engine (peak boost pressure: 16.5 psi/1.13 bar; 10.6:1 compression ratio), the cylinder head features "strategic" cooling with coolant jackets surrounding exhaust ports, and sodium-cooled exhaust valves. The underside of each

FCA's significantly upgraded 3.6-L Pentastar V6 now includes a liquid-cooled EGR module. (Paul Weissler)

piston crown is cooled by a pair of oil jets. The exhaust manifold is cast integrally with the head, following the industry trend toward faster catalyst light off.

To optimize space in the compact, 4-valve combustion chamber M12-type spark plugs rather than the larger M14 type are used.

A low-friction, silent-chain drives the two camshafts—both of them hollow for reduced reciprocating mass. And low-friction oil seals are used throughout.

Turbo Civic models offer a Honda-engineered CVT that was developed from the unit used in 4-cylinder Accord models, but with a final-drive ratio that is 4.7% higher, for reduced engine rpm during highway operation. Uniquely, Honda's CVT uses a twin-damper torque converter to help reduce turbocharger lag during acceleration. In a series of test drives of the 2016 Civic Turbo, *Automotive Engineering* found performance to be far superior to that of the 2.0-L model, and about on par with Honda's 2.4-L engine, with linear power delivery through the 5500-rpm torque peak.

FCA adds water-cooled EGR to Pentastar V6

FCA's "Pentastar" 3.6-L gasoline V6 receives significant upgrades for 2016 that enable the broadly-used engine to gain efficiency, while positioning it for a move to direct injection and advanced aftertreatment strategies at a future date.

The addition of new liquid-cooled EGR, a new two-step variable valve lift system on the intake side, and increased compression ratio to 11.3:1 (from 10.2), enable the V6 to deliver 6% greater fuel economy on the combined U.S. FTP along with a 5.0 hp/3.7 kW increase (to 295 hp/220 kW) and 15% more torque under 3000 rpm, according to Bob Lee, FCA North America Vice President of Engine, Powertrain and Electrified Propulsion.

The new water-cooled EGR, typically a feature of heavy diesels, reduces exhaust-gas temperature from 650°C to 130°C (1202°F to 266°F), Lee told *Automotive Engineering*. The reduced gas temperature helps enable the higher compression ratio by suppressing knock at higher loads. And the EGR in itself delivers a 0.8% improvement in fuel economy and low NOx emissions, he said. High-tumble intake ports and shrouded valves further enhance fuel, air, and exhaust mixing.

The new valvetrain (https://youtu.be/YZtqCq9TXZg) is situated in a new, lighter thin-wall cylinder head. It is activated by oil pressure under control by four solenoid valves—two for each cylinder head. Each roller cam follower incorporates a high-lift section held in place by a spring-loaded lockpin; the high-lift mode (10.3 mm/0.41 in) is the default.

On acceleration, a solenoid valve opens and oil pressure pushes the lockpin, releasing the high-lift follower section. It pivots down on a bushing, and the roller follower runs on low-valve-lift (5.75 mm/0.23 in) cam lobes, in which the engine stays through to the 2800-rpm switchover point.

The switchover reduces pumping work and contributes to improved combustion, which delivers both the modest increase in horsepower and boosts fuel economy by 2.7%, Lee explained. New eight-hole fuel injectors (vs. the previous four-hole), high-tumble intake ports and 100-mJ ignition coils combine for a claimed 1% fuel economy improvement. The 2016 engine's VVT authority has been increased to a range of 70°, vs. 50° previously. (VVT on the old **Chrysler**-designed engine was part of the control system that eliminated the need for EGR.) And the system expands the operating range of the carryover idle stop/restart system—a real-world fuel economy benefit that also gives FCA a CAFE credit.

These upgrades added 13 lb (6 kg) to the engine's overall mass, the EGR and variable lift system accounting for over 7.5 lb/3.4 kg. Along with the lighter head castings, weight reduction actions include a lighter (by almost 2 lb/0.9 kg) and stronger block; smaller oil pan; the new two-piece intake manifold, and even details like nodular cast-iron main bearing caps vs. the old powder cast iron—a 0.8-lb (0.4-kg) savings. On average the upgraded Pentastar V6 weighs 4 lb/1.8 kg less than its predecessor.

Various friction-reducing improvements, including slimmer crankshaft journals and crankpins, improve fuel economy 1%. ■

CITIZEN of the WORLD

Cuneyt L. Oge begins his term as 2016 SAE International President with a vision about auto-mobility and aero-mobility 2050.

By Patrick Ponticel

He was born in Turkey, spent time in the U.S. as a young adolescent, graduated high school in Europe, returned to the U.S. for college, learned to speak multiple languages, married a Greek, and traveled the world.

"As my name implies, I'm a bit of a curiosity," allowed incoming **SAE International** President Cuneyt Oge (pronounced June-eight Oh-gay). The veteran management consultant, who officially took over as SAE President in January, puts no negative spin on that self-appraisal. Quite the contrary, as he goes on to say: "I think I qualify as a bona fide citizen of the world."

That attribute should prove beneficial in raising SAE's global profile and making its products and services more relevant in a flattening and fast-changing world.

"I've worked all around the world," Oge said. "I learned that to be effective in this global world of ours, you have to learn how to be global personally."

That means, among other things, speaking multiple languages and learning to have empathy for the unique situations in which different countries and peoples find themselves. "And you can only learn that by being on the ground and using all your senses in different situations," he asserted. "I've had the privilege of working, literally, in most of the developed countries of the world in some capacity or the other – working with engineers, with business people and having friends and relationships around the world. To me, that's all natural. That's the way I grew up, that's the way I've made my life."

Oge retired as Partner in **PWC**'s **PRTM Management Consultants** in 2013 and spent his career serving the automotive and aerospace industries in charting new strategies and improving operations. He has held numerous consulting jobs throughout his career, which began with an engineering position at **Olin Chemicals** Corp. in 1977 and he currently serves on the Board of

Cuneyt L. Oge,
2016 SAE International President

CITIZEN of the WORLD

Ohio State's Bailo begins term as SAE Automotive VP

Carla Bailo, Assistant Vice President for Mobility Research and Business Development at **The Ohio State University**, began Jan. 22 as 2016-18 **SAE International** Vice President–Automotive.

As SAE Vice President–Automotive, Bailo will be responsible for providing leadership and continuity for SAE's automotive initiative and for integrating the needs of the automotive industry in SAE International's standards, events, and educational programs. She succeeds Jeff Hemphill, Vice President and Chief Technical Officer at the **Schaeffler Group** in North America, who served from 2013-15.

Bailo joined OSU in March 2015 to help the university accelerate sustainable mobility and transportation innovation, while integrating related research and education across the university's academic units. She also is charged with increasing and expanding Ohio State's corporate, foundation, state, and federal partnerships.

Previously, Bailo served as Senior Vice President of Research and Development for **Nissan North America** Inc., where she was responsible for vehicle engineering and development operations in Michigan, Arizona, Mexico, and Brazil, managing a $500-million budget and 2,500 employees.

A 15-year member of SAE International, Bailo led the SAE 2013 World Congress, which was hosted by Nissan; presented the Nissan Altima at the SAE 2013 World Congress; presented the Nissan Frontier, Pathfinder, and Xterra at the SAE 2005 World Congress; and has participated in several young professional panels.

"I've always found SAE to be a great organization, especially the young professional side where we're driving STEM with our children," Bailo said. "What a great a balance to be from academia and also in this role. It's a great way to get SAE into the campus life. A lot of students get memberships, but I'm not so sure what they do with them, even though there're plenty of opportunities to get involved. It's a great opportunity to be able to bridge that and also as the Automotive VP be able to work with both industry and academia, where I've been in both roles and try to make SAE more relevant to both sides of the equation."

Carla Bailo, Assistant Vice President for Mobility Research and Business Development at The Ohio State University

For a video profile of Bailo, visit http://video.sae.org/12101.

Directors of **Delta Wing Technologies** Inc. Oge has a BS in industrial management and an MS in industrial engineering and operations research—both of those degrees from the **University of Massachusetts**. He also did postgraduate work at the **Stanford Business School**.

A 21-year member of SAE, Oge has served on the SAE International Board of Directors and on the SAE Foundation Board of Trustees. He first got involved in SAE by helping to develop conferences and along the way met SAE leaders who would become his mentors, among them past SAE Presidents John Leinonen (1995), Don Ableson (1999), and Dan Hancock (2014). "Being asked to serve as SAE President is truly an honor, and I'm delighted to be here."

During an orientation day for new 2016 SAE Officers at the Society's Pittsburgh headquarters on Dec. 9, Oge provided an overview of his goals as the new SAE President. Some highlights of his remarks:

"Each President tries to put things in motion in hopes that they will outlast them and actually take root. My focus is going to be in three areas.

"Number one is what I call the changing worlds of aero-mobility and auto-mobility—think of it as auto-mobility 2050 and aero-mobility 2050. The world of auto-mobility is fundamentally going through a revolution. The powertrains that power our vehicles are changing. We have over 76 alternative-powertrain models in the U.S. market today. Never been seen before.

"The second area that I think we need to focus on," he continued, "is our global network. SAE International has a global network, but that network has to continue to grow and get stronger. The Brazilian engineer sitting in Brazil should be networked and talking seamlessly with the engineer in the U.S. or the engineer in India or the engineer in China. That's how engineers like to work, how they need to work. And I'm not talking about tools for collaboration. Those already exist. I'm talking about informal networks: the knowledge networks that SAE can help feed with its extraordinary depth of knowledge in specific technical areas, its intellectual property, and its historical files and libraries that contain invaluable information.

"Third, as we continued to globalize, we have to think in terms of what I call altruistic capitalism. As we go out to the world, I think we have to never lose sight of the fact that SAE is there to provide a value, a service, to society, as well as its members. But at the same time, we should do it in a way where it can generate revenues to cover at least the expenses of the value created. Because SAE, at the end of the day, is a business. Yes, it is a nonprofit. Yes, it is a business for creating value. But it has to have a business mind-set as it approaches the world." ■

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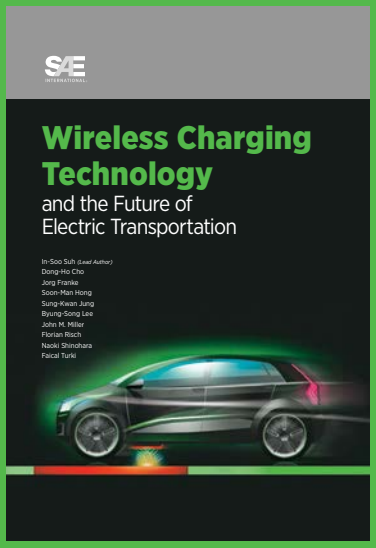

By In-Soo Suh

Globally, major automakers are developing strategies for conductive and wireless charging technologies, with concerted efforts to establish technical standards on wireless electric vehicle charging, with a focus on safety considerations and inter-operability.

This unique publication covers the current status of wireless power transfer technology and its applications to road transportation systems. It was written collaboratively by nine experts in the field, led by Dr. In-Soo Suh, a professor and researcher from the Korean Advanced Institute of Technology (KAIST).

The book covers the most important areas of interest, including:

- Working principles of wireless power transfer technology
- Current technology and its projected future impact
- Comparison between conductive and wireless charging
- Introduction to dynamic wireless charging systems
- Technological challenges and international technical standards activities
- Applications in consumer electronics, rail, aviation, marine, and off-road transportation
- Long-distance electrical energy transfer

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List Price: $89.95
Product Code: R-444
ISBN: 978-0-7680-8153-4
Published: June 2015

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2017 Cadillac XT5 debuts GM's new lightweight crossover architecture

Underpinned by GM's all-new architecture for midsized utilities, the 2017 Cadillac XT5 will compete with the Audi Q5, Lexus RX, and other premium crossovers.

XT5 stands for Crossover Touring 5, **Cadillac**'s all new mid-sized luxury utility unveiled recently at, of all places, a high-end fashion show in Dubai. Slated to replace the SRX, the 2017-model XT5 made its North American debut at the 2015 Los Angeles Auto Show. Start of production begins at GM's revamped Spring Hill, TN, plant and in China in spring 2016.

The XT nomenclature will adorn the Cadillac crossover range going forward, noted Cadillac President Johan de Nysschen during the Dubai event. The CT nameplate will cover the brand's cars.

Exemplifying GM's aggressive mass-reduction engineering strategy, the XT5 is underpinned by a clean-sheet vehicle architecture called C1XX. It's a flexible platform designed to accommodate standard short-wheelbase and long-wheelbase (3-row) products with transverse engine orientation and both FWD and AWD drivelines. Known internally as "Chi," the C1XX replaces the old Lambda and Theta architectures, according to a GM body engineering source.

The mixed-materials construction enabled the development team to reduce base curb weight by 278 lb (126 kg) versus its predecessor and undercut its closest competitor, the mass-efficient **Audi** Q5, by a claimed 100 lb (45 kg), despite the Cadillac being 7 in (178 mm) longer overall.

For a more extreme comparison, GM engineers noted that XT5 is more than 650 lb (295 kg) lighter than the **Mercedes-Benz** GLE-Class. The larger overall package enabled rear-seat legroom to be increased 3.2 in (81 mm) compared to the SRX, with full-recline and fore-aft sliding functionality.

A new all-wheel drive system is optional; GM engineers collaborated with **GKN Driveline** in development and integration of the lightweight twin-clutch system aimed at increased fuel efficiency.

XT5 drivers will likely appreciate the GM-patented Rear Camera Mirror system that launches first in the 2016 CT6 sedan. The mirror, made by **Gentex**, offers a wider field of view than traditional optical mirrors. The mirror takes an image from a high-definition rear-mounted camera and displays it within a LCD display where the rearview mirror would normally be. The mirror can also function as a conventional optical mirror in case the camera is blocked by snow, dirt, or malfunction.

Cadillac says the LCD display increases the driver's rear field of view by 300% compared with incumbent mirror technologies. Obstructions like headrests, body pillars, and rear-passenger heads that block significant portions of the view from a conventional mirror are not visible in the Rear Camera Mirror because the camera is mounted outside the car. Gentex software adjusts the lighting contrast for every pixel of the image, creating a very clear image, the companies claim.

Powertrains for North America pair GM's 3.6-L (LGX) naturally aspirated V6 that's also used in the ATS, CTS, and CT6. It features GM's cylinder deactivation (Active Fuel Management) for DOHC valvetrains, as well as the new ultracapacitor-based stop-start system. As fitted to the new crossover, the engine is expected to deliver **SAE**-certified 310 hp (231 kW) and 270 lb·ft (366 N·m); **EPA** fuel economy testing has not yet been completed. China-market XT5s will come standard with GM's 2.0-L Ecotec turbocharged inline four, also fitted with stop-start.

The new 8L45 8-speed planetary automatic is the standard transmission, fitted with Electronic Precision Shift, the first electronically-controlled transmission shifter for a Cadillac. The setup, appearing similar to those used by **BMW** and others, is claimed to reduce noise and vibration while freeing up center console space.

In addition to the new rearview display mirror, there's a hands-free liftgate actuated by gesture control; an optional head-up display; GM's 4G LTE connectivity; an integrated wireless charger for smartphones; Wi-Fi hotspot capability; and a bird's-eye-view camera system to aid parking in tight spots.

Lindsay Brooke

Porsche and Bentley plan electric future

Porsche and **Bentley**, two of the **Volkswagen** Group's star premium performance players and now positioned to share advanced technologies, are heading for pure-electric production models, each targeting 500-km (310-mi) range, huge acceleration capability, and 15-20 min 800-V battery charging times.

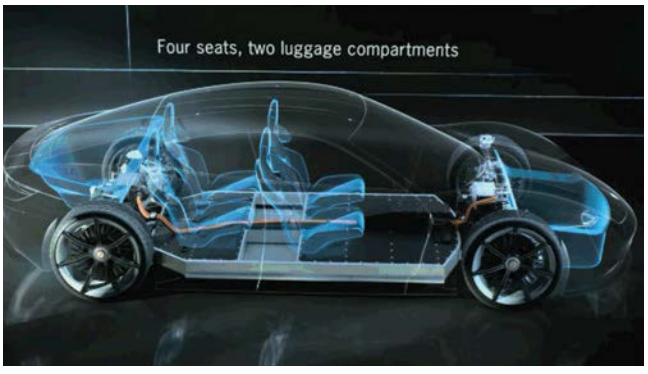
In a major statement, Porsche Chairman Dr. Oliver Blume has confirmed that its Mission E concept seen at the 2015 Frankfurt Motor Show will be in production by about 2020, and Bentley Director Kevin Rose told *Automotive Engineering* that the two-seat Bentley EXP10 Speed 6 concept, which looks set to become a production reality, may be offered with a pure-electric powertrain as an option.

Other Bentley models may also be available in pure electric form. "There are aspects of all-electric technology that are very Bentley, including quiet running, effortless acceleration, and almost instant high-torque delivery," said Rose. These assets would be delivered via all-wheel drive as they are on the Mission E.

With strong Porsche 911 styling cues, the Mission E concept is likely to be very similar to the production version.

With the possible exception of "quiet," all this is the parallel thinking at Stuttgart-Zuffenhausen, where Porsche has announced a €700 million spend on production facilities that will include manufacture of electric motors.

With VW's avid enthusiasm for technology synergies where appropriate across the Group, motor expertise and possibly some hardware could be expected to be shared between Porsche



Specter view of Porsche's production bound Mission E.

Pure-electric Porsche Mission E should be on sale by 2020.

Virtual instruments for the Porsche Mission E.

and Bentley (and battery modules between Porsche and sister company **Audi**), although no detailed decisions have yet been reached—or at least announced—and a Porsche spokesman underlined: "The electric motors we develop will be reserved for Porsche specifically."

Mission E uses two electric motors, one for each axle. But neither company is going into specific details yet.

Official production targets and likely pricing have not been released, but some 20,000 units per annum and a sticker price around that of higher end 911s look likely, with Mission E tussling with **Tesla**.

The scheduled introduction of the Mission E indicates that the emissions crisis faced by VW and the resultant costs to the company with inevitable knock-on effects to many projects, will apparently not stymie such advanced electric R&D work.

These electric developments mesh to some degree with Audi's work on a Combined Charging Systems (CCS) that will offer a range of over 400 km (249 mi) after 30 min. Technology of this type has been fitted to the limited-production Audi R8 e-tron and e-tron quattro concept.

At the recent ELIV (Electronics in Vehicles) Congress in Baden-Baden, Germany, Audi made a presentation together with its partners (including Porsche) in the Charging Interface Initiative (CharINev) suitable for charging with 150-kW power. CCS facilitates charging of electric cars with AC or DC using a standardized charging interface combo plug.

This still means finding a power source along the highway and also using one at home or office. Bentley's Rose said that indications at present point to many PHEV (plug-in hybrid electric vehicle) owners not wanting the hassle of plugging in such systems.

Induction charging could be the answer, but Bentley customers may be offered an interesting solution, according to Rose: "If we had all-electric Bentleys, one thing we could do would be to take the power to them."

This would be a service to individually charge a Bentley owner's electric car's batteries wherever (within reason) it was parked. Not something that would be feasible for high-volume models, he agrees, but a possibility for Bentley's very low, super premium EVs.

As well as electric motor production, Porsche's big spend will see a new paint shop commissioned and a new assembly plant built. The present body shop is also being expanded, and Porsche's R&D center at Weissach is receiving new investment. Around 1000 extra engineering, design, and technician jobs will be created.

The company regards the expansion as an indication of its priorities. Dr. Wolfgang Porsche, Chairman of the Supervisory Board, stated: "With Mission E, we are making a clear statement about the future of the brand." He describes it as a "fascinating sports car." It certainly promises to be, although just how much of the concept will be carried over to the production car is not fixed.

At 4850 mm (190.9 in) long versus 5015 mm (197.4 in) for the Porsche Panamera, but only about 1300 mm (51.2 in) tall, the Mission E is regarded by the company as having a character akin to that of a four-door 911, making it more a four-seat sports car than a GT (Gran Turismo).

Porsche also puts emphasis on the car being day-to-day usable in urban environments as well as having long distance capability and "reproducible" acceleration. "The driver should be able to again and again accelerate and not suffer any degradation in performance (up to a point, of course)," said Porsche's technology spokesman.

Power output is 440 kW with 0-100 km/h (0-62 mph) capability of 3.5 s and 0-200 km/h (0-124 mph) in 12 s. A 100% charge of its lithium-ion batteries would provide a 500-km range but a 15 min, 80% charge would be sufficient for 400 km. The car is being engineered to be recharged by ground-installed induction coils.

The powertrain, incorporating two permanent magnet synchronous motors, will be based on technology

Bentley's EXP10 Speed 6 may be offered with a pure electric drivetrain and 500-km range in production form.

developed for Porsche's Le Mans race winning 919 hybrid. They are said to be able to deliver full power "even after multiple accelerations at short intervals," adding that the Mission E concept's lap time of the Nürburgring's Nordschleife is under 8 min.

Battery position is underfloor longitudinal, stretching between both axles, each of which is driven by an electric motor.

The concept's bodyshell comprises aluminum, steel, and carbon fiber; the production car's is likely to be similar although the proportional make-up of materials is not certain.

The body style of the Emission E is highly distinctive with rearward pivoting rear doors (counter-opening) which obviate the need for a B-pillar. That configuration can bring torsional rigidity challenges and raise questions of passenger safety, so it will be interesting to see if solutions are found and both aspects make it to production.

Aerodynamic details of Mission E include integrated air guides to reduce turbulence around its wheels. Headlights are described as a "new type" of matrix LED.

Another significant design feature is the use of camera systems (mounted in the front fenders) to replace door mirrors. Again, it is a matter of whether they meet legal criteria in all markets. As a member of the Volkswagen Group, the car will benefit from experience gained via a similar system used for the ultra-low-volume VW XL1. The big plus is the benefit to the car's Cd figure. The screens, placed in the lower corners of the windshield, can display other safety information too.

Cabin details include use of OLED (organic light-emitting diodes) for instruments. An eye-tracking camera detects at which instrument the driver is looking. The driver can then activate and navigate the menu of the instrument when appropriate via a button on the steering wheel. The whole instrument display "follows" the driver if seat height is changed, so ensuring the steering wheel does not block information.

The dashboard is a veritable party piece of technologies including a holographic display showing virtual apps stacked in virtual space and arranged by priority with a 3D effect. Gesture control is also used for function selection.

For both Porsche and Bentley, super premium electric promises to take on a new dimension: fast cars and fast chargers.

Stuart Birch

PRODUCT BRIEFS

SPOTLIGHT: DATA ACQUISITION

Measuring module with TEDS support

IPETRONIK supports the use of TEDS (Transducer Electronic Data Sheet) sensors with a Lemo-2B-version of its multifunctional module Sx-STG, under the IEEE-1451.4 defined plug-and-play standard. It enables the flexible, faultless adjustment of the module on new sensor parameters. The Sx-STG detects, e.g., IEEE-1451.4 Class 2 sensors (multi-wire connections, e.g. as bridge sensors) automatically and reads the sensor-specific data via the TEDS connection; the user does not have to enter the scaling data manually. Channel-specific settings such as operation mode, filter, excitation voltage, sampling rate, etc. are performed with the data-acquisition software IPEmotion. TEDS is suitable for vehicle development and production as well as for on-site applications at the customer. Sx-STG is an eight-channel multi analog measuring module with sensor supply for various applications inside the vehicle cabin. The module supports three different signals according to measuring input: voltage, IEPE (Integrated Electronics Piezo Electric) or ICP (Integrated Circuit Piezoelectric), as well as strain gauge sensors. Eight analog inputs cover measuring ranges with voltages of ±0.01 to ±50 V. Each input has its own configurable sensor supply of ±15 V with up to ±45 mA. The measuring data output occurs via Ethernet or the CAN bus. It operates in a temperature range of -40 to +85°C (-40 to +185°F). Sx-STG operates within a supply voltage range from 9 to 36 VDC.

CAN card for embedded data acquisition

Kvaser AB has introduced the Kvaser PCIEcan 4xHS, an integrated controller area network (CAN) card that adds four high-speed CAN channels to any standard computer board with PCI Express capability. Offering silent mode, error frame detection/generation, and an onboard buffer, this add-on board fits many embedded data-acquisition systems and is CAN-FD ready. The CAN controller was developed in-house, implemented in an FPGA. Kvaser claims that PCIEcan 4xHS is its fastest network card ever. It has an average response time of 45 µs. An onboard buffer ensures that there is no risk of the card "dropping" messages, which is very useful in "ping-pong protocols" such as firmware updates, the company notes. The low-profile card—86 x 69 mm (3.4 x 2.7 in)—is fully compatible with **SAE** J1939, CANopen, NMEA 2000, and DeviceNet. With an operating temperature range of 0 to 85°C (32 to 185°F) and galvanically isolated CAN bus drivers, it is designed for standard and industrial computers alike. Kvaser's PCIEcan boards are supported by device drivers and program examples for Windows and Linux. All Kvaser CAN interface boards share a common software API, Kvaser CANLIB, that is free to download. Kvaser CanKing, a general-purpose interactive CAN bus monitor, can also be downloaded at no charge (www.kvaser.com).

Low-volatility gap filler

Henkel Adhesive Technologies has formulated Gap Filler 3500LV to deliver high thermal conductivity of 3.5 W/m-K and the mechanical property benefits of a silicone, but with low volatility for reduced outgassing. The miniaturization trend has put new demands on thermal management requirements, according to Henkel. Providing adequate material coverage for thermal control is challenging, so the use of a liquid material that can fill tiny gaps and flow around complex architectures is critical to ensuring product functionality and reliability. Gap Filler 3500LV is a two-part material that cures at room temperature with the option of accelerated curing through the addition of heat. The Gap Filler's low volatile content is tightly controlled lot to lot, according to Henkel, ensuring outgassing is kept to a minimum. The solution is beneficial in applications that require the optics to remain free of lens fogging such as automotive headlamps and high-intensity LEDs, in addition to infotainment, cameras, and lighting systems. Once cured, Gap Filler 3500LV is a soft material that provides protection from shock and vibration.

Electronic vision system

Ficosa has developed an electronic mirror composed of cameras and displays as an alternative to the traditional exterior rearview mirrors of the vehicle. The Camera Monitor System allows the integration of ADAS (advanced driver assistance systems), such as the traffic detection function, which provides information to the driver about the vehicles around it. Ficosa has been working on electronic mirror R&D since 2007, evolving it to create the 4th generation of the system. The latest version is a prototype that is reportedly "very close" to the mass production concept; the company is already working with several clients to customize it according to their specific needs. The 4th-gen electronic mirror, which is designed to comply with the latest regulations, is composed of two cameras integrated into the sides of the car chassis, which transmit the image with very low latency to two high-resolution displays installed inside the vehicle. The cameras are equipped with wide-angle lenses, High Dynamic Range sensors of 1.3 megapixels, and 60 frames/s.

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AEB test equipment

The Strikeable Surrogate Vehicle (SSV) is the new test system that **NHTSA** (National Highway Traffic Safety Administration) will be using to test Autonomous Emergency Braking (AEB) systems in the U.S. As of 2018 the U.S. NCAP (New Car Assessment Program) will be adopting AEB as a recommended safety technology in the assessment criteria for all new vehicles. In the test, the SSV simulates a vehicle ahead, which is registered by the test specimen's assist system and triggers a braking or evasion maneuver. The SSV's main component is a carbon target that mimics the rear end of a car. Though the industry is still discussing differences in U.S. and EU test procedures, German crash test facility manufacturer **Messring** is already adapting the SSV to its own towing system, which has become the standard in Europe and Asia, it claims. In cooperation with carbon fiber specialist **Wolf Composite Solutions** (NHTSA's development partner), this work has resulted in a new hybrid solution that enables testing according to both procedures, and combines the SSV target with the advantages of the EuroNCAP towing system from Messring. Without conversion work, the user can switch between U.S. or EuroNCAP testing, providing flexibility in terms of the required test scenarios and preventing the need for additional space in the form of a track rail permanently installed on the test track.

Audio network analysis

Mentor Automotive has introduced its A^{2}B Analyzer, which the company claims is the industry's first third-party development platform supporting the Automotive Audio Bus—or A^{2}B—technology developed by **Analog Devices**, Inc. The A^{2}B technology facilitates the design of in-vehicle audio networks with reduced cost and complexity, and the A^{2}B Analyzer helps to reduce the development time for these systems, according to Mentor. A^{2}B utilizes a master-slave line topology to deliver audio and control data, together with clock and power over a single two-wire, unshielded twisted pair cable. The low-latency, deterministic nature of the A^{2}B technology is suitable for in-car audio applications such as hands-free systems, speech recognition, and active noise cancellation. Mentor Automotive designed the A^{2}B Analyzer system hardware and software solution in close cooperation with Analog Devices. The system is part of the Connected OS software development platform which includes the IVI head unit, enabling a distributed speaker network for audio throughout the vehicle, and microphones for active noise control, and the A^{2}B Analyzer system for easy setup, configuration, and functional testing: a complete cockpit development platform utilizing A^{2}B technology. The analyzer system and the Connected OS software platform are now available for evaluation (https://www.mentor.com/embedded-software/xse-automotive/a2b/).

CAD toolbox

Maplesoft has released the MapleSim CAD Toolbox, a new add-on to MapleSim that allows engineers to understand and improve their mechanical designs by bringing their CAD assemblies into the advanced system-level modeling and simulation platform. The MapleSim CAD Toolbox imports CAD models directly into MapleSim, recreating the model components and preserving their kinetic and kinematic properties as well as the spatial relationships between components. It offers feature detection, allowing users to easily add new coordinates at points of interest, such as the center of a hole or along the edge of a component. The toolbox also makes it easy to share coordinate frames between separate bodies, ensuring the bodies will be properly aligned when joined. The MapleSim CAD Toolbox handles files from "virtually any" CAD system, through direct support for a large number of proprietary formats, including those from Inventor, NX, and SolidWorks, as well as the widely supported STEP and STL file formats. Once in MapleSim, the models can be shared with other users, or online using the MapleSim Server, without requiring that the end user have access to the original CAD system or CAD files. Engineers can detect and correct problems at the virtual prototyping stage, long before expensive prototypes are built, according to Maplesoft. The MapleSim CAD Toolbox is available on Windows for both the English and Japanese versions of MapleSim.

Testing of low-friction seals

A new test service introduced by **Bal Seal Engineering**, Inc. offers verified performance results for the company's low-friction spring-energized seals used in rotary/face applications. Rotary/face seals are frequently used in dynamic housings and mounts to protect electronics and other internal components from environmental contaminants that can compromise performance. To minimize stick-slip and meet motor torque requirements, the seals must exhibit very low friction—but they also must minimize leakage over long periods of exposure. Bal Seal's seal test equipment measures friction and leak rate using customer-defined hardware tolerances and operating conditions, including pressure and speed. Fixtures can accommodate seals up to 22-in OD, and can be modified for larger seal dimensions. The fixtures can produce a range of pressures and exert specific frictional forces to accurately simulate a seal's performance under real-world conditions. Rotating plates on the fixtures are connected to digital force testers, which measure the friction of rotation. A vacuum tester simulates airflow over the housing. The tester pulls a vacuum across the plates, creating suction inside the seal to measure the leak rate across its surface. Both friction and leak rate are measured simultaneously. Bal Seal's spring-energized seals, which are machined from polymer-filled PTFE materials, exhibit a low dynamic coefficient of friction. The seals minimize "stiction" to facilitate smooth rotation and bi-directional motion.

COMPANIES MENTIONED

AD INDEX

Q&A

"I view the truck almost like an iPhone, in that it's got all these modules on it—on your iPhone we call them apps," said Navistar CIO Terry Kline.

Connectivity a core pillar at Navistar

Navistar announced last year its plans to offer over-the-air (OTA) reprogramming of engine control modules in 2016 for **International** trucks powered by its N9, N10, and N13 proprietary engines. This technology joins the company's already-in-service OnCommand Connection tool as part of its overall connectivity strategy. OTA reprogramming can be performed at the customer's facility over a secure Wi-Fi connection. Future advancements include expanding to other software modules on the truck like transmissions and chassis, according to Terry Kline, Senior Vice President and Chief Information Officer at Navistar Inc. Kline recently spoke with *Off-Highway Engineering* about the company's vehicle connectivity plans and its current solutions. Read the full transcript at http://articles.sae.org/14551/.

What is Navistar's connected vehicle strategy?
It's one of the core pillars of our corporate strategy to the Board of Directors; a cornerstone of what we're investing in and moving forward. The connected vehicle strategy is a key enabler to some of the other strategies like "up time," meaning that the trucks are running and moving down the road.

We've got OnCommand Connection as one of our cornerstones, and it basically is a diagnostic tool that's an open system, open architecture, that works with and across all the telematics providers...We've got about 160,000 vehicles tied to that system today that we're reading data from and able to do everything from health reports to repair maps—given these codes from the truck that means you need these parts, this kind of technician, and this bay capability. Based off these codes you can drive 1500 more miles but don't drive 1501. So we know what's going to happen to that truck and we've been able with OCC to take repair and maintenance, which averages 15 cents a mile according to ATA (**American Trucking Associations**) and some others, down to 2 to 3 cents by doing predictive maintenance, predictive analytics on when things need to be done vs. doing them the traditional way; this is with customers that we're actively working with [who have] fleets of 200, 300 trucks.

This year, probably one of the biggest things coming out is what we call 'smart routing.' When your truck throws a code or throws a set of codes, we'll know where you're at, what the urgency of that repair is, what parts are necessary, and we would actually allow our dealers to offer up their services to you. It's not just about what's the price going to be but 'when can I get my truck back,' because one of your trucks is sitting idle.

What's the idea behind OnCommand's open architecture?
The 160,000 trucks we've got on OnCommand, it's really important to know that more than 50% of those aren't our trucks, they are competitors' trucks. And that's important for a couple of reasons. One, if you own a fleet of trucks, it's not likely you're going to own one brand. So we give that fleet owner one place to shop for this type of data, whether they own an International brand, or they own a **Freightliner**. We're pretty proud of the fact that we're open, and we believe we're unique in that we accept other brands into the solution. Why would we do that? Well, we believe everybody that owns a truck is a potential future customer, and whether that's tomorrow at the service department buying parts, or that's the next time they buy a new truck.

As you can imagine we're getting tons of data; it's like having 160,000 test trucks on the road. So whenever we have a 'what if,' we generally have a fleet of trucks we can look at to study that [scenario]. It's been invaluable to increase the quality of our vehicles by looking at these trucks and how they're performing, or even help customers to understand that the way they're using the truck is not how it was engineered. In the trucking business, trucks are highly customized; they're highly designed for [specific] applications—a truck built to have a cement mixer put on the back is much different than a long-haul truck. So maybe people aren't using these trucks the way they were engineered. We're starting to notice those things and we can reach out and help; sometimes it's as easy as reprogramming the shifting patterns of the truck.

How does over-the-air reprogramming fit in?
It's another key piece of our strategy, and we believe it's unique in the truck space. Obviously people are doing over-the-air programming in other spaces—I'm sure you've got a smart phone; it gets programmed over the air all the time. But especially in the heavy trucking industry that we play in, we believe we're first to market...We've got it running in our plants right now, reprogramming trucks. We've got it in pilot at some of our dealers and at some of our big customers. And as you would imagine, we're using it heavily on our own captured fleet.

What's the goal with OTA reprogramming?
Engines are first. I view the truck almost like an iPhone, in that it's got all these modules on it—on your iPhone we call them apps. On a truck we call them engine control modules, transmissions have software, brake systems, etc. We want to get to where we program and have the ability to reflash all these devices that have software on them remotely, wirelessly.

Ryan Gehm

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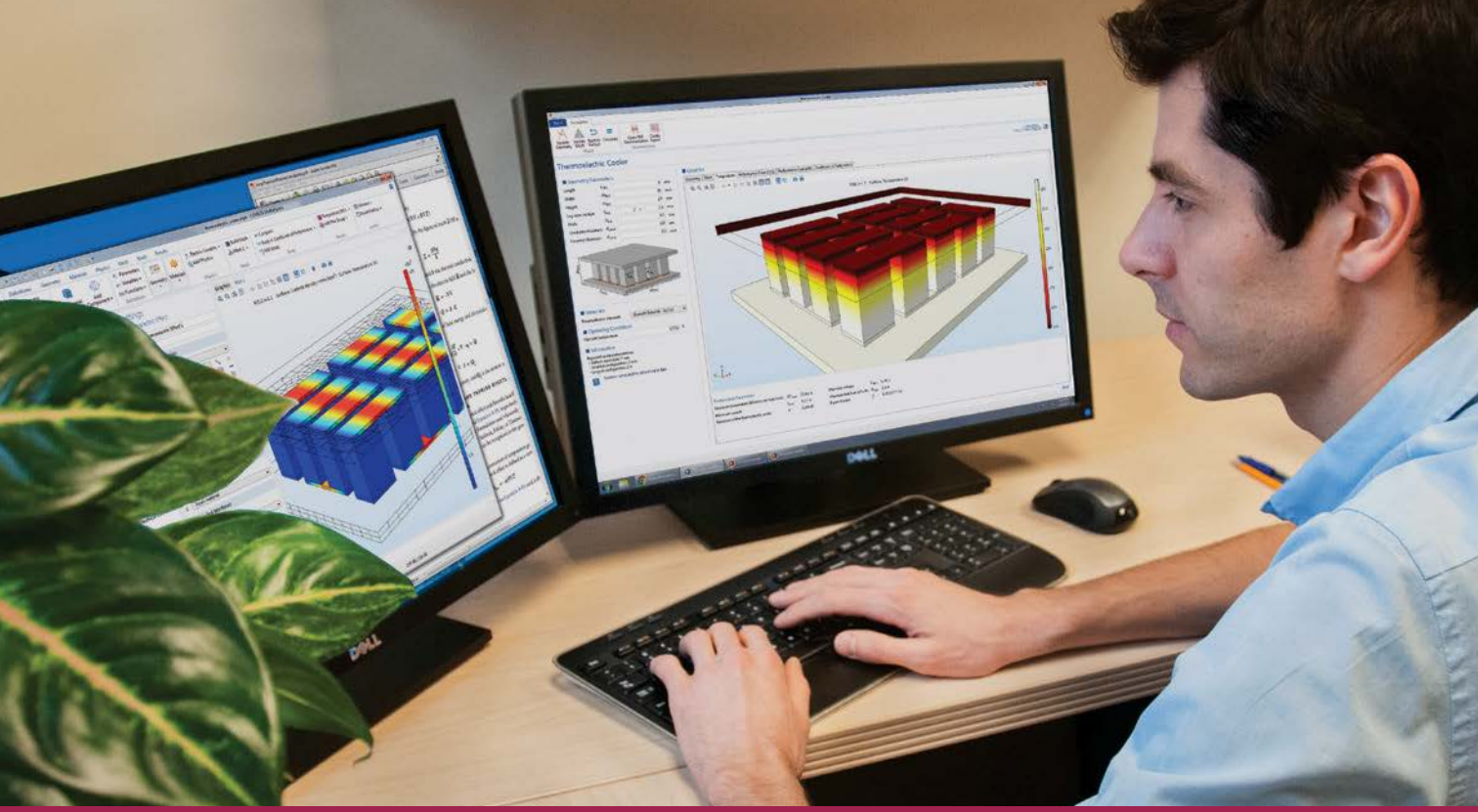

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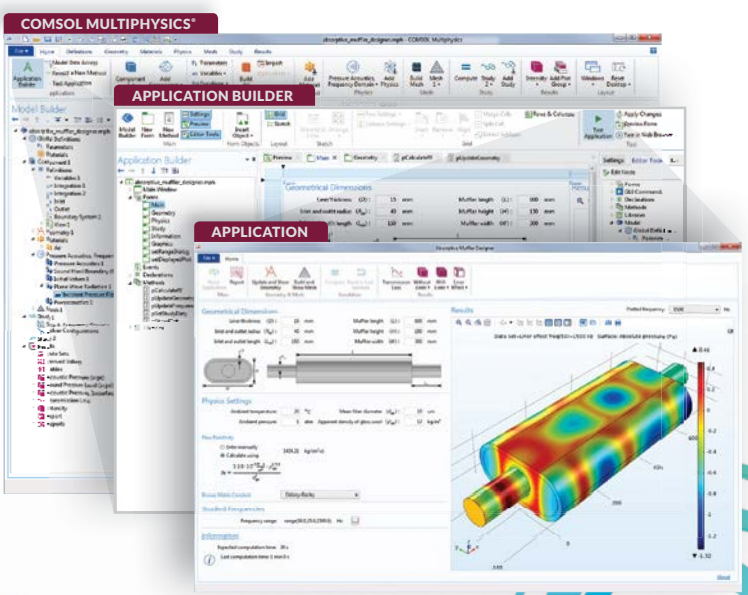

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